

Movement Synchrony, Social Bonding and Pro-sociality in Ontogeny

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Abstract

Human sociality, with its wide scope, early ontogeny and pervasiveness across cultures, is remarkable from an evolutionary perspective. We form bonds with other individuals and live in large social groups. We help, empathise with and share our resources with others, who are unfamiliar and genetically unrelated to us. It has been suggested that interpersonal coordination and rhythmic synchronisation of movements may be one proximate mechanism that enables such widespread human sociality and facilitates cooperation. In the last decade, considerable research has examined the effect of movement synchrony on social bonding and cooperation. However, when this thesis started, there was virtually no experimental study investigating the ontogeny of the movement synchrony-social bonding link, which is proposed to have deep evolutionary roots and important, long-lasting consequences in social life.

This thesis aims to investigate the effects of movement synchrony on social bonding and cooperative behaviour across different time points in ontogeny. Three experimental studies were conducted examining infancy, early childhood and middle childhood. Each study explored a different aspect of social bonding and cooperation based on the motor, social and cognitive developments that mark that age group.

Study 1a found that at 12 months of age, infants prefer individuals who move in synchrony with them, when the individuals are social entities, but not when they are non-social. Study 1b showed no preferences for synchrony at 9 months in either social or non-social contexts, however. Study 2 revealed that in early childhood, performing synchronous movements actively with a peer facilitates helping behaviour among the children, as well as eye contact and mutual smiling during the interaction. Finally, Study 3 showed that the social bonding effects of movement synchrony applied to inter-group settings and that performing synchronous movements with out-groups increased bonding towards the out-group in middle childhood.

This thesis followed an interdisciplinary, integrative and naturalistic approach, where (i) literature from a wide range of disciplines motivated and guided the present research; (ii) links between motor, social and cognitive aspects of development, which are often investigated separately, are formed; and (iii) the experiments were designed in ways that represent the real-life occurrences of the investigated phenomena. The current findings provide the first substantial evidence that movement synchrony facilitates social bonding and cooperation in childhood and thereby provides a foundation for future research.

To Denise and Hend

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1

INTRODUCTION AND THE BIG PICTURE

1.1 AIM OF THE THESIS AND THE SCIENTIFIC APPROACH

A vast variety of cooperative interactions are displayed in human societies, where individuals work together with and for others in order to achieve outcomes that benefit one another. Raising children together, helping others in need and forming institutionalised systems are only a few examples. Human cooperation is distinguished from cooperation observed in other animals by its massive scale, unprecedented variety and early development (Tomasello, 2009). Unlike other social animals, humans help, share with and have feelings towards individuals they do not know and with whom they are genetically unrelated. Increasingly, research shows that the precursors of these elaborate forms of cooperative behaviours can be observed early on in development (Drummond, Paul, Waugh, Hammond, & Brownell, 2014). How and why human cooperation might have evolved and which mechanisms enable it have been topics of interest for a wide range of researchers in fields of evolutionary biology, genetics, anthropology, archaeology, economics and social, developmental and evolutionary psychology.

One proximate mechanism that is thought to facilitate cooperation and social bonding in humans is interpersonal coordination and rhythmic synchronisation of movements (Dunbar & Shultz, 2010). These movements are marked by their specific pattern of shared timing among performers; the moves either follow the same rhythmic pattern or complement each other by occurring at the same time as the other person's movements (see Section 1.5 for more details on definitions). Examples of such movements include a mother and infant's coordination of movements in line with each other's demands (Bernieri, Reznick, & Rosenthal, 1988; Isabella, Belsky, & von Eye, 1989; Jaffe et al., 2001), unconscious alignment of body postures during a conversation (Condon & Ogston, 1966; Kendon, 1970; Lafrance & Broadbent, 1976; Lafrance,

1979), groups of people swaying their bodies back and fro simultaneously in a religious ritual (Henrich, 2009), or individuals dancing in time to musical rhythms (Ehrenreich, 2006).

Although the meanings, specific actions and the rhythms employed may depend on the cultural context in which they occur (Clayton, Sager, & Will, 2004), variants of rhythmically synchronised human behaviours are prevalent across cultures (Ehrenreich, 2006; Merriam, 1964). Importantly, only a few species other than humans can synchronise their movements to auditory rhythms (Schachner, Brady, Pepperberg, & Hauser, 2009). This ubiquitous human phenomenon of synchronous group movement, once thought to serve no evolutionary function (e.g., Darwin, 1839), has been proposed by many to emotionally and socially bond people together, facilitate pro-social behaviour and to have deep evolutionary origins and consequences in our genus (e.g., Dunbar & Shultz, 2010; McNeill, 1995). The terms social bonding and pro-sociality will be more precisely defined in Section 1.5. Briefly, social bonding refers to a state of positive emotionality and social closeness, constructed through social encounters. Pro-sociality is used to refer to other-oriented actions that are motivated by and result in benefiting others, usually apparent in the form of helping, sharing and comforting (Dunfield, 2014). Pro-social motivations and behaviours are typically viewed as being oriented towards engaging with and benefiting others more than being oriented towards the self (Batson & Powell, 2003; Jaeggi, Burkart, & Van Schaik, 2010).

The aim of this thesis is to investigate the effects of interpersonal movement synchrony on social bonding and cooperative behaviour at certain time points in ontogeny. To that end, three experimental studies that focus on three different age groups were conducted. The selection of the three time points - infancy, early childhood and middle childhood - was based on their known significance for children's motor

development, social cognition and cooperation. This thesis aims to make at least three key contributions to the existing literature. First, the investigation of the proposed link between synchronous movements and social bonds aims to contribute valuable ontogenetic data and perspectives to developmental and evolutionary accounts of the functions and mechanisms of movement synchrony (Tinbergen, 1963; Bateson & Laland, 2013). Second, through investigating social development and cooperation in relation to physical movement coordination, the thesis aims to highlight the importance of an integrative approach in developmental research, which takes into account interactions among motor, cognitive and social domains (Prinz, Beisert, & Herwig, 2013). Finally, the novel study designs contribute to the literature by developing naturalistic methods that examine movement synchrony and social bonding in controlled laboratory settings. Each one of the 3 studies that comprise this thesis aims to answer a different, previously unexplored research question about the hypothesised movement synchrony-social bonding link in children (more details in Section 1.4).

In this endeavour, several principles were adhered to, which, together, define the scientific approach underlying the current studies. From the formulation of research questions to how the methods were designed and implemented and to the way findings are interpreted, a broad evolutionary and interdisciplinary approach was followed. The study ideas were motivated by research in social and cultural anthropology, evolutionary biology and evolutionary and developmental psychology. Also, in constructing the developmental framework, an integrative approach was followed, in that different aspects of development, namely motor, cognitive and social, were viewed as continuously interacting with and influencing each other. For that reason, the literature review chapters to follow will emphasise the developments in motor skills, pro-social behaviour and their interactions with cognitive abilities simultaneously.

Finally, special care was given to constructing as naturalistic a context as possible in the experimental designs. All of the experimental set-ups resembled real-world conditions, in which children perform movement activities and engage socially with others. Where known methods did not meet this criterion, new games, tasks and measures were devised and adapted as appropriate. The current studies thus offer novelty not only in terms of the questions they answer but also in terms of their comprehensive approach and methodology.

1.2 EVOLUTIONARY THEORIES OF THE MOVEMENT SYNCHRONY-SOCIAL BONDING LINK

Humans are a social species. This means that individuals routinely interact with each other in organised social structures and form enduring bonds with one another. In our evolutionary history, sociality has manifested in forms of cooperative hunting, cooperative child rearing and group living. In all these contexts, individuals cooperate with each other by sharing information and valuable resources, by taking turns to help each other and by performing their assigned roles within the group. Working together towards a common goal (e.g., rearing children) may require making sacrifices (e.g., spending time and effort on taking care of another group member's baby) and taking risks (e.g., leaving your baby alone with a member of the group). Thus, cooperation is potentially costly for the actor, while it benefits the recipient(s) (West, Griffin, & Gardner, 2006). The evolution of costly cooperation that benefits others (altruism) is only possible if cooperation incurs greater direct benefits on the cooperator in the long run (e.g., as a result of reciprocity) or if the costs of cooperation are sufficiently offset by genetic relatedness (e.g., via kin discrimination; West et al., 2006).

Due mainly to the large scale social groups that humans form, human cooperation presents an interesting theoretical challenge for evolutionary approaches. When group

size is small and individuals are genetically related to one another, the likelihood of benefiting from group living is higher (be it directly, through increasing one's own chance of survival or indirectly, through benefits incurred to other group members who share similar genes; Dawkins, 1976). In contrast, in large groups composed of genetically unrelated individuals, the probability of receiving direct or indirect benefits in return for cooperation costs incurred is lower. Free-riding, or benefiting from others' cooperation while incurring none of the costs, is made easier through relatively higher anonymity and mobility in large groups. Increased pressure on scarce resources and conflicts of interest create tension among the group members. For successful cooperation to persist under these conditions, certain mechanisms need to be in place (a) to alleviate aggression and antagonism among group members and (b) to facilitate trust, togetherness and motivation for engaging in potentially costly cooperation with non-kin.

Considering human social bonding and cooperation specifically, some of these mechanisms may have their origins in the facts of birth and development. The attachment between infants and their carers (in most cases, mothers) stands out as one of the most essential and intense social bonds (Broad, Curley, & Keverne, 2006; Okabe, Nagasawa, Mogi, & Kikusui, 2012). Humans, unlike other great apes, are cooperative breeders, where adults take care of each others' infants (alloparenting) even if the infant is genetically unrelated to them (Hrady, 2007). By increasing the number of carers per infant, this behaviour eases the rearing of the young, who, in the case of humans, are born very helpless and needy and who have a long childhood period, reflecting the long postnatal development of the human brain (Martin, 1983). This has important implications for the relationship between infants and their carers; infants' state of helplessness raises the importance of bonded, continuous caregiving for survival into childhood. These pressures appear to have led to adaptations that favour long-term

investment by the carer and that enable infants to both express their needs and to be receptive to verbal and non-verbal signs of social interaction (Rosenberg & Trevathan, 2002). Comparisons among primates reveal that, compared to non-cooperative breeders, species that engage in cooperative breeding (i.e., callitrichids and capuchin monkeys) have more sophisticated socio-cognitive abilities, including social learning, communication, teaching, gaze understanding and cooperative problem solving (Burkart & van Schaik, 2009). Cooperation between adults is also more frequent in these species, as evidenced by greater amounts of spontaneous food sharing compared to non-cooperatively breeding primates such as chimpanzees (Burkart, Hrdy, & Van Schaik, 2009). This suggests that mechanisms that initially serve to forge the infant-carer bond may extend to other relationships, including relationships between adults, having been co-opted for bonding within groups of genetically distantly related or unrelated individuals (Broad et al., 2006).

Physical movement properties are immensely important for early carer-infant bonding, as the bonds between human infants and carers are formed long before the infant is able to use verbal language. Early bonding processes rely, among other things, on gestural communication, coordination of movements and alignment of emotional states between the interactants (Feldstein et al., 1993; Trehub, 2001). Of particular importance to the current thesis are physical coordination, imitation and rhythmic engagement. Infants' natural interactions with their mothers often involve mutual alignment of the timing of body movements and vocalisations (Jaffe et al., 2001) and mothers' imitation of the babies' facial and vocal expressions (de Barbaro, Johnson, & Deák, 2013). Infants also seem to have a preference for rhythmic stimuli; they prefer listening to infant-directed speech (IDS) and lullabies over adult-directed speech, which lacks the rhythmic, melodic structure of the former two (Cooper & Aslin, 1990). Infants

also enjoy being rocked and bounced in synchrony to the rhythms of lullabies (Kinsbourne, 2002; Meerloo, 1961) and observing repetitive gestures that often accompany IDS (Brand, Baldwin, & Ashburn, 2002). It has been suggested that interactions that involve coordinated movements, imitation and IDS facilitate emotion understanding and sharing between the infant and the carer, thereby strengthening their connection to each other (Feldman, 2007; Monot, Foley, & Ross, 2004). The coordination and rhythmic synchronisation of movements with others, which initially originated to enhance infant-carer interactions, may also function to facilitate bonding among individuals into adulthood (Dissanayake, 2000).

Coordination and synchronisation of movements is important for successful face-to-face cooperation; without attending to and aligning carefully with the timing of your partners' movements and complementing them, common goals are difficult to achieve (Sebanz, Bekkering, & Knoblich, 2006). An evolutionarily relevant example of this is the elaborate movement coordination displayed in cooperative hunting contexts, where all individuals involved in the hunt need to keep track of what the others are doing and to perform their part in a highly time-locked manner (Tomasello, Melis, Tennie, Wyman, & Herrmann, 2012). A simpler example is a group of people trying to move an object, say a table, from one point to another (Knoblich & Sebanz, 2008); carrying the object is physically costly and requires the individuals to coordinate movements and to cooperate closely in order to successfully reach the outcome. Observations across cultures and languages have also shown the more implicit and automatic side of interpersonal movement coordination. During conversations, for instance, turn-taking and arranging the timing of one's speech in relation to another person's speech is essential for successful communication to take place (Stivers et al., 2009).

Sometimes, coordination can take the form of rhythmic synchronisation (i.e., individuals performing movements at the same time with each other, much like following a metronome beat). Daily life examples of this can be found in group dancing, marching, work on the factory production lines or the performance of laborious tasks, such as harvesting or building (Bücher, 1897; Ehrenreich, 2006; McNeil, 1995). Although it is hard to quantify the prevalence of rhythmic movement synchronisation in our distant ancestral past, these examples reveal its widespread usage in modern settings. Coordination and rhythmic synchronisation of movements are thought to make cooperation possible and efficient, for example, by directing the participants' attention to mutual goals and ensuring that all participants play their part at the right moment.

It has been proposed that coordination and movement synchrony also facilitate cooperation by altering and aligning participants' attentional and emotional states and making them feel more similar and closer to one another. When people dance in groups or when they move their bodies in rhythmic synchrony, for example in a ritual context, a sense of transcendence or even exaltation can emerge, of reaching out of one's self and merging into the group; a "collective effervescence" (Durkheim, 1915). These experiences are thought to bond people together by blurring the boundaries between self and other and by creating a sense of shared emotionality and collective joy (Ehrenreich, 2006). In extreme cases, this sense of elevation and merging of the self with the group can result in self-sacrificial behaviour too (Konvalinka et al., 2011; Swann, Jetten, Gómez, Whitehouse, & Bastian, 2012). Thus, it has been proposed that coordinated and synchronised movements foster social bonding and cooperation by diminishing differences among individuals and by creating a context in which group members share similar emotional states and have a sense of merging of their selves and the group (Dunbar & Shultz, 2010). Once initiated, the positive effects of coordination and

movement synchrony on social bonding and cooperation likely reciprocate in a virtuous cycle, whereby individuals who cooperate are more likely to successfully coordinate movements with each other and the more they coordinate, the more likely they are to cooperate.

It has been also proposed that group synchronous movements signal coalitional strength and unity to other groups and thereby incur advantages in inter-group encounters and war contexts (Hagen & Bryant, 2003; Merker, 2000). Military practices of synchronous movement during drills, marching and chanting of soldiers and tribal war dances that are performed right before the start of battles exemplify the prevalent usage of movement synchrony in inter-group conflict contexts (McNeill, 1995). In addition to helping the advancement of war techniques, these practices are also thought to strengthen the participants' feelings of comradeship, level out discrepancies that may exist among the group members and show strength to opposing groups (McNeill, 1995; Roy, 2011). Together with the coalitional-strength hypothesis of movement synchrony (Hagen & Bryant, 2003; Merker, 2000), the within-group bonding hypothesis (McNeill, 1995; Dunbar & Shultz, 2010), with an emphasis on mother-infant bonding, may explain some aspects of how movement synchrony might have facilitated large-scale cooperation in human evolutionary history. To speculate: The unprecedented increase of the neo-cortex size in humans may have brought about the pressure for infant-carer bonding for extended childhood periods (Hrdy, 2007) and for bonding among non-kin adults now living in groups of increasing size (Dunbar, 1993). Physical coordination and synchronisation of movements may have served to facilitate the formation and maintenance of social bonds in infant-carer pairs (Dissanayake, 2000) and non-kin adults alike (Dunbar & Shultz, 2010). Once individuals started to excel in coordinating their movements with each other, groups with high synchronisation capacity may have

been more advantageous in warfare compared to groups that failed to coordinate their behaviours; in turn, success in an inter-group conflict may have further entrenched within-group cohesion (Hagen & Bryant, 2003).

Regardless of its specific phylogenetic and functional origins (i.e., whether it is to facilitate infant-carer bonds, to facilitate bonding of non-kin adults such as in cooperative hunting contexts or to signal coalitional strength to out-groups), rhythmic synchronisation of movements appears to be a powerful and versatile proximate mechanism, potentially with ancient roots, that helps sustain cooperation in humans across a variety of contexts. Investigating its ontogenetic roots is therefore important for understanding both why and how humans do it (Tinbergen, 1963). To date, the empirical literature has largely focussed on adults. Only very few developmental studies exist (all published since this thesis research began: Rabinowitch & Knafo-Noam, 2015; Trainor & Cirelli, 2015). This thesis addresses this developmental gap by investigating whether and how movement synchrony plays a role in infants' and young children's social bonding and cooperative behaviours. Despite the relative lack of evidence on the synchrony-bonding link in children, a wealth of relevant work in cognate areas suggests that its core physical, psychological and social components emerge from early infancy. The findings from this research provide a robust motivation for the empirical aims of the current thesis.

Drawing examples from ethnographic and experimental studies conducted with children and adults, the next section will demonstrate the prevalence of movement coordination and synchronisation in various social and cultural settings and how they are associated with social bonding among participants. Following this, section 1.4 will lay out the research questions and aims, hypotheses and the significance of the three studies conducted within the scope of this thesis.

1.3 ETHNOGRAPHIC AND EMPIRICAL EVIDENCE FOR THE MOVEMENT SYNCHRONY- SOCIAL BONDING LINK

In many different contexts, people all around the world move their bodies together in highly coordinated, rhythmically synchronised ways. Many European travellers, historians and anthropologists have noted the existence of such group movement displays cross-culturally. Darwin (1839), for example, recounts upon observing a rite in Australia:

“(...) the dancing consisted in their running either sideways or in Indian file into an open space, and stamping the ground with great force as they marched together. Their heavy footsteps were accompanied by a kind of grunt, by beating their clubs and spears together, and wriggling their bodies. It was a most rude, barbarous scene, and, to our ideas, without any sort of meaning. (...) After the dancing was over, the whole party formed a great circle on the ground, and the boiled rice and sugar was distributed, to the delight of all.” (p. 219)

Although the unfamiliar scene is apparently not to Darwin’s taste, collective rhythmic movement performances have long been ubiquitous also in Western cultures (Ehrenreich, 2006; Watson-Jones & Legare, 2016). In festivals, celebrations, ceremonies, protests, workplaces, schools, military exercises, religious rituals and sports settings, people frequently chant, dance or otherwise move their bodies in highly coordinated, rhythmically synchronised ways with each other. As McNeill (1995) rightly states, this wide variation of contexts and movements make up an “odd assortment” (p. v). Yet, one obvious commonality is that all of the movements in this assortment are performed in group contexts and in synchrony with certain rhythms, eventually creating a group of highly coordinated individuals, who move in unison.

Turning to the early years of childhood, high interpersonal coordination and rhythmic group movements are also frequently observed in children’s peer-play. While performing collaborative tasks with peers, children as young as 3.5 years of age coordinate the timing of their movements in reference to those of their partners

(Brownell, Ramani, & Zerwas, 2006). Cross-cultural observations of children's natural play with peers reveal that young children spend huge amounts of time engaged together in physical activities, that require interpersonal coordination, such as tag, hide and seek, jumping, skipping or dancing (Evaldsson & Corsaro, 1998; Jarvis, 2006; Oke, Khattar, Pant, & Saraswathi, 1999; Pellegrini, Blatchford, Kato, & Baines, 2004; Schwartzman, 1978). Notably, many games are also initiated with a rhyme that have accompanying movements that the children perform in synchrony with the rhythms of the rhymes (Goldman, 1998). Such physical play requires motor skills, close attention to the movements of the playmates and rhythmical movement in coordination with other children (Gallahue & Ozmun, 2005). During physical play, children also often copy each other's behaviours, which may contribute to goal- and emotion-sharing among friends (Abramovitch & Grusec, 1978); in fact, facilitating imitation can reportedly improve peer interactions of children with social difficulties, such as is the case with autism spectrum conditions (Garfinkle & Schwartz, 2002). Ethnographers maintain that the context of physical play transcends cultural, social and economic boundaries and provides opportunities for the children to master social-communicative skills, make friends and create their own peer culture (Evaldsson & Corsaro, 1998; Schwartzman, 1978; Whiting & Edwards, 1988).

This observation is corroborated by numerous empirical findings showing strong correlations between the amount of time children spent on physical play and friendship formation (Humphreys & Smith, 1987) and the development of social competence, communication and motor movement skills (Jacobs & Vernon, 2009; Pellegrini et al., 2004; Salvy et al., 2007; Timmons, Naylor, & Pfeiffer, 2007). Neuroscientific studies with rats have shown that juveniles' rough and tumble play predicted brain development, particularly the development of orbitofrontal and prefrontal cortices,

which are related to recognising social signals, discriminating social stimuli and decision making (Pellis & Pellis, 2007; Pellis, Pellis, & Bell, 2010). Similar links are thought to exist between human children's physical play and social development too (Graham & Burghardt, 2010; Pellis et al., 2010). Although physical play involves many other elements than synchronous movements, it is reasonable to speculate, based on this and other relevant research, that activities that involve copying others' actions or performing rhythmic synchronisation and coordination of movements with other children can facilitate children's social interactions and bonding with peers.

Similarly, in adult group settings, music, dance and coordinated movement performances abound and they seem to play a role in forging social bonds across time and cultures (Lange, 1976; Roederer, 1984; Wallis, Merker, & Brown, 1963). In his comprehensive work on the Near East and southeast Europe in Neolithic and Chalcolithic periods, archaeologist Garfinkel (2003) writes: "The dancing scenes, it should be emphasized, were a most popular, indeed almost the only, subject used to describe interaction between people" (p. 6). Examples of this have been observed in a variety of cultures and contexts, from the sports tournaments and celebrations of ancient Greece to the shamanist rituals of Asia, from street festivals in Europe to ritualistic and social gatherings in Africa, Australia and the Americas and modern day sports clubs, music bands and fans' behaviours (Ehrenreich, 2006; Watson-Jones & Legare, 2016). In performing these rhythmic movements at the same time with one another, individuals experience collective joy and thrill (Ehrenreich, 2006), where perceived differences between them diminish and a sense of belongingness and merging of self to the group emerges (Kinsbourne, 2002; McNeill, 1995).

In the past decade, this proposed social bonding function of collective synchronous movements has been increasingly investigated in laboratory settings. In an

attempt to isolate the effect of movement synchrony, studies have typically followed a methodology whereby the participants (in pairs or small groups) first performed a movement task (e.g., walking, finger tapping) in synchrony with certain rhythms that were introduced to them via individual auditory channels. If the participants heard and followed the same rhythms, they moved in synchrony with each other; if not, they moved non-synchronously. Following the movement task, social bonding among the participants was assessed using questionnaires and/or various economic games that measure cooperative behaviour.

Findings of these studies show that compared to non-synchrony, participants who move synchronously with each other report higher amounts of liking and rapport (Drolet & Morris, 2000; Miles, Griffiths, Richardson, & Macrae, 2010; Miles, Nind, & Macrae, 2009), similarity (Valdesolo & Desteno, 2011; Valdesolo, Ouyang, & DeSteno, 2010; Wiltermuth & Heath, 2009), trust (Launay, Dean, & Bailes, 2012) and groupishness (Cohen, Mundry, & Kirschner, 2013; Reddish, Fischer, & Bulbulia, 2013; Wiltermuth & Heath, 2009; Wiltermuth, 2012a, 2012b). They also cooperate more by sharing their resources and helping others (Reddish, Bulbulia, & Fischer, 2013; Reddish, Fischer, & Bulbulia, 2013; Valdesolo et al., 2010; Wiltermuth & Heath, 2009). These experimental findings, combined with the ethnographic records, provide support that movement synchrony facilitates social bonds within groups.

In addition to facilitating in-group bonding, ethnographic and experimental findings also provide evidence for the effect of movement synchrony on signalling coalitional strength in inter-group contexts. Synchronous movements are part of routine military practices globally, be it in the form of music making, war dances, marching in drills or chanting in unison (McNeill, 1995). From the Ottoman army's *mehter* team in the 13th century onwards, many armies around the world have established military

bands, where the members play musical instruments together and march and dance in time to the musical rhythms (Eric, 1999). One of the earliest records on the use of rhythmically synchronised movements for military purposes can be seen in the writings of the great Chinese general Sun Tzu in 5th-6th century BC. In the *Art of War*, the training of women on halberds is described as follows:

“He repeated the signal on the drums, and the women faced left, right, and to the front, to the rear, knelt and rose all in strict accordance with the prescribed drill.” (Tzu, 1963, p. 58)

Such synchronous group practices in military settings supposedly increase cohesion, perceptions of strength, comradeship and trust within the army and bring the participants in tune with one another both physically and psychologically (McNeill, 1995; Roy, 2011). The aforementioned experiments which have shown increased bonding among participants following synchronous movement, but not non-synchronous movement, have also revealed that in synchrony conditions, feelings of groupishness (Cohen, Mundry, & Kirschner, 2013; Reddish, Fischer, & Bulbulia, 2013; Wiltermuth & Heath, 2009; Wiltermuth, 2012a, 2012b) and perceived similarity among partners (Valdesolo & Desteno, 2011; Valdesolo et al., 2010; Wiltermuth & Heath, 2009) increase. Participants also become more likely to conform to their synchronising partners' requests (Wiltermuth, 2012a, 2012b). These studies provide some indirect support for the coalitional strength hypothesis, though the effects of synchronous movement performances on outsiders/observers need to be investigated to test the coalitional strength hypothesis more directly.

Relevantly, it has also been shown that when presented with auditory and visual stimuli corresponding to groups of individuals' music making or rhythmic walking, the observers perceive the synchronous stimuli, compared to the non-synchronous stimuli, as indicative of higher cohesion and stronger relationships among the performers

(Edelman & Harring, 2014; Hagen & Bryant, 2003; Lakens, 2010; Lakens & Stel, 2011). Altogether, these findings may be taken as preliminary evidence that synchronised movements increase groupishness and yield observers to have a stronger impression about the synchronising group's unity, which can be potentially useful in inter-group contexts.

The mechanisms through which synchrony incurs these effects on social bonding are, however, less clear, although several psychological and physiological mechanisms have been proposed. One such mechanism is homophily. In large human groups, similarity in physical traits, behaviours, group membership and emotional and psychological states can all constitute proxies for familiarity and genetic relatedness thereby guide social affiliation and cooperation among group members (Haun & Over, 2015). Even within the first year of life, infants display preferences for own-race faces to other-race faces (Kelly et al., 2005), for individuals who speak their native language to foreign speakers (Kinzler, Dupoux, & Spelke, 2007) and for receiving objects (i.e., toys) from adults who share similar food preferences with them (Shutts, Kinzler, McKee, & Spelke, 2009). As children develop, these differences come to mark socially meaningful groups and can guide the children's relationships with peers, pro-social/anti-social behaviours and how they identify themselves (Abrams & Rutland, 2008; Bennett & Sani, 2011; Denham, von Salisch, Olthof, Kochanoff, & Caverly, 2004).

Even arbitrary group assignments determined with the toss of a coin can be the basis for such social categorisation and evoke inter-group biases (Baron & Dunham, 2015; Nesdale & Flesser, 2001), which are characterised by a favouring, positive attitude towards the in-group and a derogative, negative attitude towards the out-group (Tajfel, 1970). Beyond the obvious physical similarity incurred, coordinated, synchronous movements seem to increase perceptions of groupishness (Cohen et al.,

2013; Reddish, Fischer, et al., 2013; Wiltermuth & Heath, 2009; Wiltermuth, 2012a, 2012b) and similarity more broadly in personality traits and psychological states (Rabinowitch & Knafo-Noam, 2015; Valdesolo & Desteno, 2011; Valdesolo et al., 2010; Wiltermuth & Heath, 2009). Movement synchrony may thus facilitate social bonding and cooperative behaviours by altering the participants' perceptions of similarity with each other.

Certain neurophysiological mechanisms have also been implicated in the social effects of movement synchrony. It has been proposed that exertive movements, such as those observed in physical exercise and group ritual contexts, activate the neuroendocrine system, leading to the release of endogenous opioids (e.g., endorphins) and endocannabinoids that modulate pain and reward processes in the brain (Naugle, Fillingim, & Riley, 2012; Raichlen, Foster, Gerdeman, Seillier, & Giuffrida, 2012; Sparling, Giuffrida, Piomelli, Roszkopf, & Dietrich, 2003). Endorphins also have well-established effects on primate social bonding both between mothers and infants (Broad et al., 2006; Martel, Nevison, Rayment, Simpson, & Keverne, 1993) and among adults (Martel, Nevison, Simpson, & Keverne, 1995). In humans, mothers' endorphin levels rise significantly during breastfeeding (Franceschini et al., 1989), which triggers the release of oxytocin (Winberg, 2005); this is thought to encourage costly social investments and long-term affiliation via psychological reward (Panksepp, Nelson, & Sivy, 1994). These findings have led to the suggestion that coordinated, synchronised movements may create positive effects on social bonding by similarly activating the endogenous opioid system (Dunbar & Shultz, 2010). In several experimental studies, where elevated pain thresholds were used as a proxy for increased endorphin activity, it has been shown that synchronous group movement increased participants' pain threshold and bonding with other participants (e.g., Cohen, Ejsmond-Frey, Knight, &

Dunbar, 2010; Tarr, Launay, Cohen, & Dunbar, 2015), though the specific contribution of synchrony to this effect was not investigated. Future research investigating endorphin activity in young children and infants could be useful in revealing the neuro-hormonal mechanisms mediating the link between movement synchrony and social bonding in development.

Another mechanism that can potentially explain the social effects of synchrony, and of physical coordination of movements more generally, is the Mirror Neuron System (MNS). Mirror neurons refer to certain brain cells in the inferior parietal lobule and ventral premotor cortex that are activated both as one performs a motor action and as one observes someone else perform that motor action (for a review, see: Rizzolatti & Sinigaglia, 2010). It has been proposed that this matching of action-observation networks helps goal understanding and prediction of others' actions (Rizzolatti & Craighero, 2004). Some researchers have even argued that this neural mirroring of others' actions in the MNS may facilitate mental state understanding and sharing of intentions and emotions with others (Fogassi et al., 2005; Uddin, Iacoboni, Lange, & Keenan, 2007). Although it is not clear whether MNS activation can yield sharing of mental states as such, there is some evidence that it is involved in emotion processing and empathy (Greimel et al., 2010; Schulte-Rüther, Markowitsch, Fink, & Piefke, 2007).

In infants, the MNS is known to show increased activation from at least 6 months of age as infants observe others perform goal-directed actions, predict others' future actions and engage in imitation (e.g., Iacoboni & Dapretto, 2006; Nyström, 2008; Southgate, Johnson, El Karoui, & Csibra, 2010). It may thus be that performing time-matched actions with another person activates the MNS, thereby facilitating social bonding outcomes.

Overall, ethnographic records suggest that coordination and synchronisation of movements are widely observed and that they serve to foster social interactions and cooperation in various cultural settings. A wealth of experimental studies with adults further confirm these observations, although examination of the developmental origins of the movement synchrony-social bonding link has only just begun (Rabinowitch & Knafo-Noam, 2015; Trainor & Cirelli, 2015). The current thesis investigates this underexplored topic of the ontogeny of social bonding and cooperation in the context of interpersonal movement synchrony. In the following section, the research questions motivating each one of the current experimental studies will be laid out together with brief summaries of relevant literatures and the study designs that were implemented.

1.4 SETTING UP THE RESEARCH QUESTIONS: THE ONTOGENY OF THE MOVEMENT SYNCHRONY- SOCIAL BONDING LINK

Human sociality and cooperation is evident from early on in childhood. As has been reviewed above, coordination and synchronisation of movements with other individuals is an integral part of young children's social interactions and cooperation, be it with their carers or peers. Yet, there is very little developmental research to date on the links between movement synchrony and social bonding. This thesis reports three experimental studies that investigate the social bonding effects of movement synchrony at three different time points in development: infancy, early childhood and middle childhood. Chapters 2 to 7 will review the relevant literature and explain the three studies in more detail; this section aims primarily to provide an overview of the rationale for the studies. The studies addressed the following research questions:

Research Question 1: Does movement synchrony, compared to non-synchrony, guide infants' social and non-social preferences?

Research Question 2: Does movement synchrony, compared to non-synchrony, facilitate pro-social behaviours in young children's peer-play?

Research Question 3: Does movement synchrony, compared to non-synchrony, facilitate social bonding across already-existing group divides in middle childhood?

1.4.1 Study 1

Research Question 1: Does movement synchrony, compared to non-synchrony, guide infants' social preferences?

From early on in life, human infants display sensitivity to human-like stimuli. They prefer spoken languages to other sounds (Glenn, Cunningham, & Joyce, 1981; Vouloumanos & Werker, 2004) and human faces to similarly complex, non-face images (Dannemiller & Stephens, 1988; Fantz, 1961, 1963). Infants also automatically align their emotional states to those of others, as is illustrated by reflexive crying in response to other babies crying (Simner, 1971) and smiling and frowning in response to the mothers' vocalisations (Yale, Messinger, Cobo-Lewis, & Delgado, 2003). This proclivity for social stimuli assists in communication with carers, which, especially in the first year of life, largely depends on gestures, facial expressions and coordinated physical movements (Trevvarthen, 1979).

From their first months, infants coordinate the timing of their actions to those of their carers in such a way as to complement the other's actions. For example, infants start taking turns as they vocalise in response to their mothers' speech (Feldstein et al., 1993; Jasnow & Feldstein, 1986) and adjust their body posture as their mothers approach them to pick them up (Reddy, Markova, & Wallot, 2013). At the same time, carers frequently imitate their infants' expressions and movements, which both parties

find pleasurable and which helps to create mutuality and shared emotional states with the infants (Flynn, Masur, & Eichorst, 2004; Pawlby, 1977). Over time, infants also start to copy their carers' facial expressions, movements and vocalisations, resulting in a closely bonded reciprocal relationship (Uzgiris, 1981). In communication contexts, infants prefer rhythmical stimuli such as listening to IDS and lullabies (Cooper & Aslin, 1990), being rocked and bounced in time to musical rhythms (Meerlo, 1961) and observing repetitive gestures that their carers perform whilst communicating in IDS (Brand et al., 2002). These studies show that from very early on in human life, action copying and coordination of movements have a crucial impact on social bonding.

Several synchrony studies with adults provide further support for this idea. It was found that when left free to move in their preferred tempo, people spontaneously fell into synchrony with each other as they walked, moved pendulums or rocked in rocking chairs (Richardson, Marsh, Isenhowe, Goodman, & Schmidt, 2007; Richardson, Marsh, & Schmidt, 2005; Schmidt & Brien, 1997; Zivotofsky & Hausdorff, 2007). Moreover, people were more likely to synchronise their movements with a partner when they had a shared social context, such as when they were mutually attending to the same object (Richardson et al., 2005), when they could see each other or hold hands (Zivotofsky & Hausdorff, 2007) and when they anticipated a future interaction (Miles, Griffiths, et al., 2010). During the process of synchronising their movements, compared to performing non-synchronous movements, people also attended to and remembered the characteristics of their partners more, a feature that potentially facilitates future interactions with that person (Macrae, Duffy, Miles, & Lawrence, 2008; Miles, Nind, Henderson, & Macrae, 2010).

Altogether, these findings point to the automaticity of interpersonal synchronisation and to the role that rhythmic synchronisation and coordination play in

facilitating social interactions. It might be that, in the same way that infants have heightened sensitivity towards social stimuli, such as human faces and speech, they may also be sensitive to the timing of others' actions, especially when it is likely to facilitate their social interactions. Studies on young infants' social cognition have revealed that infants prefer those individuals who are similar to themselves to those who are dissimilar in terms of age, gender, race, native language, food preferences and so on (Kinzler, Shutts, & Correll, 2010). Similarity in the timing of movements may be yet another factor that affects infants' social preferences.

Inspired by these previous research findings and methodologies, the first research question was examined in two studies (Study 1a and Study 1b) that separately investigated infants' movement synchrony preferences at 9 and 12 months of age. In a within-subjects design, movement synchrony (synchronous versus non-synchronous) and social context (social versus non-social) were manipulated. Methods that have successfully assessed infants' social preferences in domains other than movement synchrony were adapted (e.g., language preferences: Kinzler, Dupoux, & Spelke, 2007; preference for pro-social versus anti-social individuals: Hamlin, Wynn, & Bloom, 2007). Using large TV set-up, which made the stimuli look a real-life sized, the infants were presented with videos of two entities (social versus non-social toys), one of which moved synchronously with them and the other non-synchronously. While watching the videos, the infants were rocked in rocking chairs by the experimenter in time to a pre-determined rhythm. Right after the movement phase was over, the toys shown on the TV were presented to the infants in real life and the infants were asked to choose between them. It was predicted that infants would prefer synchronous individuals to non-synchronous ones in the social condition, but not in the non-social condition. This pattern of preferences was expected to be observed especially with 12-month-olds; the

9-month-old group was investigated later to explore developmental patterns, specifically whether they would show preferences similar to the 12-month-old infants.

1.4.2 Study 2

Research Question 2: Does movement synchrony, compared to non-synchrony, facilitate pro-social behaviours in young children's peer-play?

The answer to Research Question 1 can inform us about whether movement synchrony guides infants' early social preferences, which may have implications for infants' social partner choices. However, choosing partners is only just the beginning of a social interaction. Bonded, cooperative relationships are marked by the give and take between partners, where what one does benefits one's partner but not necessarily oneself, and at the same time often being costly to self (Batson & Powell, 2003).

Cooperative actions require the ability to understand the intentions and desires underlying others' actions. Although children start to form action-intention-outcome links around the age of 1 (Woodward, Sommerville, & Guajardo, 2001), it is not until early childhood years that they truly understand the effect that other people's beliefs and emotional states might have on their behaviours. For example, 14-month-old infants help adults fetch objects that are out of their reach (Warneken & Tomasello, 2006). This suggests that, by this age, infants can comprehend the adult's intention and inability to reach for the object and infer the type of action needed in order to realise this aim. However, it is unclear whether the demonstrated helping behaviour has self-oriented (e.g., desire for social interaction or desire to see an action completed) or other-oriented motivations (Kenward & Gredebäck, 2013; Paulus, 2014). Around 4-5 years of age, children start to develop a more sophisticated understanding of others' minds and emotional states (Laible & Karahuta, 2014). This development manifests itself in

children's improved empathy skills, in the more frequent and elaborate cooperative behaviours that they display, and in the stronger bonds that they form with their peers (Denham, Bassett, Brown, Way, & Steed, 2013; Zahn-Waxler, Radke-Yarrow, & Brady-Smith, 1977).

Coordination and synchronisation of movements is an important aspect of young children's social interactions with peers. With their improved motor skills in early childhood years, children engage in physical play, where they perform movements that are synchronised and coordinated with other children in time (Gallahue & Ozmun, 2005). The context of physical play provides an important forum for children to socialise and make friends (Timmons et al., 2007). A considerable amount of imitation also takes place among friends during physical play (Abramovitch & Grusec, 1978). All this research shows that performing similar actions in close coordination with each other is important in the context of children's peer-play and relationships with friends. Yet, no research to date has looked directly at how performing synchronous movements with peers might affect children's cooperative behaviour.

Research on adults provides a wealth of evidence that moving in synchrony with another person increases cooperation, such as sharing resources with partners (e.g., Wiltermuth & Heath, 2009), helping (Valdesolo & Desteno, 2011), trusting them (Launay et al., 2012) and having increased feelings of closeness and rapport (Miles et al., 2009; Tarr, Launay, Cohen, & Dunbar, 2015; Valdesolo et al., 2010). Recent developmental studies have also shown that 14-month-old infants who were bounced synchronously with an adult subsequently helped the adult more than those who were bounced non-synchronously (Cirelli, Einarson, & Trainor, 2014; Cirelli, Wan, & Trainor, 2016, 2014). Performing synchronous movements with peers at 8-9 years of age were also shown to increase cooperative attitudes, as evident by increases in perceptions

of similarity and closeness towards synchronising partners (Rabinowitch & Knafo-Noam, 2015). Although these developmental studies are insightful, their designs do not fully represent the theorised effects of movement synchrony, either because the participants did not actively perform the movements themselves due to their restricted motor capabilities (Cirelli, Einarson, et al., 2014; Cirelli et al., 2016; Cirelli, Wan, et al., 2014) or because measures of cooperative attitudes, but not of cooperative behaviour, were taken (Rabinowitch & Knafo-Noam, 2015).

In order to overcome these limitations, the second study of this thesis followed a methodology more similar to that implemented with adults, where the children were required to actively perform the movements themselves and to engage in a cooperative behaviour task afterwards. First, the children played a movement game in pairs, where they either synchronised their movements with their partners or not, depending on the rhythms that they heard from their individual headphones. Next, a helping task was introduced to measure cooperative behaviour within pairs. In addition, implicit indicators of social bonding, such as mutually smiling at each other and keeping eye contact, were assessed. Given the importance of children's developing emotion understanding and empathy abilities, self-report measures were also taken to examine how much children empathised with their partners as they witnessed them have an accident. It was hypothesised that in pairs where the children played the movement game synchronously, there would be more helping behaviour, mutual smiling, eye contact and empathy between the partners, compared to when pairs played the movement game non-synchronously. Exploratory analyses were conducted to assess whether mutual smiling, eye contact and empathy mediated any effects that synchrony had on helping behaviour.

1.4.3 Study 3

Research Question 3: Does movement synchrony, compared to non-synchrony, facilitate social bonding across already-existing group divides in middle childhood?

The results of Study 2 reveal whether active performances of movement synchrony can facilitate helping behaviour and social interactions in pairs of young children. In addition to and beyond facilitating one-to-one relationships, movement synchrony is also proposed to create a group feeling among individuals. From an evolutionary perspective, this feeling of groupishness and within-group bonding is particularly salient in an inter-group context. Thus, it is important to investigate whether social bonding effects of movement synchrony occur at the group-level as well.

Children start categorising the world into groups from very early on in development. For instance, even 3-month-old infants display a preference for looking at own-race faces to other-race faces, suggesting that they categorise human faces based on skin colour (Kelly et al., 2005). However, constructing these categories as socially meaningful ones occurs only towards the end of the early childhood period (Kinzler et al., 2010). It is around this time that children demonstrate inter-group biases (i.e., in-group favouritism and out-group derogation). In middle childhood years, social groups further guide children's friendship choices, pro-social and anti-social behaviours and self-identification (Abrams & Rutland, 2008; Bennett & Sani, 2011; Denham, von Salisch, Olthof, Kochanoff, & Caverly, 2004). In addition to real-world social divides such as race or gender, minimal group assignments, which are based solely on random allocation, can also readily trigger inter-group biases and negative attitudes towards out-group members (Baron & Dunham, 2015; Dunham, Baron, & Carey, 2011; Nesdale & Flessner, 2001).

Through facilitating connectedness and togetherness, movement synchrony can contribute to the formation of a group feeling, which may surmount negative attitudes that emerge from already-existing group divides in children. Both movement synchrony and group-level peer interactions are prevalent in middle childhood. By this age, children have achieved mastery of many basic motor skills (Goodway, Gallahue, & Ozmun & Goodway, 2013), their rhythmic synchronisation abilities have reached adult levels (Drake, Jones, & Baruch, 2000; McAuley, Jones, Holub, Johnston, & Miller, 2006) and engagement with physical activity is high (Malina, 2001). Participation in organised physical activities, such as sports teams, dance clubs etc. also increases, which brings abundant opportunities for performing rhythmic, coordinated movements with other children in group contexts (McGee, Williams, Howden-Chapman, Martin, & Kawachi, 2006). Thus, movement coordination and synchronisation may positively affect children's social bonding with their own and other groups in middle childhood.

Experimental studies with adults have shown that, compared to non-synchrony, moving synchronously leads to increased feelings of connectedness and closeness and of being on the same team with the group members (Reddish, Bulbulia, et al., 2013; Reddish, Fischer, et al., 2013; Tarr, Launay, Cohen, & Dunbar, 2015; Wiltermuth & Heath, 2009). Rabinowitch and Knafo-Noam (2015) have similarly reported that 8- to 9-year-old children experienced increased closeness (as measured by the Inclusion of Other in Self Scale) after performing a simple movement task in synchrony with their partners, compared to performing it non-synchronously or solo.

There is also preliminary evidence suggesting that movement synchrony can facilitate social bonding across group divides. One study showed that, compared to a control activity which did not involve any rhythmic movement (i.e., puzzle solving), people who moved synchronously in groups subsequently shared more resources with

out-group members, who were not involved in the movement/ puzzle solving activity (Reddish, Bulbulia, et al., 2013). Another study with adults showed that people who were split into minimal groups unconsciously synchronised their movements with an out-group member more often than with an in-group member (Miles, Lumsden, Richardson, & Macrae, 2011). It was reasoned that by synchronising their movements with the out-group, participants might have attempted to increase similarity and alleviate the arbitrary social distance incurred by minimal groups. However, no study to date, whether with adults or children, has directly assessed the social bonding and groupishness effects of movement synchrony (compared to non-synchrony) in an inter-group context.

Study 3 examined whether movement synchrony would forge social bonds across existing group divides. Although inter-group biases start to be displayed at the end of early childhood, this study was conducted with 7- to 12-year-olds, to obtain a more pronounced groupishness effect (see Section 6.2.2) and to ensure children could proficiently perform all the moves without being distracted from each other in a group setting. Children were first split into two minimal groups of 3 individuals each. Children's level of social bonding towards their in-group and towards the out-group was assessed with a brief questionnaire at baseline. The two groups then performed a rhythmic movement task either synchronously with the other group (i.e., performing identical movements in time to the same rhythm) or non-synchronously (i.e., performing different movements and following different rhythms). After the movement task, an implicit behavioural measure of social closeness (called the Island Game), which was devised specifically for this study, was implemented. The Island Game assessed children's willingness to stay physically close to the in-group and the out-group, which was considered an implicit indicator of social closeness. Finally, another social bonding

questionnaire, including the Inclusion of the Other in the Self (IOS) Scale was given to the children. It was expected that compared to baseline, a greater increase in out-group bonding in the synchrony than in the non-synchrony condition would be observed following the movement task. Similarly, the IOS Scale responses were expected to indicate more closeness towards the out-group in the synchrony than in the non-synchrony condition. Regarding the implicit behavioural measure, it was hypothesised that children in the synchrony condition would stay physically closer to the out-group compared to children in the non-synchrony condition. The findings of this study further our knowledge about the extent of the social bonding effects of movement synchrony by testing the issue, for the first time, in an inter-group setting.

1.5 DEFINITIONS AND MEASUREMENT OF CONSTRUCTS

The main aim of this thesis is to investigate the link between movement synchrony and social bonding and cooperation in childhood. It is therefore important to clarify the scope of the thesis and how these variables are defined and measured. Due to a scarcity of prior research on this topic, this thesis serves as a foundation for understanding the proposed movement synchrony-social bonding link. Certain implications follow from this foundational nature of the thesis. Firstly, the empirical contributions focus primarily on determining whether movement synchrony is associated with social bonding, rather than testing directly the various possible mechanisms via which this association may be formed. Secondly, the studies are inspired and informed by a rich literature on the development of children's movement abilities and social/cooperative skills, but it is important to note that most of this literature is drawn rather narrowly from what have been dubbed as WEIRD populations: Western, educated, industrialised, rich and democratic (Henrich, Heine, & Norenzayan, 2010). Despite acknowledging the wide cross-cultural variation in children's daily

practices and their developing motor, social and cognitive abilities, this thesis was conducted with children living in Europe, albeit coming from mixed socio-economic backgrounds and ethnicities. This way, the samples of the current studies more closely matched and could therefore be more directly informed by the existing literature. Future studies are needed, however, to ascertain the mechanisms of how any of the found effects emerge as well as how generalisable they are to non-WEIRD populations.

Turning now to the definition of constructs, in real life interactions, synchrony typically entails coordination of timing of actions with another person. As such, it may resemble imitation and mimicry, where people copy each other's movements consciously or unconsciously. Synchrony differs from these two constructs by its emphasis on rhythmicity in the movements and necessitating a match in the timing of the rhythms rather than in the morphological features of the actions. Still, where relevant, the literature from neighbouring fields, namely on interpersonal movement coordination will be reviewed and guide the implementation of movement synchrony in the current studies.

To test specifically the effect of matched timing of movements, the current studies will follow the operationalisation widely used in the existing literature with adults and manipulate rhythmic synchrony. Even though this operationalisation entails coordination with the individual auditory stimulus and not spontaneous coordination with another individual, it has several advantages that make it the most suitable method for a foundational study like the current one. Firstly, using rhythmic synchronisation increases control and precision and thereby ensures that synchrony and non-synchrony conditions are clearly distinguished from one another by the match/mismatch of the timing of movements. Secondly, interpersonal synchrony emerging as a by-product of coordination with individual rhythms enables controlling for other extraneous variables

such as shared intentions and mutual goals between the participants. Finally, the precedent from the adult literature showing that the manipulation of movement synchrony in this way does produce pro-social outcomes reassures that the proposed effects can be found under these conditions as well.

In line with its widely accepted use in musicology, rhythm here is defined as a “serial pattern of durations marked by sounds (notes) and silences (rests)” (McAuley, 2010, p. 166). For all three studies presented here, rhythmic auditory tracks were prepared. The synchrony manipulation was done by presenting the participants with one auditory track each and asking them to synchronise their movements with the rhythms that they hear. At least two types of rhythmical movement are widely recognised in the literature as synchronous: in-phase and anti-phase. In-phase synchrony is when the position of the movements of individuals match each other perfectly (e.g., both individuals raise their finger up at exactly the same time in a finger tapping task) and anti-phase synchrony is when they are reversed by 180° (e.g., one person raises their finger up while the other person taps on the table right at the same moment). Research has repeatedly shown that in-phase synchrony is more intuitive and sustainable for participants (Haken, Kelso, & Bunz, 1985; Schmidt & Brien, 1997); hence, the synchrony conditions of the current studies were arranged such that the participants would engage in in-phase synchrony.

For the current studies, movement synchrony is operationalised as the matching of rhythmic movements among two or more individuals, where the positions of the individuals’ movements also match with each other. In order to isolate and assess the pure effect of interpersonal movement synchronisation, the synchrony conditions were always contrasted with non-synchrony conditions in the present thesis. In the synchrony condition, the participants were presented with the same auditory track and hence

moved synchronously with each other, while in the non-synchrony condition, different tracks were presented to the participants, and hence, they moved in time to different rhythms.

In order to examine the hypothesised effects of movement synchrony on social bonding, a multi-dimensional conceptualisation of the dependent variable was needed. In the literature, social bonding has been defined as being comprised of two parallel processes: a cognitive mechanism, which enables individuals to recognise others, infer intentions from behaviours, and remember past events, and an emotional mechanism, which enables appropriate (e.g., empathic) behavioural responses and forms the basis of attachment (Baron-Cohen et al., 2000; Dunbar, 2010). This view of social bonding highlights a state of positive emotionality, closeness and connectedness, constructed on the basis of previous social encounters. Thus, the theoretical and empirical emphasis here is on the psychological state that individuals experience during social interaction and cooperation.

Employing this definition of social bonding in the present thesis, individuals' behaviours were investigated as indicators of social bonding. Specifically, pro-social behaviours were observed. In the social and psychological sciences, pro-sociality refers to positive, cooperative motivations towards others and their resulting behaviours, usually measured in the form of helping, sharing and comforting (Dunfield, 2014). Pro-social motivations and behaviours are typically viewed as being oriented towards engaging with and benefiting others more than being oriented towards the self (Batson & Powell, 2003; Jaeggi et al., 2010). Although pro-social attitudes and behaviours are highly likely to emerge in closely bonded social relationships, they are not a necessary condition for social bonding; nor is social bonding a prerequisite for pro-sociality and

cooperation. It is thus important to be clear about what exactly the measures used in the current studies measured and what can (and cannot) be inferred from the findings.

In each study, a different aspect of social bonding was measured, taking into account the social abilities of the children, depending on their ages. The first study with 9- and 12-month-old infants examined social preferences. The act of choosing one of the two individuals does not necessarily incur any obvious benefits on the individual chosen. Hence, the measurement of social preferences does not fit strictly into the definition of cooperative behaviours. Still, infants' preferences are telling about who they like more and wish to approach, thereby indicating preliminary pro-sociality and bonding towards that individual.

In the second study, involving 4- to 6-year-old children, instrumental helping behaviour was assessed. With its early emergence around 14 months of age (Warneken & Tomasello, 2006), helping behaviour is known to be fairly robust by early childhood (Dunfield, 2014). Additional measures that characterise the more emotional and implicit aspects of children's social bonding and interactions, such as empathy, eye contact and mutual smiling between peers, were also analysed. Therefore, the second study measured cooperative behaviour and implicit indicators of social bonding that are representative of children's social interactions in early childhood years.

The third study, conducted with children aged 7 to 12, used implicit behavioural measures (i.e., Island Game) and self-report questionnaires to investigate various aspects of social bonding in an inter-group context. The questionnaires assessed the children's feelings of closeness, similarity, connectedness, liking and willingness to help and share with their peers. The Island Game measure assessed children's willingness to be physically close to their own and the other group. This measure was devised specifically for this study and was adapted from social bonding measures used

in the social psychology and animal behaviour literature. Thus, the final study incorporates measures of cooperative attitudes, implicit pro-social attitudes and social bonding behaviour. Altogether, the measures used in the present studies assessed different components of social bonding and pro-sociality that aimed to capture the theorised effects of movement synchrony at specific points in development, and that are appropriate to the children's age-dependent abilities.

1.6 OVERVIEW OF THE CHAPTERS

The following chapters will review in more detail the relevant literature motivating the research questions separately and report the studies conducted. Where relevant, the points made in this chapter, particularly the developmental trajectories of certain skills, will be elaborated. Even-numbered chapters will provide thorough reviews of the literature of the relevant age group (Chapter 2: Literature review of Study 1, Chapter 4: Literature review of Study 2, Chapter 6: Literature review of Study 3). Within each one of the review chapters, the literature covered will comprise (a) the development of motor synchronisation skills, (b) the development of social bonding and pro-sociality, and (c) how the developments in these domains, motor and social-cognitive, interact with each other. Following each literature review, the methods and the results of the studies conducted will be presented, together with brief discussions of the findings in the odd-numbered chapters (Chapter 3: Study 1, Chapter 5: Study 2, Chapter 7: Study 3)¹. Finally, Chapter 8 (General Discussion and Conclusion) will

1

In all of the reported studies, the Experimenter (E) refers to me. Where there are multiple raters, one of the raters (not blind to the hypotheses but always blind to the conditions) was also me.

Manuscripts reporting the findings of these studies have been published in the following journals:

evaluate the theoretical significance of the current findings, situate them within prominent evolutionary and developmental debates, examine the implications of the current results for applied fields and suggest directions for future research.

Study 1: Tunçgenç, B., Cohen, E., & Fawcett, C. (2015). Rock with me: The role of movement synchrony in infants' social and nonsocial choices. *Child Development*, 86(3), 976–984. <http://doi.org/10.1111/cdev.12354>

Study 3: Tunçgenç, B., & Cohen, E. (2016). Movement synchrony forges social bonds across group divides, *Frontiers in Psychology*, 7(May), 1–12. <http://doi.org/10.3389/fpsyg.2016.00782>

Study 2: Tunçgenç, B. & Cohen, E. (in press). Interpersonal movement synchrony facilitates helping among peers. *Developmental Science*.

Study 1 was conducted in collaboration with Dr Christine Fawcett at Uppsala Child & Baby Lab. I confirm that the conception of the study idea, formulation of the hypotheses, study design, data collection and analyses and writing up the findings have been conducted by myself. The collaboration entailed access to the laboratory facilities of the Uppsala University, which enabled me to recruit infants as participants.

2

INTERPERSONAL MOVEMENT SYNCHRONY, COORDINATION AND PRO-SOCIALITY IN INFANCY

Rhythmicity and coordinated interactions are ubiquitous in infants' daily lives. Even babies in the womb are exposed to rhythmical stimulation, be it in the form of their mothers' biological rhythms or the sounds of human speech in the outside world. Within the first months after birth, infants experience rhythmicity and coordinated movements in numerous settings. They listen to lullabies, take turns to express their emotions, and coordinate their movements with their carers. The current chapter concerns these and other examples in the early development of interpersonal coordination and synchrony. In the first year of life, important development takes place in the social domain also. Infants start to form action-outcome links, distinguish goal-directed actions of others from non-goals, establish joint attention and develop social preferences based on certain characteristics that other individuals have. Having considered the connections between movement synchrony and social bonding from a broader evolutionary, cultural and developmental perspective in the previous chapter, we now turn specifically to consider the empirical literature on the ontogeny of coordinated/synchronous joint movements in infancy.

The topics reviewed in this chapter will provide a framework in which to interpret the first study of this thesis and inform the design and methodology of Study 1 in important ways. Study 1 will investigate whether infants have a preference for partners who move synchronously over those who move non-synchronously with themselves and whether any such preferences differ between social and non-social partners. This chapter opens with a review of infants' rhythm perception and production of rhythmical, synchronous movements. Based on this review, the exact age range to test in Study 1 will be determined; while we aim to test the earliest age possible to see the ontogenetic roots of a synchrony preference, it is crucial that infants are old enough to be able to perceive different rhythms. The literature that will be reviewed in Section 2.1 will

provide insights into the infants' abilities to perceive rhythms and produce coordinated and rhythmically synchronised movements. Next, in Section 2.2, the early development of pro-social skills and behaviours will be examined. This review will reveal the motivation for the hypothesised difference between social and non-social partners and guide the measures of pro-sociality that can be used in Study 1. Finally, in support of the integrative approach endorsed in the current thesis, the first two sections will be linked together in Section 2.3. More specifically, research on the social correlates of performing interpersonal coordination and synchrony will be covered. This chapter will be followed by the first study of this thesis, in Chapter 3, which investigates infants' preferences for synchrony over non-synchrony in social and non-social contexts.

2.1 SYNCHRONY AND COORDINATED MOVEMENTS IN INFANCY

From very early ages onwards, coordination and synchronisation of behaviours frequently occur in children's interactions with others. These interactions are marked by the elaborate ways in which two or more individuals match the timing of their behaviours with each other. A feeding scene provides an example from infants' everyday life, whereby infants open their mouths precisely at the time their mothers bring the spoon closer to feed them. This intricate match in the timing of behaviours is the precondition for successful completion of the feeding action (Reddy et al., 2013).

Such coordinated behaviours take different forms throughout development. One reason for this is children's changing ability to perceive the timing of others' actions or rhythmical beats. Another development is in the precision with which children align their behaviours to external rhythms. These changes might be related to developments in various domains including the social, cognitive and motor domains. Further, research points to a divide between coordination and synchronisation observed in social and non-social contexts. In social contexts, the external stimuli are produced and provided by a

social source (e.g., human speech and movements of a person performing rhythmical actions) whereas in non-social contexts, the external stimuli are produced and provided through machines. This point will recur throughout the remainder of this chapter and form the basis of the first core hypothesis that is tested empirically in Chapter 3. Specifically, the hypothesis developed from the literature reviewed here is that synchronisation in social and non-social contexts bring about different outcomes in children's social preferences.

In the following three subsections, the development of interpersonal coordination and synchrony will be investigated. The first subsection, 2.1.1, will focus on the forms of interpersonal coordination as observed in infancy. When do infants first start to display coordinated movements? Which forms do the movements take and what social outcomes emerge from coordinating actions with others? The next two subsections will look more closely into children's developing abilities of synchronisation. Precise synchronisation with an external stimulus requires (i) perceiving the rhythms involved, (ii) motor capacity to produce rhythmical stimuli and (iii) the ability to match one's own rhythm to that of the external stimulus (Phillips-Silver, Aktipis, & Bryant, 2010). Thus, while section 2.1.2 will examine the development of rhythm perception, section 2.1.3 will focus on children's abilities to produce rhythmical and synchronised movements.

2.1.1 Interpersonal coordination in infancy

Coordinating one's behaviours with another person is a physically and cognitively complex endeavour. Perceiving and anticipating the timing of another person's actions requires the integration of several cognitive, social and motor skills. Still, elaborate forms of coordination can be observed even in young infants as they interact with their carers. For this reason, much of the research investigating the origins of interpersonal coordination has focused on these interactions between infants and their carers.

Coordination observed in these settings is usually mutual, bidirectional and involves contingency of actions. These properties of the interaction help the infant understand how their own and carers' actions complement each other. This understanding is helpful for sharing attention and for understanding role distributions in joint action settings later in development. Thus, in addition to the benefits of coordination for facilitating the complementary aspects of an interaction, it might have long-lasting social effects as well.

The first attempt to systematically analyse the origins of coordination in infancy was carried out by Condon and Sander in 1974. By doing a frame-by-frame video coding of natural interactions between mothers and infants, the researchers measured contingencies between the infants' and mothers' behaviours. The infants tested in this study were as young as 12 hours to 14 days of age. Results revealed a correspondence between the timing of the infants' head and body movements and mothers' speech patterns, a construct the authors termed as "interactional synchrony". These initial findings attracted considerable academic interest and, ever since, the contingency of infants' behaviours in their interactions with others has been investigated widely. Despite obvious restrictions on infants' movement capabilities, research on interactional synchrony has made substantial progress. One study has shown that shortly after birth, at approximately 3 days old, infants move their arms and legs according to adults' speaking patterns (Kato et al., 1983). Interestingly, infants did not show any signs of coordinated movement as such when presented with tapping sounds or white noise, indicating a difference in infants' behaviour in response to social versus non-social stimuli.

With the advancements in children's motor capabilities, coordination between mothers and infants can take various forms: the interactants may coordinate their eye

gazes, position their heads and bodies accordingly and vocalise and touch each other in turns (Feldman, 2007a). Starting from 6 weeks of age, infants time their eye gaze movements with their mothers' vocalisations by shifting the direction of their gaze at the mother's face or away according to the time when the mothers start or stop talking (Crown, Feldstein, Jasnow, Beebe, & Jaffe, 2002). At 4 months, the timing of infants' vocalisations can be predicted from the timing of their mothers' vocalisations and speech (Feldstein et al., 1993). By 9 months, infants start comprehending the structure of adult-like communication and take turns in their vocalisations as they interact with their mothers (Jasnow & Feldstein, 1986). It must be noted, however, that it is usually mothers, rather than the infants, who initiate and monitor the coordination, with special attention being paid to the infants' emotional states and needs (DeBoer & Boxer, 1979; Gable & Isabella, 1992). Thus, it can be posited that a wealth of social information is contained in these various forms of coordination. Such interactions can be highly important for children's development in the long run, preparing children for adult-like ways of communication and improving their understanding of other people's intentions and emotional states.

Besides coordinating behaviours, mothers also synchronise their emotional states with their infants. This is measured by looking at the contingent facial expressions and gaze shifts between the mothers and infants. For instance, one study has found that mothers imitate their infants' emotional expressions and they do this more often with 3-month-olds than with 6-month-olds and more with boys than with girls (Malatesta & Haviland, 1982). Although reasons for these age and sex differences are unclear, mothers' perceptions of their infants' need for facilitated affect expression might be guiding the differences observed. Synchronisation of affect might also have important socio-cognitive implications in the long term. Through being imitated and imitating the

adults' expressions, infants learn how to regulate their emotions (Feldman, Greenbaum, & Yirmiya, 1999) and form shared representations with the way their mothers express emotions (Dawson, Hill, Spencer, Galpert, & Watson, 1990; Decety & Jackson, 2004). Affect synchronisation between mother-daughter and father-son pairs at 3 and 9 months appear to facilitate children's symbolic representation capacity and self-control at 2 and 3 years of age (Feldman, 2007a; Feldman et al., 1999). Development in symbolic representation and self-control skills are especially important as they indicate children's capacity to reflect on mental states of others and their theory of mind development (Tomasello, Carpenter, Call, Behne, & Moll, 2005).

In line with the bidirectional and mutual nature of the relationship, factors stemming from both the mother and the infant play a role in shaping coordination. It has been found that maternal postpartum behaviour and mothers' depression levels are correlated with how synchronised the mothers are as they interact with their infants (Feldman & Eidelman, 2007). Interacting with a depressed mother might also have important consequences for the infant's emotional development. One study in particular found that 6-month-old infants of depressed mothers displayed increased neural activation as compared to infants with non-depressed mothers while looking at their mothers' angry faces (Feldman, 2007a). Another factor identified as influential in mother-infant synchrony relates to the infants' birth conditions. Several longitudinal studies revealed a link between infants' prematurity at birth and decreased amounts of interpersonal synchrony observed in toddlerhood (Karger, 1979; Malatesta et al., 1989).

Further, the environment in which coordination takes place seems to matter for infants' developing coordination abilities. To investigate the effects of contextual factors, researchers investigated the role of familiarity with the person and with the environment on the amount of interpersonal coordination observed. It was found that

both mothers and infants within the first year of life find it easier to coordinate their vocal rhythms with each other in a familiar context than in a novel laboratory environment (Jaffe et al., 2001). Another study has examined the coordinated interactions of 6-week-old infants with familiar and unfamiliar adults in familiar and unfamiliar environments. Interestingly, highest coordination was observed when both the adult and the context were unfamiliar to the infant (Crown et al., 2002). Although surprising at first sight, it can be reasoned that the increase in coordination was owing to greatest affiliation demands incurred by the totally unfamiliar environment. These findings support the view that coordinated movements and interactional synchrony are important for social development from early on in life. A number of studies have looked more closely into the association between interactional synchrony at early ages and later socio-cognitive development. For instance, the frequency of bidirectional coordination observed between mother-infant and stranger-infant pairs at 4 months was shown to predict infants' cognition, communicative competency and socio-emotional adaptation at 12 months of age (Jaffe et al., 2001).

One of the most important and widely-studied predictors of social development is the type of attachment infants develop with their primary carers in the first years of life. Attachment quality early in life has been claimed to have long-term effects on how children approach others and handle their inter-personal relationships (Claussen, Mundy, Mallik, & Willoughby, 2002). A longitudinal study tracing mother-infant interactions at 1, 3 and 9 months of age revealed that synchronous, complementary interactions predicted secure attachment with mothers (Isabella et al., 1989). Likewise, Jaffe and colleagues (2001) showed that moderate amounts of coordination with a stranger at 4 months of age were predictive of secure attachment at 12 months of age, whereas low coordination with a stranger was related to avoidant type attachment.

Notably, some researchers have noted the relationship between active engagement in joint attention and attachment type. It was found that even though infants may respond to other people's joint attention bids equally positively regardless of their attachment type, infants securely attached to their parents initiated joint attention significantly more than infants who had no organised, consistent way of affiliating with their parents (Claussen et al., 2002). These studies further corroborate the view that early social interactions that involve affect-sharing and coordination have long-term effects on children's social cognition and development of pro-social skills.

This section has reviewed the literature on the origins of interpersonal coordination observed in infancy. The studies demonstrate that human infants are able to perceive the timing of others' actions from very early on. Further, they respond to these perceived rhythms of other people's movements by aligning the timing of their own movements and vocalisations. Such interactional synchrony aids in conversing and communicating both verbally and non-verbally, through gaze and posture sharing. Highlighting the importance of coordinated actions in the first weeks of life, it has been claimed that biological rhythms between mothers and infants may be reflected in social rhythms later in childhood and adolescence (Feldman, 2007b). Moving on into development, a sensitive developmental period that falls within the first few months of life has been proposed; experiencing deficiency of coordination and synchronisation during this period might result in life-long social and emotional difficulties. Although evidence for such a sensitive period is still scarce, coordination during mother-infant interactions clearly has a significant effect on various aspects of social and cognitive development.

Despite references to social rhythms, movements investigated in interactional synchrony studies do not have a recurring, rhythmical structure. Although interactional

synchrony relies on a broader understanding of the timing of other people's actions and matching one's own actions to them, it may nevertheless contribute relevant insights to a growing understanding of rhythms and more precise synchronisation to rhythmical stimuli. However, as has been mentioned at the start of this section, precise synchronisation of movements that characterise social interactions in, for example, music, dance and other joint activities, requires perceiving rhythmical structures and performing rhythmical movements that match the perceived rhythms. Hence, these two aspects of synchronisation, the development of rhythm perception and the development of (synchronous) rhythm production, will be investigated in greater detail in the following two sections.

2.1.2 The development of rhythm perception

People are exposed to rhythmical stimulation from very early on in life. Some of these stimuli come directly from social sources, such as is the case with human speech or singing, while others, such as instrumental beats, can be categorised as non-social. Research shows that starting from infancy, humans have a sophisticated ability to perceive consonant patterns and harmonic rhythms in auditory stimuli (Trehub, 2003). Investigating the development of this ability is important to understand how synchronous movement production might emerge and influence children's social cognition. Studies focusing on infants' rhythm discrimination reveal a distinction in how the ability is manifested in response to social versus non-social stimuli. This distinction between perceiving social and non-social rhythms will be reviewed in this section.

One of the most salient and widely-studied social cue that infants are exposed to even prenatally is the human speech. Even though we, as linguistically competent adults, may not experience it like that, human speech is rhythmical (Cutler, 1994).

Languages belong to different rhythmical classes based on their units of segmentation, which is determined by the variability in vowel and consonant durations in each language (Ramus, Nespor, & Mehler, 1999). An assessment of infants' differentiation within and between these rhythmical classes of languages will be informative for understanding infants' rhythm perception. It has been shown that due to the prenatal exposure to language, even at 3 days of age, differential brain activation is observed while infants process languages coming from different rhythmical classes (May, Byers-Heinlein, Gervain, & Werker, 2011). Another method used to gauge infants' preferences for, as well as abilities to differentiate between, languages is called the head-turning paradigm. In this method, stimuli from two different languages are presented to the infants from two sides, left and right. The presentation of a stimulus starts when the infants turn their heads towards the direction of this stimulus and stops when they turn away. This way, experimenters can assess infants' interest in each one of the linguistic stimulus. Using this method, it has been shown that newborns younger than 1 month old differentiated between languages that come from different rhythmical classes (Mehler & Christophe, 1995; Nazzi, Jusczyk, & Johnson, 2000).

As striking as this ability of the 1-month-olds' may seem, some other animals, including cotton-top tamarins, have also been shown to be able to differentiate between languages coming from different rhythmical classes (Ramus et al., 1999; Tincoff et al., 2005; for similar results with rats, see Toro, Trobalon, & Sebastián-Gallés, 2003). This suggests that our capacity to perceive rhythms in auditory stimuli may have a long ancestral history. Yet, what seems to be unique to humans is the ability to distinguish between languages that come from the same rhythmical class (Nazzi et al., 2000; Ramus, 2002; Tincoff et al., 2005). Using a variant of the head-turning paradigm with infants' sucking behaviour instead of head-turning, it was found that newborns with a

mean age of 33 hours could differentiate between their native language and an unfamiliar language of the same rhythmical class (Moon, Lagercrantz, & Kuhl, 2013). This precision in rhythm discrimination is claimed to aid in language development by helping infants to comprehend the structure of their native language (Nazzi et al., 2000; Provasi, Anderson, & Barbu-Roth, 2014).

A specific type of human speech, which is called motherese, or infant-directed speech (IDS), is another salient linguistic cue for infants. IDS is the form of speech most mothers use to communicate with their infants across cultures (Broesch & Bryant, 2013; Bryant, Liénard, & Clark Barrett, 2012; Ferguson, 1964). Similar to musical stimuli such as lullabies, IDS is characterised by the use of high pitch, distinctive spacing between vowels, stronger emphasis (intonation) and a melodic and rhythmical structure (Kuhl et al., 1997). Rhythmical and intonational properties of language are especially important, as they signal the emotional content of the words and thereby elicit differential brain activation in newborns of 0 to 5 days old (Cheng, Lee, Chen, Wang, & Decety, 2012). These features of IDS as well as the higher and wider range of tones, slower tempo and exploitation of more restricted and repetitive vocabulary mark its difference from adult speech (Masataka, 2007).

It has been shown that starting from the first month after birth, infants show a preference for listening to IDS to adult speech (e.g., Butler, O'Sullivan, Shah, & Berthier, 2014; Cooper & Aslin, 1990). IDS has thus been linked with improved language development (Karmiloff & Karmiloff-Smith, 2001), joint attention (Falk, 2004), communication (Fernald, 1989) and emotion regulation (Corbeil, Trehub, & Peretz, 2015). Similar to IDS, mothers' songs and lullabies are proposed to carry a great deal of social information (Trehub, 2003; Dissanayake, 2004; Masataka, 2007). Through exposure to IDS and mothers' singing, infants learn to communicate more

effectively by taking turns as they vocalise and to coordinate their movements and emotional states with others (Benzon, 2001). Thus, investigating infants' early understanding of and entrainment to musical stimuli might also provide insights into their rhythm perception and its social correlates in development (Trehub, 2003).

The ability to perceive rhythmical stimuli in music emerges slightly later than the ability to perceive rhythms in human speech and vocalisations. It has been shown that infants can discriminate between rhythmic non-human sounds that have different temporal patterns at 2 to 4 months of age (Baruch & Drake, 1997; Demany, McKenzie, & Vurpillot, 1977). It has been also shown that at 5 months, infants' heart rates change in response to being presented with auditory sequences that have a different rhythmical pattern than the one that they have been habituated to (Chang & Trehub, 1977). One cross-sectional study has been illuminating in revealing the development of rhythm perception by presenting the participants with different beats. Whereas 6-month-olds could discriminate between rhythms that differed from each other by 20ms inter stimulus intervals (ISIs), 5½-year-olds could discriminate 15ms ISI changes and adults discriminated changes as small as 10ms ISI (Morrongiello & Trehub, 1987). This indicates that the ability to perceive subtle changes in rhythms improves with age.

Another good indicator of the development of rhythmical pattern perception is children's understanding of meter in music. Meter refers to "the abstract, hierarchical structure of music, which is experienced as a strong and weak alternation of "beats"" (Trehub & Hannon, 2006, p.82). It relies on the listeners' inferences of the periodic regularities and how they are emphasised in the stimuli (Campbell & Scott-Kassner, 2014). It was shown that when the rhythm is kept constant, 7-month-old infants looked preferentially longer at a piece with a new meter, indicating that they can distinguish between different meters (Hannon & Trehub, 2005). Further, it has been claimed that

feeling the beat in one's own movements might be important for rhythm discrimination and that the metrical positions may be easier to grasp for infants who are being rocked or bounced to music (Trehub & Hannon, 2006). In line with this view, infants of 7 months of age have been found to make use of movement cues to infer meter; they preferred listening longer to those pieces that shared the same meter as the one they had been previously bounced to (Phillips-Silver & Trainor, 2005). Yet, merely observing another person's bouncing was not sufficient for infants to infer meter, and the importance of first-person experience with movement held true for adult participants as well (Phillips-Silver & Trainor, 2007). With refined metrical perception at 9 months, infants also start developing preferences for certain types of meter (Bergeson & Trehub, 2006). Towards early childhood ages, formal education and cultural exposure further guide children's understanding of complex and culture-specific rhythmical patterns (Morrongiello, 1992).

Many real-life stimuli are multimodal, including not only auditory but also visual cues. For successful synchronisation, it is thus often important to perceive the rhythmical structure in both modalities and to assess the relations between them. It has been found that 4-month-old infants were able to cross-match an auditory rhythm (e.g., syllable utterances) that they heard to a visual rhythm (e.g., mouth opening movements of a puppet) that they viewed subsequently (Mendelson & Ferland, 1982; for similar results using different stimuli, see: Mendelson, 1986; Spelke, 1979). Recognising synchronicity of events when both modalities are presented simultaneously seems to develop slightly later, however. Although infants can distinguish between different rhythms and detect audio-visual synchrony at 4 months of age, they can detect desynchronisation of an audio-visual stimulus at 10 months, but not at 8 months (Lewkowicz, 2003). However, infants' detection of audio-visual rhythmic synchrony

can be facilitated in certain circumstances. For example, one recent study has found that prior first-person experience with the rhythm producing objects facilitated 6-month-old infants' sensitivity to audio-visual synchrony (Gerson, Schiavio, Timmers, & Hunnius, 2015).

Overall, rhythm perception starts developing within the first half-year of life and improves gradually throughout childhood. Studies on children's rhythm perception point to a delayed developmental pattern for non-social rhythms as compared to social ones. This may be because other cues involved in social settings facilitate perception and embodiment of the rhythms. In fact, neuroscientific studies show how merely listening to rhythms activates not only perceptual areas but also motor areas in the brain (for a review see Cameron & Grahn, 2014). The reverse is also true; rhythmic movement influences rhythm perception too. It was found that bouncing 7-month-old infants in time to a certain rhythm facilitated the infants' later recognition of that rhythm (Phillips-Silver & Trainor, 2005). Researchers have thus proposed both rhythm perception and rhythm production as the main building blocks of what constitutes social coordination among individuals (Phillips-Silver et al., 2010). The following section will look more closely into the growing body of research on children's developing abilities to move in time to the perceived rhythms.

2.1.3 The development of rhythm production

Due to the slow development of gross and fine motor skills throughout childhood, infants are restricted in how much and how precisely they produce rhythmical and synchronised movements. Moreover, a similar social/non-social divide, as has been observed in rhythm perception, exists in rhythm production too. Children's abilities to produce rhythms and in doing so, the difference between responding to the rhythmical

movements of other individuals and to non-social auditory beats will be the focus of this section.

In their natural environments, infants as young as 1 month old were observed to display rhythmical body movements, including the movement of legs, torso and fingers (Thelen, 1979). Longitudinal observations of these infants' rhythmical body movements revealed further that the breadth and frequency of infants' body movements increase within the course of the first year. Strikingly, from the very first days after birth onwards, these spontaneous rhythmical body movements can be influenced by the presence of external stimuli in the environment. It was shown that 3-day-old newborns displayed more rhythmic stepping (air-kicking) movement when presented with a rhythmical audio-visual stimulus than when presented with the same audio-visual stimulus in a continuous, non-rhythmical manner (Provasi & Barbu-Roth, 2009 as cited in Provasi et al., 2014).

In a comprehensive cross-sectional study investigating the rhythmical movements of children aged between 5 months and 24 months, Zentner and Eerola (2010) found that 5-month-old infants moved their bodies rhythmically when exposed to auditory rhythmical stimuli. In order to better understand the influences on infants' rhythmic movements, the researchers also compared movements produced in response to IDS, instrumental musical stimuli, musical stimuli composed of beats only and adult speech. Infants' rhythmic engagement was enhanced when the external rhythms came from musical stimuli and IDS, compared to when they came from adult speech. Although 5- to 7-month-olds displayed less rhythmic movement than older age groups, the amount of rhythmical movement production did not differ between 9 and 24 months of age. It is important to note, however, that the rhythmic body movements of children observed in

this study cannot be called synchronisation, as their timing did not necessarily match the auditory stimuli.

One important concept that can shed light on the development of synchronisation abilities is the individual's internal rhythm, or so-called Spontaneous Motor Tempo (SMT). SMT refers to the most comfortable tempo at which an individual can produce rhythmical output (Drake et al., 2000). Where synchronisation with an external rhythm is concerned, congruency of the external rhythm with the child's SMT becomes of crucial importance. In order to determine their SMT, participants are asked to constantly tap or drum in their preferred tempo, while their beats are being recorded. The interval between each tap is then measured (i.e., Inter Stimulus Interval- ISI) to determine the SMT of that individual. Studies done with various age groups show that SMT slows down during the lifespan. On average, it stabilises around 300-400ms ISI at 2^{1/2} to 5 years of age, 478ms ISI at 10 years, 500-600ms ISI in young adulthood and 700-800ms ISI in older adults (Drake et al., 2000; Fraisse, 1974; McAuley et al., 2006; Provasi & Bobin-Bègue, 2003; Vanneste, Pouthas, & Wearden, 2014). The gradual increase in ISI means that people tend to produce faster rhythmical movements when they are younger; the time difference between two taps or drum beats is 300-400ms for the youngest group and 747ms for the oldest group. Importantly, the variability in ISI also decreases with age, meaning that the SMT of adults is more stable than the SMT of children (Repp, 2005).

The flexibility in entraining to rhythms beyond one's SMT range is an important indicator for synchronisation ability. Unsurprisingly, this ability increases with age as well (McAuley et al., 2006; van Noorden & De Bruyn, 2009). Children's capacity for synchronisation may be influenced by SMT as a factor of (a) how stable and robust their internal rhythms are against disruptions by external stimuli, and (b) attentional

processes which improve with longer exposure to similar stimulation (McAuley et al., 2006). Both of these factors change with age, suggesting a developmental improvement in synchronisation performance (Provasi, Anderson, & Barbu-Roth, 2014). It has been shown that 2-month-old infants, but not newborns, can accelerate their non-nutritive sucking rhythm to an auditory rhythm that differs by 15% from their own sucking rhythm (Provasi & Marks, 1994). The study also revealed that both age groups found it easier to synchronise with the auditory rhythm when it was faster than when it was slower than their own rhythm. Between 1^{1/2} and 3^{1/2} years of age, infants' synchronisation ability shows further improvement. In one study, when asked to tap in time to an external rhythmical stimulus, 1^{1/2}- and 2^{1/2}-year-old infants did not alter their tapping rhythm, but 3^{1/2}-year-olds accelerated their tapping rhythm when the tempo of the external stimuli got faster (Bobin-Bègue & Provasi, 2008). Notably, the external tempo needed to be at least 20% faster than the children's own pace in order to result in a change in the tapping rhythm of the 3^{1/2}-year-olds. The reason for these seemingly contrasting findings from 2-month-olds and 1^{1/2}-year-olds might be explained by the significance of the action being investigated (i.e., sucking being of vital importance as compared to tapping), and/or by infants' motor competency in the respective domains (i.e., mouth being easier to move at different paces than hands).

All in all, these data on infants' rhythm production reveal significant differences from infants' rhythm perception. Despite elaborate perception of differences in rhythms within the first 6 months of life, infants over 1 year old still perform poorly in synchronisation tasks. Still, rhythmic engagement in response to rhythmical stimuli is observed starting at least from 5 months of age. This suggests that poor synchronisation with external rhythms may be mainly due to underdeveloped motor skills. The literature reviewed in Section 2.1.1. supports this view; infants can understand the timing of

others' actions and coordinate their own movements accordingly. Yet, precise rhythmical matching of movements seems to take longer to develop. The contexts in which interpersonal coordination takes place are also of high social significance and may further influence infants' proficiency in synchronising their movements.

2.1.4 Conclusion

The studies reviewed in Section 2.1 clearly point to a gradual developmental trend in infants' abilities to perceive and produce rhythmical movements and to synchronise their rhythms with external stimuli. Within the first few months, infants can already distinguish between rhythms and start moving their bodies rhythmically to external beats. Still, even after the first year, infants cannot synchronise their rhythmical movements to external stimuli. This observed deficiency in synchronisation with external rhythms may be attributable to a combination of insufficiently developed motor skills, attentional constraints and various social, contextual and cognitive factors (Bispham, 2006). Therefore, in the first study of this thesis, the infants will not perform volitional movement in time to external rhythms, but will instead be moved by the Experimenter. Due to it being familiar and soothing for the infants, rocking movement will be used.

Moreover, both rhythm perception and synchronisation with external rhythms seem to be facilitated when the external rhythms are presented in a social setting. Given the importance of coordination with carers in the early years of life, infants might be more attuned to perceiving rhythms that a social partner produces and to synchronising with them as compared to a non-social partner. This idea will form the basis of Research Question 1, which the first study of this thesis aims to answer: Do infants have a preference for individuals whose timing of movements are synchronous with

themselves compared to those who move non-synchronously? Does the partners being social versus non-social influence infants' preference for synchronous movement?

The review of the literature on the development of children's synchronisation abilities in early childhood years will be continued in Chapter 4. Here, we will continue reviewing how infants' developing synchronisation abilities relate to aspects of their social development. To this end, the following section will present infants' social abilities within the first year of life.

2.2 PRO-SOCIALITY IN INFANCY

Despite its high complexity, infants seem to adapt to the social environment around them readily from very early ages onwards. Within the first two years of life, infants acquire a remarkable amount of social, cognitive and motor skills that they use as they engage with others. Observations of infants in their everyday environments show that from the first few months of life, infants interact playfully with adults (Ross & Lollis, 1987). As they grow, infants become more proficient in using communicative tools such as pointing to objects, expressing their emotions by frowning or smiling and turn taking while 'talking' or playing with others (Hay, 1979; Hay & Murray, 1982). One of the most frequently used proxies for infants' pro-social attitudes in the first year of life is their social preferences. Infants are adept at indicating who/what they like and dislike by pointing, looking and crawling to or reaching for their preferred individual/object (see more in Section 2.2.4).

However, in order to engage with others in pro-social ways and in joint settings, it is essential to have an understanding of other people's actions and their potential consequences. This understanding of the link between others' actions and their outcomes emerges in the second half of the first year (Woodward, 1998). Built on this is the ability to understand the goals and intentions of other people (Falck-Ytter,

Gredebäck, & von Hofsten, 2006). As this understanding develops, infants respond differently to others' actions according to whether those actions appeared to be intended or accidental (Behne, Carpenter, Call, & Tomasello, 2005). Around the same age, infants start joining attention with others; they pay attention to the objects that other people are pointing to and also point at objects themselves to inform others (Behne, Liszkowski, Carpenter, & Tomasello, 2012). Infants also have distinct social preferences based on certain characteristics of people and/or based on how those individuals behave (Kinzler et al., 2010). All these hallmarks in development contribute to their developing pro-social skills and behaviours. This section will provide an overview of the developmental trajectory of these skills.

2.2.1 Understanding action-outcome links

One of the cognitive requisites for joint actions is to understand what other people intend to do when they perform a particular set of actions. Since intentions may be rather abstract and sophisticated, it is useful to start the examination with whether and how infants link actions of other people to the observed outcomes of these actions. For instance, do infants understand that a person aims to retrieve a cup as their hand starts reaching for it from a distance? How do they construe multiple levels of goals behind actions (e.g., is the ultimate goal to hold the cup or to drink tea from the cup)? What if the tea spills as the person carries it? Is this included in the intended action sequence or do children perceive this action differently (i.e., as accidental)?

Due to the obvious limitations of asking pre-verbal infants what they think, a method called habituation has been frequently employed by developmental psychologists to provide insights into the early origins of various psychological phenomena, including infants' understanding of action-outcome links. In habituation studies, infants are first shown a stimulus until they habituate (i.e., look away),

apparently having lost interest. The aim of this habituation phase is to present infants with a pattern (e.g., woman reaches for the tea cup and not for the milk bottle) and to thereby build certain expectations in the infants about future events (e.g., the woman is more likely to choose the tea cup over the milk bottle in the future). Next, the infants are shown two stimuli in the test phase; one that supposedly meets their expectations (e.g., the woman approaching the tea cup), and one that does not (e.g., the woman approaching the milk bottle). The amount of time that infants spend looking at each test event is measured and the difference between them is taken as an indicator of the infants' ability to discriminate between the two stimuli. If infants have developed the aimed at expectation, they should look longer at the stimulus that does not meet their expectation (i.e., show surprise reaction) than the one that meets their expectation.

In her ground-breaking study, Woodward (1998) habituated 6- and 9-month-old infants to a scene depicting an action-outcome sequence of an actor reaching for one of two toys shown in the scene. After infants were habituated to this scene, the test phase began, where the places of the two toys were swapped. In the test phase, infants viewed (i) the actor reaching for the same toy (old goal/novel path), and (ii) the actor reaching for the other toy (novel goal/old path). It was found that infants looked longer at the novel goal/old path scene than the old goal/novel path scene. This indicates that 6-month-old infants had built an expectation that the actors' previous actions were executed specifically to reach the observed outcome. In fact, even younger infants seem to link others' actions to their outcomes, provided that the infants have first-person experience with the objects being acted upon. It was found that when 3-month-old infants were first given a chance to play with the toys that later appeared on the scene, they also looked longer at the novel goal/old path scene than at the old goal/novel path scene (Sommerville, Woodward, & Needham, 2005). Yet, the infants did not

distinguish between the two scenes when they were not given a chance to explore the toys for themselves. It seems that preliminary understanding of action-outcome links starts to emerge at 3 months, although significant development takes place in the months to follow. It is important to recognise, however, that these results are based on single actions of grasping an object. Most real life interactions involve a sequence of actions rather than single actions. Can children understand the means, sub-goals and higher-goals in an action sequence?

Using a similar habituation paradigm, studies showed that 12-month-olds, but not 10-month-olds, understand the hierarchical structure of action sequences (Sommerville & Woodward, 2005; Woodward & Sommerville, 2000). When presented with a scene where an adult pulled a piece of cloth that had a toy on it, thereby bringing the toy closer, 12-month-olds understood that the ultimate goal of this pulling action was to retrieve the toy. Importantly, their understanding is not informed merely by the temporal correspondences between the actor and the object acted upon, but by the causal links between the actor, action, and the object's movement (Sommerville & Woodward, 2005). However, following habituation to the same scene of cloth pulling and toy retrieval, 10-month-old infants did not seem to distinguish between the old goal/novel path and the novel goal/old path scenes. This suggests that these children did not comprehend the cloth pulling action as directed towards retrieving the toy. Further, this (lack of) understanding in 10-month-olds was not facilitated even when the infants were given a chance to experience executing the action themselves. Thus, it can be said that even though action-outcome links start to be formed irrespective of infants' own experience from around 6 months of age, important development is observed in the next few months. It seems that more complex action sequences can be coded hierarchically only towards the end of the first year of life.

Once it is known that infants can match observed outcomes with others' actions, the question that follows is how infants link these action-outcomes to the actors executing these actions. Ultimately, for interactions between people, it is the goals and intentions of the actors that matter. It is crucial to have the ability to identify a potential future collaborator's goals and intentions (e.g., as desiring or intending to engage in a collaborative activity). What do infants know about other agents' intentions? Do they assume that the observed outcomes of actions always reflect the intended goals of the agents? How can one tell when an undesired outcome occurs despite the agent's intention to do otherwise? The answers to these questions involve elaborate understanding of other people's minds, which develops gradually over the second year of life and beyond.

2.2.2 Understanding goal-directedness in others' actions

The ability to form links between actions and outcomes provides a good basis for understanding the goal-directedness of actions. Still, it is another thing to assign intentions to agents who execute these actions. Not all action-executers are intentional agents; washing machines that clean clothes or loud speakers that play music act upon objects but they do not *intend* to do so. Moreover, a number of contextual factors may prohibit people from doing what they intend to do. Thus, the observed outcomes of actions may not always be a reliable source for inferring the intentions of others. Research on how infants link action-outcomes to their executers and how they respond differently to the actors inform us about their understanding of others' intentions.

The habituation studies reviewed in the previous section can be interpreted to reveal that infants attribute intentionality to the agents performing those actions. Yet, caution is needed when interpreting these and similar studies done with infants. One of

the biggest debates within developmental psychology concerns whether and how much infants understand others' minds (Baillargeon, Scott, & He, 2010; Heyes, 2014; Rakoczy, 2012). Stringent testing needs to be done before ruling out lower-level interpretations of the results to conclude that infants understand the beliefs and intentions of others (Heyes, 2014). In our case, the rich interpretation of the aforementioned studies would be that during the habituation phase, infants attribute to the actors the intention to go for a certain object. Therefore, in the test phase, infants show more surprise reactions (i.e., look longer), when the actors change their goal than when they change their path. The lower level interpretation, on the other hand, would be that infants merely form associations between actors and the objects that they act upon. That these associations are made between the actor and the object (experimental condition) rather than between the actor and the path (control condition) does not necessarily show that infants attribute intentionality to the actors. Several other, more salient features of the actors and the objects may make it easier for the infants to associate individuals with solid objects rather than with more abstract pathways.

A number of methods can be employed to shed light on this controversy. Heyes (2014) recommends comparing social conditions to non-social conditions. If infants can distinguish between the actions of animate and inanimate actors, it would imply that they attribute goal-directedness to one type of actor but not to the other. Another way to study infants' intention understanding can be to examine their predictive gaze. While traditional looking time studies measure infants' differential looking times to events that have happened, predictive gaze focuses on where infants' eye gaze fixates *before* an event happens (Gredebäck, Johnson, & von Hofsten, 2009). Thus, predictive gaze provides richer information by examining what infants know and expect about the outcomes of an action even before the action takes place. This is especially important

for social and cognitive development, as most information in the real world is partial and relies on prospective inference-making (von Hofsten, 2004). With respect to the high-level versus low-level explanations debate, predictive gaze studies can help rule out lower-level explanations, as infants' response is measured before the object or path to associate with the actors have arrived at the scene. Finally, infants' emotional expressions and behavioural responses whilst performing and observing a range of actions can be insightful about their understanding of others' goals and intentions. Yet, such studies using active behavioural measures may be harder to design with young infants who have limited responding capabilities.

Several traditional looking time studies have compared social conditions to non-social conditions. The results of these studies show that infants do in fact take into account different features of animate and inanimate actors and respond to their actions differently. One of the first studies investigating this was the above-mentioned study by Woodward (1998). In that study, 6- and 9-month-olds were habituated to an action sequence of an actor reaching for a toy. Critically, the reaching action was done either by a human (animate actor) or a rod (inanimate actor) that shared similar physical features to the human arm being shown. Although both 6- and 9-month-olds looked longer at the novel goal/old path scene than the old goal/novel path scene when the reaching action was performed by the human arm, neither showed such differentiation in their looking times when it was performed by the rod. This suggests that infants did not distinguish between a novel goal and a novel path when the actor under question was inanimate. It can be concluded that infants selectively attributed goal-directedness to the animate actor. It is striking that infants this young could discriminate between a human hand and an otherwise similar inanimate object based on the very limited differences in their visual properties.

Infants also seem to take into account what is called the ‘biological motion’ characteristics (Reid, Hoehl, & Striano, 2006) of actors (i.e., movements that are human-like, possibly indicating agency) while attributing goal-directedness to their actions (Csibra, Gergely, Bíró, Koós, & Brockbank, 1999). The characteristics comprising biological motion were defined as: the actor initiating its own movements (self-propulsion), the actor getting bigger/smaller in response to the size changes of the target object (contingency), the actor pursuing contact with the target object even when the positions of their locations change (equifinal variation) and the actor following alternative paths in order to reach the target object (flexibility in actions). In their study, Csibra and colleagues first habituated infants to a scene of a small circle chasing up a large circle by jumping up obstacles to reach it. In the test phase, infants were shown (i) the small circle jumping up in the absence of the obstacle (irrational action); or (ii) the small circle following a straight path in the absence of the obstacle (rational action). Nine-month-olds looked longer at the irrational action than the rational action, indicating that they inferred the goal of the small circle to be to make contact with the large circle, and therefore showed surprise when their expectation of the small circle to move rationally was violated. Similar results were obtained with 3-month-olds (Luo, 2011). Infants first viewed a self-propelled box, which consistently made contact with one of the two objects on the scene and displayed equifinal variations in its actions. When, in the test phase, the box changed its goal, infants looked longer at this novel goal/old path scene than the old goal/novel path scene. These findings indicate that biological motion characteristics influence infants’ understanding of goal-directedness in others’ actions.

Studies measuring infants’ predictive gaze further enhance our knowledge on infants’ goal attributions. One study has shown that 12-month-old infants’ predictive

eye gaze fixated at the goal-state of an action only when the action was performed by a human, but not when the action was presented as a self-propelled mechanical motion (Falck-Ytter et al., 2006). This suggests that infants can identify humans as goal-directed agents and predict the goals of their actions at 12 months of age. In fact, even 6-month-olds were found to take into account the outcomes of others' previous actions while predicting their future action goals (Hunnius & Bekkering, 2010). In order to understand more clearly what the predictive eye gaze studies show us and how they differ from the traditional looking time studies, Daum and colleagues conducted a study, where they directly compared the two methods (Daum, Attig, Gunawan, Prinz, & Gredebäck, 2012). They replicated the original looking time studies' findings that 9-month-olds looked longer when an actor changed their goal (novel goal/old path) than when they changed their path (old goal/novel path). Yet, the predictive gaze measure yielded different results. Infants were equally accurate in predicting the old goal/novel path scene and the novel goal/old path scene. A follow-up study revealed further that it is not until the age of 3 that children can integrate specific information on goal identity in their predictions of others' actions.

Taken together with the traditional looking time studies, the predictive eye gaze studies show that (i) infants reliably form action-outcome links with respect to the goals of the actors by 6 to 9 months of age; (ii) infants take into account the actors' properties, while attributing goal-directedness to them (e.g., visual properties or biological motion properties); and (iii) despite forming goal-related expectations about other actors by 9 months of age, infants start to predict the goals of other people's actions only around 12 months.

Once infants develop an understanding of others' action goals, the next step would be to investigate which intentions to attribute to these agents. In real life, the

observable outcomes of people's actions may not always match with what they intend to do. So, how do infants deal with it when different intentions give rise to similar outcomes? Can they tell whether an outcome occurred because the agent intended it to be so or because of factors external to the agent? Imitation studies have been insightful in answering these questions. By looking at children's imitation patterns, researchers could infer which parts of a previously demonstrated action children think are essential and which parts are done unintentionally. One early study has found that 18-month-old children differentiated between intentional and accidental actions demonstrated by an adult and imitated only the former (Meltzoff, 1995). Interestingly, the children did not imitate the target act at all when the actions were demonstrated by an inanimate actor (i.e., a mechanical device). When the demonstrated actions were marked by accompanying verbal expressions such as "There!" versus "Whoops!" for intentional versus accidental actions respectively, similar differentiation and selective imitation were observed at 14 month of age (Carpenter, Akhtar, & Tomasello, 1998).

However, it could be that younger infants are also able to distinguish between intentional and accidental acts, but that the imitation paradigm introduces additional complexity beyond the infants' cognitive abilities. To investigate whether this is the case, some researchers developed simpler measures with groups of younger infants. One study looked at the frustration levels of infants in response to an adult being unwilling versus unable to give them a toy. It was found that 9-month-olds, but not 6-month-olds, tried to reach for the toy and looked away from the adult more when the adult was unwilling to give them the toy than when she was willing but unable to do so, for instance due to clumsiness or phone ringing right at that moment (Behne et al., 2005). This indicates that, starting from 9 months of age, infants react differently to seemingly similar outcomes, when the intentions underlying the actions are different. This finding

is in line with the findings of the looking time and predictive eye gaze studies in that 9 months is about the time for understanding others' goals.

From these findings, it can be concluded that the second half of the first year of life brings a growing understanding of other people's goals and intentions. Knowing what others intend to do is useful for future collaborative encounters with these people. This knowledge enables one to assess whether future collaborators' intentions are similar to one's own, shared or completely different. Further, it informs one about where a potential collaborator's attention is directed at, which is crucial for sharing attention and engaging in joint actions. The next section will elaborate further on this issue of how joint attention develops.

2.2.3 Joint attention development

Joining attention with another individual is a critical development that builds upon more preliminary understanding of others' actions and that improves with increased exposure to shared social practices (Racine & Carpendale, 2007). Children's abilities to follow the attention of others indicate that they are able to (a) link other people's behaviours to referred objects, and (b) view others as intentional agents (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998). Joining attention with others requires not only following another person's attention, but also incorporating an object of mutual interest into the relationship between the two individuals. This incorporation, or so-called transition from dyadic (person-person) to triadic interactions (person-object-person), is of crucial importance for the development of higher social and pro-social skills. Whereas dyadic interactions typically involve face-to-face vocal and gestural exchanges between an infant and an adult, triadic interactions require the infant and the adult to jointly attend to something (Scaife & Bruner, 1975; Striano & Rochat, 1999). Arguably, information obtained from dyadic interactions and from observations of

adults' dyadic interactions with objects aid in the formation of joint attention when infants start initiating triadic interactions towards the latter half of the first year of life (Liszkowski, Carpenter, Striano, & Tomasello, 2006).

In initiating triadic interactions with other people, it is important to understand the other people's willingness to participate. Numerous studies have shown that starting from as early as 2 to 3 months; infants are sensitive to adults' facial cues and understand when adults become unresponsive. In return, infants react by looking away (Adamson & Frick, 2003) or smiling less (Hains & Muir, 1996) to an adult's averted face. In more controlled, yet less naturalistic environments, infants have been shown computerised images of adult faces gazing directly at them versus faces with an averted gaze. It was found that 3- to 4 month-old infants could distinguish between faces with a direct and an averted gaze, albeit under more restricted circumstances than when the faces are presented in real life (Hood, Willen, & Driver, 1998; Vecera & Johnson, 1995). Infants' early ability to tell apart direct versus averted gaze can be viewed as initial signs of their sensitivity towards other people's attention and willingness for an interaction.

Joint attention also requires the ability to track the direction of the other party's attention as it changes over time. Information on this comes from studies gauging infants' abilities to follow others' eye gaze, head turn and pointing gesture. Infants start following an adult's head turn (D'Entremont, 2000; Flom & Pick, 2005; Scaife & Bruner, 1975) and eye gaze (Hood et al., 1998) at around 3 to 6 months. From 4 months onwards, infants also process the object that the adults refer to with their head turn or eye gaze more than other objects (Reid & Striano, 2005). These findings can be considered as an indication of preliminary formation of triadic relations early on in infancy. Yet, gaze following is reserved to certain perceptual and attentional conditions, such as the proximity and visibility of the referred object or the number of objects being

referred to, until 10 to 12 months of age (Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; D'Entremont, 2000). At around 18 months, infants' ability to follow their mothers' gaze enhances so much that they can comprehend the referred object even if it is out of their sight (Butterworth et al., 1991). Hence, it can be concluded that although preliminaries of joint attention are observed within a few months after birth, it establishes around 18 months of age with increased precision and flexibility in the triadic relationships.

Similarly, infants start following an adult's pointing gesture reliably towards the end of the first year of life (Carpenter, Akhtar, et al., 1998). Some early research suggests, however, that 9-month-old (Murphy & Messer, 1977) and 10-month-old infants (Leung & Rheingold, 1981) can follow others' pointing gestures under restricted circumstances. Still, it is only at 12 months that infants can understand the goal-directedness of a pointing gesture, as indicated by their longer looking times to a novel goal/old path than an old goal/novel path scene (Woodward & Guajardo, 2002). Thus, it can be said that around 1 year of age, infants begin to understand when somebody wants to attract their attention to something and share attention with them. Does this understanding of other people's prompts to join attention develop in parallel with children's own attempts to initiate joint attention? A close look at infants' comprehension and production of the pointing gesture at younger ages reveals bidirectional development. From 8.5 months of age onwards, those infants who comprehend others' pointing gestures as goal directed also point themselves to share attention with others and vice versa (Behne, Liszkowski, Carpenter, & Tomasello, 2012; Leung & Rheingold, 1981; Woodward & Guajardo, 2002). Further, from 12 months onwards, infants point to objects to inform others of their location (Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004; Liszkowski et al., 2006; Liszkowski,

Carpenter, & Tomasello, 2008; Tomasello & Haberl, 2003). This indicates that the infants' use of the pointing gesture is a means of sharing attention and assistance rather than an attempt to merely grab attention or demand objects.

Altogether, these findings reveal that within the first year of life, important developments prepare the infants for more elaborate forms of social interactions. Infants start paying attention to what others are referring to by following their gaze or pointing gesture. The infants also start pointing to objects to share attention with other individuals by the age of 1. This means that infants process a considerable amount of social information and start to integrate it in their actions as they interact with others. How do these improvements in the social domain relate to the development of pro-sociality? To shed light on this issue, the following section will investigate how certain types of social information guides infants' pro-social preferences.

2.2.4 Social preferences in infancy

In the previous sections, we have seen infants gradually become more and more capable of interpreting the social world around them. By the age of 1, infants seem to be able to process rather complex social cues to infer other individuals' goals, interests and needs. Yet, a core element of pro-sociality and social bonding is choosing partners- and the right ones who will engage with you cooperatively in return. Hence, it is important to look at how all this social information that the infants process feeds into their social preferences. Do infants prefer individuals who possess certain social characteristics? Can infants tell apart individuals who are pro-social (i.e., who benefit others) from those who are anti-social? The literature investigating these questions will be reviewed in this section.

Infants seem attuned to human social interaction from very early on. Starting from 5 weeks, infants respond differently to humans and inanimate beings. Longitudinal

studies between ages 9 and 15 weeks (Legerstee, Corter, & Kienapple, 1990) and 3 and 25 weeks (Legerstee, Pomerleau, Malcuit, & Feider, 1987) show that, even when familiarity with and activity levels of the interactants are controlled for, infants display more positive affect (smile and vocalise more) and approach behaviours as they interact with their mothers than as they interact with a doll. This difference in responding to social and non-social others is manifest in infants' imitation patterns as well. Five- to 8-week-old infants imitate selectively only the tongue protrusion actions of humans but not of a mechanical device (i.e., a white tube with a red elongated object extending from inside to mimic the tongue; Legerstee, 1991). As they get older, infants start to have more fine-grained preferences regarding social entities.

Similarity to self and familiarity are among the most important determinants of infants' early social preferences. When shown pictures of adults, 3- to 4-month-olds looked longer and recognised better faces that were of the same gender as their primary caregivers (Quinn, Yahr, & Kuhn, 2002). At around the same age, a preference for same-race faces starts to show itself too (Kelly et al., 2005; Sangrigoli & de Schonen, 2004). Notably, this same-race preference is not only confined to Caucasian infants, but is also observed in African (Bar-Haim, Ziv, Lamy, & Hodes, 2006) and Chinese populations (Kelly et al., 2007). In addition to gender and race, infants seem to have an age-based preference as well. When given the option to listen to sounds of their own, of their peers and of inanimate objects, 5- and 8-month-olds preferred listening to longer the sounds of their peers (Legerstee, Anderson, & Schaffer, 1998). Similarly, 6- and 9-month-old infants preferred looking at the images of faces of peers to faces of older or younger infants and adults (Sanefuji, Ohgami, & Hashiya, 2006). In fact, by 7 months, infants expect to observe this similarity bias in the social interactions of others as well. In one study, where infants observed groups of entities act in certain ways, they looked

longer when the members of a social group, but not of a non-social group, failed to act alike, for example, by performing different behaviours than the rest of the group members (Powell & Spelke, 2013).

Another salient factor guiding infants' social preferences is linguistic cues. Even before they start uttering their first words around the age of 1, infants learn a great deal about the affective (Paquette-Smith & Johnson, 2015), phonological and structural features of their native language (Sosa & Stoel-Gammon, 2006). As has been reviewed in Section 2.1.2., infants prefer listening to infant-directed speech (IDS) over listening to adult speech (e.g., Butler et al., 2014; Cooper & Aslin, 1990). At 5 months of age, infants' preference for IDS extends into their preferences for individuals. When pictures of adults who had previously spoken with the infants in IDS versus adult-directed speech were paired with the pictures of novel individuals, infants preferred looking at the IDS-speakers than the novel individuals, but no such preference was found for individuals who had used adult-directed speech (Schachner & Hannon, 2011). Similarly, 5- to 6-month-old infants were found to look at an adult longer in the silent test-phase if the adult has previously uttered meaningful words compared to unmeaningful words (reversed speech). Importantly, infants do not make this discrimination when the 'speakers' are geometrical shapes instead of humans (Kinzler et al., 2007). Kinzler and colleagues also found that 6-month-old infants preferred looking at an adult who had previously spoken in their native language than in a foreign language. At 10 months, linguistic cues further inform infants' object preferences; after viewing adults who spoke the infants' native language versus a foreign language, 10-month-olds preferred the toys that the native speakers have played with (Kinzler, Dupoux, & Spelke, 2012) and offered (Kinzler et al., 2007; for similar results with 12-month-olds' food preferences, see (Shutts et al., 2009).

A series of ingenious studies have investigated infants' social preferences based on the pro-sociality/anti-sociality of the behaviours of others. In these studies, researchers played a puppet show to the infants, where one character (Helper) helped a neutral character to achieve their goal (e.g., climb up a hill), while another character (Hinderer) prevented the neutral character from achieving their goal. Following this, the infants' preferences were assessed by measuring their looking times to the Helper and Hinderer puppets (younger infants) and/or their active choice of either the Helper or the Hinderer puppet (older infants). It was found that, starting from 3 months and throughout toddlerhood, infants preferred pro-social individuals to anti-social individuals (6- to 10-month-olds: Hamlin, Wynn, & Bloom, 2007; 3-month-olds: Hamlin, Wynn, & Bloom, 2010; 3- to 9-month-olds: Hamlin & Wynn, 2011; 10- and 29-month-olds: Buon et al., 2014; 15-month-olds: Burns & Sommerville, 2014; for contrasting findings with 12- and 24-month-olds, see: Cowell & Decety, 2015; 12- to 36-month-olds: Scola, Holvoet, Arciszewski, & Picard, 2015).

Importantly, most of these studies involved a non-social control condition, where infants did not display any preference for pro-social others. In fact, it seems essential for infants' pro-social choices that the neutral character's goal to climb up the hill is very clear in the stimuli with a fixed eye gaze directed at the target (i.e., top of the hill), rather than rolling eyes or looking down (for a discussion, see: Hamlin, Wynn, & Bloom, 2012; Hamlin, 2015; Scarf, Imuta, Colombo, & Hayne, 2012; Scarf, Imuta, Colombo, & Hayne, 2012). Initially, this pro-sociality preference of infants seems to stem from an urge to avoid anti-social individuals (Hamlin et al., 2010; Hamlin, Wynn, Bloom, & Mahajan, 2011; Hamlin, 2013). At 6 months, however, infants start taking into consideration the degrees of pro-sociality; they prefer pro-social others to neutral others and neutral others to anti-social others (Hamlin et al., 2007).

After the age of 8 months, infants start to be even more selective in their preferences for pro-social individuals and make inferences about others' social interactions too. Infants prefer individuals who behave positively only towards similar others (Hamlin, Mahajan, Liberman, & Wynn, 2013) and only towards those who are pro-social (Hamlin et al., 2011). Ten-month-olds look longer when they view an individual behave anti-socially towards an unfair third party than towards a fair third party (Meristo & Surian, 2014). The infants also gradually start to integrate the intentions of others as they make social preferences. While 5-month-olds base their preferences only upon the positivity/negativity of the outcomes, 8-month-olds prefer individuals who act with pro-social intentions, regardless of whether their actions yield a positive or a negative outcome (Hamlin, 2013). Similarly, 10-month-olds prefer intentional Helpers to accidental Helpers and accidental Hinderers to intentional Hinderers (Le, 2015). These pro-social contexts seem to enable infants to make rather complex inferences about others' behaviours more broadly. For instance, 12-month-olds infer that individuals who have acted pro-socially in an earlier instance will act pro-socially in the future as well (Kuhlmeier, Wynn, & Bloom, 2003). At 16 months, infants start using group memberships as a predictor of behaviour and they look longer when the members of two conflicting groups cooperate than have a conflict with each other (Rhodes, Hetherington, Brink, & Wellman, 2015).

These pro-social preferences of infants are crucially important as they may be related to the infants' own pro-social behaviours. Recent neuroscientific research supports this view. Infants' pro-sociality preferences activate brain regions that are associated with mentalising abilities (i.e., reading others' beliefs and intentions; (Gredebäck et al., 2015) and emotion regulation (Paulus, Kühn-Popp, Licata, Sodian, & Meinhardt, 2013). Moreover, neural activation early in infancy predicted infants'

immediate preference for pro-social individuals (Cowell & Decety, 2015b) as well as the infants' helping and sharing behaviour in the second year of life (Paulus et al., 2013). Behavioural measures are in line with this view too. It has been found that 15-month-old infants who expected others to behave fairly (as assessed by infants' looking times to fair versus unfair events) were more likely to share with others themselves as well (Schmidt & Sommerville, 2011). One longitudinal study supports this link further by showing that pro-sociality preferences at the age of 12 months, as assessed by the Helper/Hinderer paradigm, predict social functioning (as measured by parental reports) at pre-school ages (Tan, 2015). The development of pro-social preferences in infants may also importantly indicate infants' beliefs about others' preferences. At the start of the second year of life, infants seem to reason that others would prefer pro-social individuals to anti-social individuals (13-month-olds: Choi & Luo, 2015; 12-month-olds: Fawcett & Liszkowski, 2012; Lee, Yun, Kim, & Song, 2015). Thus, infants' use of social cues and preferences for pro-social individuals are important in informing us generally about how infants see the social world around them.

The literature reviewed in this section shows that starting from the very first months in life, infants have a preference for similar others and for individuals who behave pro-socially. These findings have given rise to intense debates on whether humans have an innate moral core (see Chapter 8 for a discussion). Notwithstanding these debates, the data clearly show advanced skills of human infants to recognise and parse social information into categories based on their similarity and familiarity with the infants. The data also show, at the very least, that infants have a proclivity for social bonding and use the social information provided by others to guide their preferences.

2.2.5 Conclusion

Together, the studies reviewed in this section reveal that important developments take place within the first few years of life in the socio-cognitive domain. Infants do not only gain a better understanding of other people's goals and intentions, but also start joining attention with them and having their own social preferences. In the preceding section (Section 2.1.), we had seen how young infants perceive external rhythms (social and non-social) and align their own movements to them. So, how, if at all, does a developing understanding of the timing of actions, and interpersonal movement synchrony in particular, interact with early social development? Does moving in synchrony with others produce social outcomes? Does it, as with adults, have a social bonding effect in the early years of life? If so, at which age can we observe the early signs of a link between movement synchrony and pro-sociality? The following section will try to provide preliminary answers to these questions by reviewing the existing literature on the social correlates of interpersonal coordination and movement synchrony in infancy.

2.3 PRO-SOCIAL OUTCOMES OF INTERPERSONAL MOVEMENT SYNCHRONY IN INFANCY

A growing amount of evidence in the psychological literature on adults links interpersonal synchronisation to pro-social outcomes. As was mentioned in Chapter 1, after moving in synchrony with their partners, increased rapport (Miles, Griffiths, et al., 2010; Miles et al., 2009), trust (Launay et al., 2012) and cooperation (Reddish, Bulbulia, et al., 2013; Reddish, Fischer, et al., 2013; Valdesolo et al., 2010; Wiltermuth & Heath, 2009) were observed among adult participants. Although direct experimental evidence is scarce for how these effects are manifested developmentally, coordinated

movements and an understanding of rhythmical patterns seem to be associated with positive social effects already in toddlerhood.

As mentioned in Section 2.1.1, interactional synchrony between mothers and infants can have long-term effects in shaping the child's attachment type, with moderate amount of synchrony being linked to secure attachment (Isabella et al., 1989; Jaffe et al., 2001). Some computational modelling studies further suggest that children's personality development may be influenced by the amount of behavioural and affect synchrony they experience early on in life (Nowak, Vallacher, & Zochowski, 2005; Vallacher, Nowak, & Zochowski, 2005). Still another case has been made with regard to the relation between the development of self-awareness and coordinated behaviours (Kleinspehn, 2008). Around 1.5 years of age, infants with greater self-awareness, as measured by the classic mirror recognition test, engage in more coordinated, imitative play with their peers (Asendorpf & Baudonniere, 1993; Asendorpf, Warkentin, & Baudonni, 1996). Such coordinated, imitative play involves understanding the play partners' goals and intentions to play together versus alone and responding to them accordingly. Coordinated play can also be related to children's understanding of other minds. Indeed, coordinated, imitative play at 2 years has been found to follow a similar developmental pattern as pretend play (Nielsen & Dissanayake, 2004), which is considered as a good indicator of children's ability to grasp others' mental states (Tomasello et al., 2005).

Children's understanding of rhythmical patterns can also have important implications for their own rhythm production abilities. One particular context in which this is manifested is language development. Different languages have different rhythmical patterns and understanding these differences is important not only for language comprehension but also for language production (Nolan & Jeon 2014). The

close link between rhythmic understanding and its production is also evident in the context of music. In one study, 7-month-old infants and their parents received a brief musical training that included listening to rhythms and bouncing the infant in time to the beats. It was found that following this brief training of only a few minutes long, infants' interest in rhythmical stimuli increased and they preferred the rhythms that they had been previously bounced to (Gerry, Faux, & Trainor, 2010).

Another musical intervention with 6-month-olds further revealed the social benefits of exposure to music. Following a 6-month-long musical training that involved listening to rhythms, singing and performing corresponding body movements, improvements were observed in the infants' social and language development (Gerry, Unrau, & Trainor, 2012). Hence, it can be concluded that exposure to certain, culture-specific rhythms promotes aspects of social development. However, it should be noted that these musical intervention studies do not provide sufficient evidence for the specific role of movement synchrony on producing social outcomes.

Researchers have recently started to investigate the specific role of interpersonal movement synchrony in facilitating pro-sociality. One study has found that 14-month-old infants who were bounced synchronously, as compared to those who were bounced asynchronously, with another adult subsequently helped the adult more by handing objects to her when the objects were out of her reach (Cirelli, Einarson, et al., 2014). In the same study, Cirelli and colleagues (2014) exposed the infants also to anti-phase synchronous movement (i.e., where the infant was moving up while the experimenter was moving down) and similarly found more subsequent helping behaviour following synchronous than asynchronous bouncing. These two studies together suggest that the increase in helping behaviour was driven by the contingency of synchronous movements rather than by morphological similarity and visual symmetry. Do these

findings show that moving synchronously makes infants more helpful generally or is the helping behaviour directed specifically to the synchrony partner? To answer this question, 14-month-old infants were exposed to synchronous versus asynchronous movement conditions using the same bouncing procedure (Cirelli, Wan, et al., 2014). It was found that infants did not help a neutral stranger as much as they helped their synchrony partner. Importantly, however, infants did help strangers, who were previously presented as the affiliates of their synchrony partners (Cirelli et al., 2016). Interestingly, despite the increase in helpfulness, synchronous movement did not seem to facilitate sharing behaviour in infants (Cirelli, Wan, et al., 2014). This suggests a discrepancy in the variety of pro-social behaviours that movement synchrony can induce and is, in fact, in line with research pointing more broadly at the differences in the age of onset of different pro-social behaviours (Dunfield, 2014).

Overall, studies reviewed in this chapter indicate a strong association between social development and interpersonal movement synchrony. Infants coordinate their movements in socially facilitated contexts and, once synchrony is attained, it is linked to positive social outcomes, such as secure attachment or increased helping behaviour towards the synchronising partners. Another interesting conclusion is that infants perceive rhythmical stimuli from non-social sources starting from very early on. Yet, no study has looked at the social outcomes of movement synchrony that take place in non-social settings and, specifically, whether social outcomes are specific to social synchrony.

The aim of the first two studies of this thesis is to begin to fill this gap by comparing infants' preferences for movement synchrony to non-synchrony in social and non-social settings. A substantial amount of research points to the importance of similarity in guiding infants' social preferences (see Section 2.2.4). In keeping with this

literature, the current studies investigated pro-sociality in infancy by assessing infants' social preferences for others whose movements were timed to the same rhythms as the infants themselves or different. This way, the findings of Cirelli and colleagues on the importance of contingency in synchronous movements were taken further to see if such contingency in timing is especially more preferable in social settings. To date, the youngest age where movement synchrony is known to induce pro-social outcomes is 14 months old. By looking at younger infants' preferences as an indicator of their pro-social attitudes, the current study will be able explore the proposed movement synchrony and pro-sociality link within the first year of life.

3

EMPIRICAL STUDY 1: THE ROLE OF MOVEMENT SYNCHRONY ON INFANTS' SOCIAL AND NON-SOCIAL PREFERENCES

3.1 STUDY 1A

This study aims to test how movement synchrony influences infants' social and non-social preferences within the first year of life. Recent research has shown that at 14 months, infants display more helping behaviour towards individuals who have bounced synchronously, compared to those who were bounced asynchronously, with them (Cirelli, Einarson, et al., 2014). Given the importance of highly coordinated, synchronised movements in early social interactions (e.g., Jaffe et al., 2001), it is hypothesised that infants will prefer synchronous others to non-synchronous others more in a social than in a non-social context. Moreover, by conducting the experiment with 12-month-olds (Study 1a) and with 9-month-olds (Study 1b), potential developmental changes during this period will be identified.

In both Study 1a and Study 1b, children were first rocked in chairs as they viewed toys (social or non-social; more details in the Materials section below) that rocked synchronously or non-synchronously with them. Children were later given the opportunity to select one of the toys that they have just been rocked together with. In order to ease rhythm perception and comparability across conditions, rocking rhythms were kept equally predictable and constant across conditions (see Cirelli, Einarson, et al., 2014 for a discussion). In Study 1a, it was hypothesised that 12-month-olds would prefer the synchronously-moving toys more in the social condition than in the non-social condition. Study 1b explored whether 9-month-olds would show the same pattern of social preferences as 12-month-olds.

3.1.1 Method

3.1.1.1 Participants

Forty 12-month-olds ($M = 374$ days $\pm$ 10.02, 21 girls) participated in the study. All participants were recruited from a database of parents who had indicated interest in

taking part in research. The database belonged to the Uppsala Child & Baby Lab, where the study was conducted. The choice of study location did not stem from any culture-specific hypothesis, but from the availability of the necessary resources to conduct the study. Children mainly came from White, middle-class backgrounds. None had any known disorders or disabilities. Parents received a voucher worth approximately 10€ for their time. Ethical approval was received from both the University of Oxford and Uppsala University prior to the study. Parents gave explicit consent for video recording of their infants in the consent form.

3.1.1.2 Materials

Rocking chair. A baby car seat was used to manipulate synchronous movement across conditions. During testing, children sat in the chair and watched videos while their chair was rocked from behind by the experimenter (E). The toys featured in the videos were seated in the same chair during recording.

Toys. In total, two teddy bears (social condition) and two colourful boxes with flower pictures on them (non-social condition) were used. Teddy bears, instead of more human-like stimuli such as dolls or babies, were chosen for the social condition to make the toys across conditions as similar and comparable as possible to one another. This was important to ensure that children would pay equal attention to both conditions and so, their subsequent choices would be representative of their liking of the non-/synchronous movement, not of differences in attention paid. Previous research supports the use of stuffed animals as social stimuli. It has been shown that 10-month-old infants imitate the successful actions of a human and a stuffed animal with facial features in similar amounts (Legerstee & Markova, 2008). Similarly, 15-month-old infants imitate the actions of and gesture at a non-human agent that has a face and communicates with the infants (Johnson, Booth, & O'Hearn, 2001). Following these findings, the social

stimuli of the current study (i.e., teddy bears) had a face and eyes and engaged in a communicative interaction with the infants prior to the start of the trials. For the sake of comparability, the boxes in the non-social condition were also accompanied by some sounds and motion, though those sounds and motions did not serve a communicative function (details below).

All of the toys were pre-recorded while being rocked in the rocking chair. During the rocking phase of the experiment, these videos were shown to the children via a TV screen. Next, in the choice task phase, children were presented with the toys in real life and were asked to choose between them. Toys within a given video were distinguished from one another via their different colours (see Figure 3.1). Pilot tests established that the colours were equally attractive within and across conditions and the pictures on the boxes were equally appealing to both boys and girls. More details on the recordings can be found in the Video stimuli section.

Video stimuli. Life-sized videos were shown from a 55" TV screen positioned approximately 1 meter in front of the child. The screen was surrounded by a partition of curtains so that it appeared as if it were a window into another part of the room rather than a regular TV screen (see Figure 3.1). The toys were recorded while being rocked at one of two speeds: 594ms (101 bpm) or 458ms (131bpm). Pilot tests showed that these two speeds were easily distinguishable, natural rocking speeds for children.

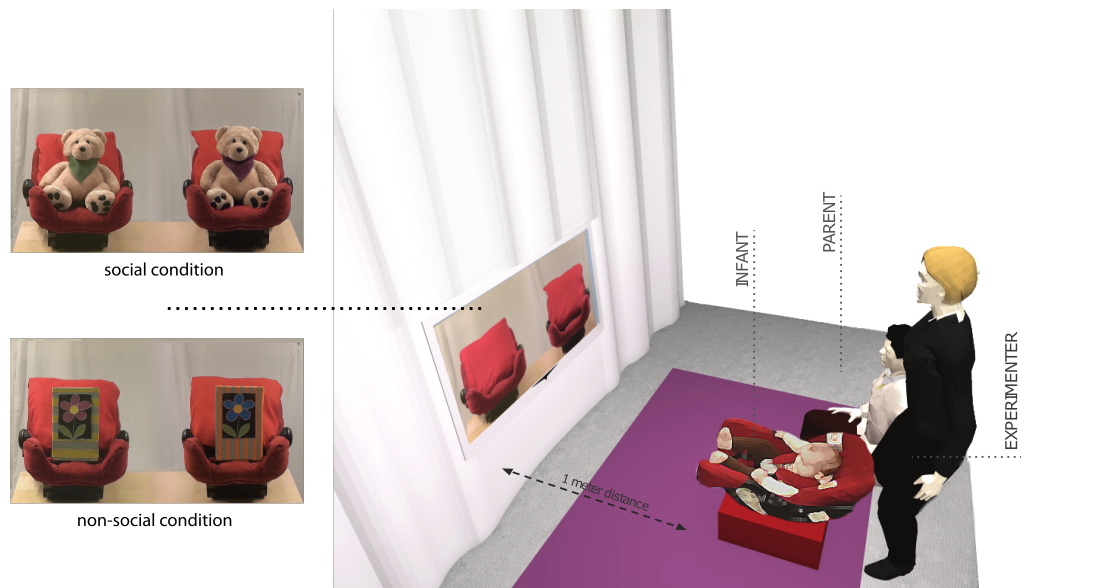


Figure 3.1. Depiction of the room setting and still frames from the social (teddy bears) and non-social (colourful boxes) stimuli

In the synchrony condition, both the child and the toy were rocked to the same rhythm (either 594ms or 458ms) with identical onset times. This meant that the chairs' positions of maximum amplitude whilst rocking forward/backward always occurred simultaneously for the child and the toy. In the non-synchrony condition, the child and the toy were rocked to different rhythms, while the onset times remained identical. This meant that during rocking, the positions of the chairs were not the same, and the distances between the two chair positions varied at each of their repeating cycles. The following parameters were counterbalanced in the stimuli: (a) colours by right-left side, (b) synchronous toy by right-left side, (c) presentation order of the synchronous versus non-synchronous toy, and (d) presentation order of the fast versus slow speeds.

At the beginning of each video, E placed the toys in their chairs from the side of the screen one at a time. In the social condition, one of the teddy bears said “Hej! Nu gungar vi!” in children’s native language (“Hi! Let’s rock”, in English), while nodding its head simultaneously. It then started rocking at one of the two speeds (duration: 40s). After the first bear stopped, there was a brief pause and then the second bear introduced

itself in the same way as the first bear and started rocking at the other speed. To replace the utterances and head nods of the social condition, the boxes in the non-social condition made a jingling or mechanical rattling sound, while being illuminated with light flashes simultaneously. In both social and non-social conditions, the toy introduction lasted for 3 seconds and involved comparable visual and auditory stimulation. Rocking of each toy was presented sequentially to ensure that children had a chance to attend to both toys. Figure 3.2 shows the progression of events in the video stimuli step-by-step, with snapshots from the non-social condition.

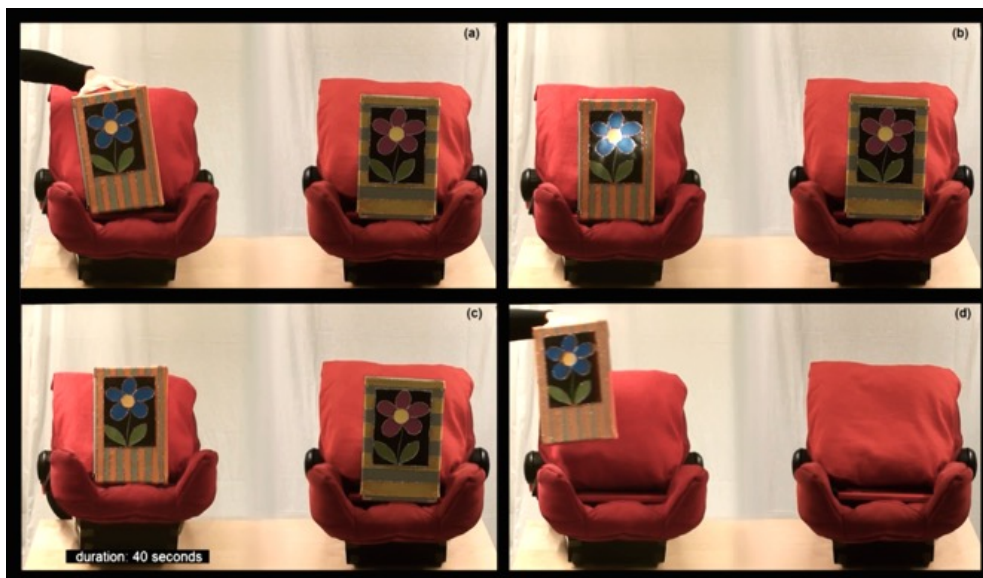


Figure 3.2. Snapshots from the video stimuli (non-social condition), showing (a) placement of the second toy on the screen, (b) introduction of the toy via light flashes and jingling/rattling sounds, (c) rocking phase- duration: 40 seconds, (d) removal of the toy from the screen.

3.1.1.3 Procedure

Each session consisted of one social trial and one non-social trial (counterbalanced). Each trial had two phases, the rocking phase followed by the choice phase. Before the experiment, E played with the children briefly to familiarise them with the environment. At all times, parents stayed in the room with children. They were asked to help keep their children motivated while watching the videos (e.g., by pointing

to the screen and saying “look”, but never by giving specific information about what was happening) and while responding to E during the choice task phase (e.g., with general encouragement, but no specific directions). Those trials where the parents commented on the stimuli (e.g., by saying “Look at the pretty bear/box!”) were excluded from analyses (see Coding Section 3.1.2).

Rocking Phase

At the beginning of this phase, children were seated securely in the chair in front of the screen. In order to create the perception of a live demonstration, children observed E show each toy, saying “Titta!” (“Look!”) and take it behind the curtains that surrounded the screen. Children saw E’s hand carrying the toy and approaching while she was placing the toy in its chair on the screen (see Figure 3.2). This was repeated for the second toy on the other side of the screen. For the duration of each toy’s rocking in the video, E rocked the child at one consistent speed, indicated by a beat, which she heard from her earphones. Having the child rock at one speed throughout the session resulted in one toy per trial rocking at the same speed as the child (synchronous toy) and the other at a different speed (non-synchronous toy). On finishing the rocking phase, E brought the toys back from behind the screen and put them on the carpet.

Choice Task Phase

For the choice task, the children were taken out of the chair and seated on the carpet in front of their parents. E showed each toy to the children in sequence, saying “Titta!” (“Look”), allowing them sufficient time to look at each toy and back at the experimenter. Following this, she asked the children which one they like best (saying “Vilken tycker du bäst om?”, “Which one do you like best?”). Children indicated their preference by crawling and reaching for a toy from approximately 1 meter away. If they

did not respond, E made a second attempt asking “Varsågod! Vilken tycker du bäst om?” (“Here you are! Which one do you like best?”). After making their choice, children were seated back in the chair for the second trial (social or non-social depending on the first trial). Previous research has established that infants this age can reliably indicate their preferences by pointing and crawling to or reaching for their preferred stimulus (Hamlin et al., 2011; Hamlin & Wynn, 2011).

The entire session was video recorded for coding purposes.

3.1.2 Coding

The first toy the children touched with a visually-guided reach was counted as their preferred choice. To eliminate accidental touches being counted as choices, children had to look at the toy they were reaching for. If there was no choice within 3 minutes, the trial was excluded. Out of 80 trials, a total of 6 were excluded from analyses because of fussiness (e.g., too irritable to sit still for the duration of the study, $n = 2$), parental interference (i.e., all parental prompts other than just “Look (at here)!”, $n = 2$), or children’s delay in responding (i.e., responses after the first 3 minutes, $n = 2$). After exclusion, 38 non-social trials and 36 social trials were retained.

To examine whether children found the toys similarly appealing and attended to them equally during the rocking phase, we conducted a looking time analysis via post-hoc coding of the study videos. Children in all conditions attended to the 40-second rocking stimuli equally well ($M = 31.35 \pm 6.32$ for social-synchrony; $M = 31.87 \pm 5.81$, for social-non-synchrony; $M = 32.43 \pm 6.98$, for non-social-synchrony; and $M = 30.99 \pm 4.85$ for non-social-non-synchrony), and their attention did not differ across the four conditions, one-way ANOVA $F(3, 39) = 0.414$, $p = .743$. As another indicator of how attractive the four conditions were to the children, we also coded for the number of times parents attempted to re-direct their children’s attention to the screen. There were

no differences across the four conditions ($M = 1.54 \pm .80$, for social-synchrony, $M = 1.33 \pm .62$, for social-non-synchrony, $M = 1.83 \pm .77$, for non-social-synchrony, and $M = 1.85 \pm .91$, for non-social-non-synchrony), one-way ANOVA $F(3, 39) = 0.900$, $p = .443$.

A second coder blind to the conditions and the hypotheses coded a randomly selected 25% of the videos. The coders' ratings were highly correlated for the duration of looking time, Krippendorff's $\alpha = .83$, and for number of instances of parental prompting, Krippendorff's $\alpha = .90$. The second coder also coded for potential experimenter bias by indicating whether any of the toys had been emphasised more by E as she offered them to the child; no instances of such bias was found.

3.1.3 Statistical Analyses

Both study 1a and Study 1b had one within-subjects independent variable with two levels (social versus non-social). The dependent variable was a dichotomous choice between two toys: one synchronous and the other one non-synchronous. The effect of social versus non-social condition on children's synchronous versus non-synchronous toy choices was assessed with a chi-square analysis. Further binomial tests were run to examine whether children's synchronous toy choices within the social and the non-social conditions were above chance. In order to assess the effect of any other potential factors (e.g., child's sex, trial number, toy colour etc.) that may have influenced children's toy choices, binomial regression tests were conducted. The p values reported are corrected for multiple comparisons.

3.1.4 Results & Discussion

A binomial test on children's toy choices showed that children did not have an overall preference for synchronous toys over non-synchronous toys (53% of participants

chose synchronous toys, 39 out of 74 trials), binomial $p = .73$. However, chi-square analysis revealed a main effect of social versus non-social condition; as expected, children preferred synchronously-moving toys more in the social than in the non-social condition, $\chi^2(1) = 8.70, p = .003, \phi = 0.36$. Further binomial tests revealed that children chose synchronous toys above chance in the social condition (66% of participants chose synchronous toys, 24 out of 36 trials), binomial $p = .041$, but not in the non-social condition (38% of participants chose synchronous toys, 14 out of 38 trials), binomial $p = .199$. The relatively small effect size may indicate that a preference for synchronous movement is just starting to develop around the age of 12 months, especially in rather restricted social settings such as the one created in our experiment. Children had no overall preferences to select toys based on other factors and their synchronous toy choices were not influenced by those factors (see Table 3.1).

Table 3.1.
Summary results for the influence of various factors on 12-month-olds' toy choices.

		Percent of choices (overall)	Binomial p (overall)	Percent of choices (sync choices)	Binomial logistic regression p (sync choices)
Child's sex	Male			52.63	.195
	Female				
Trial number	1st trial			43.59	.187
	2nd trial				
Child's rocking speed	594ms			57.89	.204
	498ms				
Toy's rocking speed	594ms	55.41	.295	53.85	.985
	498ms				
Side of presentation	Right	58.11	.201	56.41	.566
	Left				
Order of presentation	First	45.83	.724	51.28	.144
	Second				
Toy colour	Green bear	60.00	.311	62.50	.402
	Purple bear				
	Orange box	61.54	.200	53.33	.700
	Yellow box				

These results suggest that movement synchrony is influential in guiding 12-month-olds' social preferences. Children did not show a general preference for synchronously-moving others; instead, it was only social entities who were preferred for their synchronous movements. To trace any developmental pattern on preferences for movement synchrony, Study 1b was conducted with 9-month-old infants.

3.2 STUDY 1B

3.2.1 Method

3.2.1.1 Participants

Forty-one 9-month-olds ($M = 276 \text{ days} \pm 10.79$, 20 girls) participated in the study. One additional child was excluded for not completing the study due to fussiness. Participants were recruited as in Study 1a.

3.2.2 Materials & Procedure

The stimuli and the procedure were identical to Study 1a, except that for 17% of the children, who were not yet capable of locomoting, the toys were brought within their reach so that they could make their choice.

3.2.3 Coding

The same coding scheme and exclusion criteria were applied as in Study 1a. Five out of 82 trials were excluded from the analyses because of fussiness (1), parental interference (1), or children's delay in responding (3). After exclusion, 38 non-social trials and 39 social trials were retained.

Looking time analyses revealed that children attended to the stimuli equally across conditions ($M = 31.36 \pm 5.63$, for social- synchrony, $M = 30.70 \pm 7.88$, for social- non-synchrony, $M = 30.04 \pm 4.95$, for non-social- synchrony, and $M = 29.75 \pm$

5.82, for non-social- non-synchrony), one-way ANOVA $F(3, 39) = 0.562, p = .641$. The number of times parents prompted the children was not different across conditions either ($M = 1.23 \pm .71$, for social-synchrony, $M = 1.38 \pm .82$, for social-non-synchrony, $M = 1.55 \pm .68$, non-social-synchrony, and $M = 1.83 \pm .93$, for non-social-non-synchrony), one-way ANOVA $F(3, 39) = 1.073, p = .362$. The two coders' ratings were also highly correlated for looking times, Krippendorff's $\alpha = .76$; and number of instances of parental prompting, Krippendorff's $\alpha = .85$. The second coder did not detect any experimenter bias.

3.2.4 Results & Discussion

Nine-month-olds did not display a differential preference for synchronously-moving toys overall, binomial $p = .82$, or across social and non-social conditions, $\chi^2(1) = 0.21, p = .646$. In fact, they did not show preferences for synchronous entities within either the social (44% of participants, 17 out of 39 trials), binomial $p = .63$, or non-social condition (61% of participants, 23 out of 38 trials), binomial $p = .87$, suggesting that they had not yet developed a preference for entities that have previously moved in synchrony.

Binomial logistic regression analyses demonstrated that children's choices were not influenced by other factors, nor was there an interaction with social/non-social condition (see Table 3.2). Children had an overall preference for slow-rocking toys over fast-rocking toys, binomial $p = .039$, potentially suggesting (i) that they perceived the differences between rhythms; and (ii) that they have sufficient memory of the kinematics of the toys to make informed choices about them later on. There was no interaction between toy speed and condition, $p = .364$; children were no more likely to choose slow-rocking toys in the social versus the non-social condition. In sum, it can be concluded that 9-month-olds did not have a preference for synchronously-rocking toys.

Table 3.2.
Summary results for the influence of various factors on 9-month-olds' toy choices.

		Percent of choices (overall)	Binomial p (overall)	Percent of choices (sync choices)	Binomial logistic regression p (sync choices)
Child's sex	Male			50.00	.922
	Female				
Trial number	1st trial			50.00	.654
	2nd trial				
Child's rocking speed	594ms			57.50	.148
	498ms				
Toy's rocking speed	594ms	62.34	.040*	57.50	.438
	498ms				
Side of presentation	Right	59.74	.110	57.50	.593
	Left				
Order of presentation	First	45.45.	.494	45.00	.671
	Second				
Toy colour	Green bear	65.79	.073	66.66	.938
	Purple bear				
Toy colour	Orange box	61.54	.200	70.59	.604
	Yellow box				

3.3 GENERAL DISCUSSION OF STUDY 1A & STUDY 1B

The results of the two studies suggest that matching the timing of movements is an important factor informing infants' social preferences for others. This effect is examined in two age groups in separate studies, mainly due to the time difference in data collection between the two studies and to one minor methodological difference (i.e., bringing the toys closer to the infants in Study 1b). It was found that 12-month-olds preferred the social entities that had moved synchronously with them to those who had moved non-synchronously. Results suggest that this preference does not stem from a general preference for synchronous movement; children did not exhibit a preference for non-social entities that moved synchronously. Previous studies have begun to provide evidence for the emergence of a preference for synchronous movements during

infancy (Cirelli, Einarson, et al., 2014). Yet, this is the first evidence suggesting an active, social preference based on matching of the timing of movements. Study 1b is further showed that preference for synchrony in social settings is not yet in place at 9 months. Indeed, 9-month-olds did not show preferences for movement synchrony at all. Investigating children's preference for movement synchrony in two age groups is informative about the developmental trajectory of this effect, though the findings should be interpreted with caution as no direct statistical tests are run to compare the two age groups to one another.

One reason for 9-month-olds' indifference to movement synchrony might be related to difficulties in perceiving synchronicity. Yet, the results of Study 1b are unlikely due to infants' inability to perceive rhythms. At least one earlier study has powerfully shown that 7-month-old infants, who were bounced in time to a certain rhythm, later preferred to listen to that rhythm over another rhythm (Phillips-Silver & Trainor, 2005). Thus, we know that infants as young as 7 months old can extract the rhythmicity from movements and make preferences accordingly. Notably, however, this previous study had used auditory beats and up-and-down bouncing movements, while in our study, infants viewed back-and-forth movements with no auditory stimuli. It is possible that our stimuli were not salient enough for young infants to detect synchrony. Even if that were the case, however, the current finding that 9-month-olds preferred slow-rocking toys indicates that the infants accurately perceived the differences in rhythms.

Another possibility to explain the null findings with the 9-month-old group could be that even though children perceived synchronicity and had preliminary preferences for synchronous entities, their preference was not strong enough to be revealed in our choice task. While a head-turn preference procedure, as was used previously (Phillips-

Silver & Trainor, 2005), is less demanding than our task, we know that even 5-month-olds can express their preferences by selecting from among toys that have acted in different ways (Hamlin et al., 2011; Hamlin & Wynn, 2011). Thus, the choice measures used in our studies were age-appropriate and the results are unlikely to be due to a problem with the measures used.

The difference between Phillips-Silver and Trainor's (2005) and the present study's results in terms of infants' preference for rhythmic stimuli might have to do with cognitive processing of different modalities of stimuli. While Phillips-Silver and Trainor's (2005) study required infants to match a novel auditory stimulus to a previously heard auditory stimulus, the current study required infants to match 3D visual stimuli (i.e., the teddy bears and boxes) to a previously observed visual stimuli (i.e., the movements of the teddy bears and boxes projected on a TV screen) that was moving in space. This might have caused the so-called correspondence problem: How does one represent a match between one's own and others' actions, when information about others' muscle activation and/or about the external consequences of one's own actions is unavailable (Brass & Heyes, 2005)?

Correspondence problem has been discussed widely in imitation literature (Catmur, Walsh, & Heyes, 2009) due to claims that imitating others' movements, and hence the solution for the correspondence problem, was innate (Meltzoff & Decety, 2003; Nagy, 2006). However, recent research testing a comprehensive range of behaviours with the largest sample size of its kind has found no evidence for an innate tendency for imitation (Oostenbroek et al., 2016). Thus, the correspondence problem seems to be valid and relevant for synchrony and other cases, where match between movements of self and others needs to be determined. It has been suggested that through associative learning, (i.e., experiencing matched movements in their interactions with

carers), infants resolve the correspondence problem (Catmur et al., 2009). If the correspondence problem does indeed play a role in perceiving and performing synchronous movements, then the current results would indicate that – arguably as a result of increased experience with moving in synchrony with others – this problem starts to be resolved at 12 months.

Still, which aspects of synchronous interactions induce the observed effects is largely unknown. It has been proposed that temporal contingency rather than morphological similarity between movements might be responsible for the pro-social effects of synchrony (Catmur & Heyes, 2013; Cirelli, Einarson, et al., 2014). Temporal contingencies are important for development as they can foster causality links and perceptions of agency (Fonagy, Gergely, & Target, 2007; Rochat, Neisser, & Marian, 1998). Further, temporal contingencies may be easy to grasp as their detection relies on phylogenetically ancient associative learning mechanisms (Catmur & Heyes, 2013). Indeed, it has been found that 5-month-old infants are sensitive to temporal contingencies between actions and outcomes even in the absence of visual cues (Bahrick & Watson, 1985). Arguably, however, both temporal contingency and topographical similarity facilitate pro-sociality, albeit in different ways. Our current study design does not permit further conclusions on the relative influences of contingency and similarity. More studies investigating how these and other factors interact in a wider range of coordinated movements are needed to shed light on this question.

Research on action timing in children's early development has been scarce. One apparent reason for this is infants' limited motor abilities to move in synchrony with others. The current study's design tried to overcome this challenge by having infants seated in a chair and rocked by an adult. Contrary to previous methods, where infants

were bounced in close physical contact with the experimenters (Cirelli, Einarson et al., 2014; Phillips-Silver & Trainor, 2005), our movement manipulation did not require bodily contact between the experimenter and the infant, potentially making the infant's experience more focused on the interaction with the synchronously- and non-synchronously moving individuals. Further, despite lacking self-propulsion, children in our study had first-person experience about the rocking movement. Thus, the synchrony manipulation was designed to be as impactful as possible, given participants' limited motor skills. Nevertheless, the current methodology leaves it to future research to address whether self-propelled actions would have a more pronounced effect on children's preferences.

In the current studies, the social agents presented to the children were teddy bears that nodded their heads and uttered some words. In contrast, the non-social items were colourful boxes that lit up and made some sounds. One critique could be that the social condition was not interpreted as such. Previous research shows, however, that children perceive toys as social entities, particularly ones that have eyes and a face and that perform contingent, communicative acts (Johnson et al., 2001; Johnson, Slaughter, & Carey, 1998; Legerstee & Markova, 2008). Infants' judgment of non-humans as social entities based on certain features is also reflected in their pro-social behaviours (Johnson et al., 2001; Legerstee & Markova, 2008; Over & Carpenter, 2009). In addition, research on early social interactions shows that mothers often talk about the internal states of dolls and toy animals and that this influences children's imitation and pretend play (Haight & Miller, 1982; Zinober & Martlew, 1985). Therefore, we are confident that the teddy bears in our study, which had a face and communicated briefly with the participants, possessed sufficient cues to be understood as social agents. To help draw stronger links to real-life social interactions, however, future research can address this

issue by manipulating the synchronising partners' agency levels and presenting them in a reciprocal communication context.

Another limitation of the current studies could be that the agents were presented via video rather than live, possibly making them less impactful for children. This method was selected because using videotaped stimuli minimises human error in rocking rhythm and eases replicability. Research has shown that integrating video demonstrations with matching auditory and visual cues and contingent social behaviours facilitates children's learning from video stimuli (see Barr, 2010; Troseth, 2010 for reviews). Accordingly, our videos were complemented with sounds that matched the movements of the objects shown. While presenting the video stimuli, the experimenter provided the children with contingent social information. Moreover, the TV screen used in our studies looked as if it were a window into another room that was behind the curtains, creating a more realistic set-up. Studies using a similar video presentation method also demonstrate that 10-month-olds can make decisions based on information presented from the screen (Kinzler et al., 2007, 2012). Hence, we are confident that the video stimuli were sufficiently comprehended by both age groups to guide subsequent choices.

Moving in time with others has important implications in a social interaction, potentially easing coordination and facilitating pro-social attitudes and behaviours among participants. How the links between movement synchrony and social behaviours are formed has been largely unexplored. The two studies showed that an active preference for movement synchrony develops towards the end of the first year of life. Importantly, this preference occurs exclusively in social contexts, as indicated by the children's selection of synchronously-moving toys only when they were presented as social agents. Although we must exercise caution in developing a generalisable

explanation of the observed preferences for social synchrony on the basis of these two studies alone, some suggestions can be drawn from the broader literature on mother-infant interactions.

It may be that due to the importance of interpersonal coordination in social settings, infants learn to pay attention to timing cues in others' movements from very early on. Hence, social entities that move synchronously with the infants are preferable as they signal being better potential cooperation partners. Alternatively, or additionally, due to the ease with which the contingency of actions is grasped from early ages onwards, movement synchrony might serve as a cue indicating similarity, familiarity and/or group membership, which motivates increased pro-social attitudes and behaviours.

These findings lend further questions about the relation between movement synchrony and pro-social development. For instance, how is that relation manifest in contexts that resemble real-life, such as in children's natural play contexts? Would more elaborate pro-social outcomes be observed if behaviours performed by participants were volitional rather than passive (i.e., performed by the Experimenter)? How, if at all, is the link between pro-sociality and social synchrony as observed in the present studies mediated by the developments in the emotional domain as children get older? The next study of this thesis aims to provide answers to these questions by investigating the effect of volitional movement synchrony on subsequent helping behaviour among pairs of older children (ages 4 to 6 years old). Before moving on to the details of this study in Chapter 5, the following chapter will provide a review of the literature on the development of movement synchrony and pro-sociality in early childhood years.

4

INTERPERSONAL MOVEMENT SYNCHRONY, COORDINATION AND PRO-SOCIALITY IN EARLY CHILDHOOD

The early childhood period marks rapid development in many domains. Interpersonal, cognitive and motor skills acquired in the first few years of life are exercised regularly in various aspects of social life. With their improved motor skills, children can intentionally and efficiently coordinate with others. Physical play with peers becomes an important avenue for forming social bonds, practising newly-acquired communicative skills and managing friendships within peer groups. Social interaction patterns also undergo a significant change, being increasingly dominated by peer-to-peer interactions in school settings rather than interactions with adults within the family context. Despite the challenges it brings, this new social environment also offers unique opportunities for pro-sociality. Children improve abilities to regulate their own emotions and to understand others' desires and intentions. This importantly guides the success of the children's interactions and relationships with others. For instance, "I know how you feel, Chris", says a 3- to 6-year-old child, to soothe his sister who has just started the school, "When I started kindergarten I cried the first day, too." (Bretherton, Fritz, Zahn-Waxler, & Ridgeway, 1986, p. 540). Examples of sophisticated emotion understanding and motivation to aid others are ubiquitous in early childhood years.

This chapter will present the motor, social, emotional and cognitive skills that the children develop in early childhood. The first section (Section 4.1) will review research on the development of general motor skills and rhythmic synchronisation skills. In Section 4.2, the socio-cognitive skills that children develop at this age will be examined, followed by an in-depth explanation on the emerging peer-play context and the manifestation of pro-social behaviours therein. Finally, the chapter will close with a review of the particular relations between motor and rhythmic synchronisation skills and social and cognitive development in Section 4.3. Building up on the theoretical and

methodological insights gained from the background information presented in this chapter, the following chapter (Chapter 5) will provide a detailed report of the second study of this thesis. The second study will investigate whether actively performing synchronous movements in a peer-play context facilitates cooperative behaviours among young children.

4.1 RHYTHMIC SYNCHRONISATION ABILITIES IN EARLY CHILDHOOD

Early childhood is a period in which children are physically very active. It is the time when movement skills, such as running, climbing or balancing, improve further as children practise them in a wide variety of settings together with their peers (Gallahue & Ozmun, 2005). Building on their rhythmic and motor skills that were apparent even in infancy, children now are better able to synchronise their behaviours with external rhythms and with other individuals. Yet, difficulties in certain areas of coordination remain and continue to develop well into late childhood years (Piek et al., 2012). To explore the extent of children's abilities to perform rhythmic and coordinated/synchronised movements, this section will start with a review of the literature on the development of basic motor skills such as running, hopping, balancing and throwing or kicking a ball (Section 4.1.1). Next, children's developing abilities to perform these movements in synchrony with external rhythms and in coordination with others will be investigated in Section 4.1.2. Insights gained from the review on motor development will importantly inform the design of the second study, where the children will be asked to perform certain movements in synchrony with external rhythms. It is thus important to understand the scope of the children's synchronised movement capacities. The review will also reveal the potential two-way link between motor skills and social-cognitive development. Although these aspects of development have been investigated largely separately, there are important connections that can be drawn and

that can help us understand how movement synchrony can facilitate social bonding and cooperation. Therefore, after covering the social-cognitive abilities of children in Section 4.2, the final section of this chapter (Section 4.3) will show how the motor, social and cognitive domains may influence each other in early childhood years.

4.1.1 The development of motor movement skills

Early childhood is a period when engagement with physical activities is abundant, often in the context of peer groups (e.g., Jago et al., 2011). As they play, children often engage in vigorous movement activities - they run, jump, hop and dance. These activities involve children moving and coordinating their bodies and often in a rhythmical way. How much they move, which parts of their bodies they move and how successfully they coordinate together with other individuals all depend on the development of motor skills. What makes investigating the development of motor skills particularly important for the current research is its close links to social development. In early childhood, physical activity (PA) “occurs within the guise of play” (Timmons et al., 2007, p. 127); hence, developments in the motor domain are telling about children’s interactions with peers and their developing social skills. Existing studies have reported a link between moderate levels of PA and psychosocial skills such as enhanced self-esteem (Alpert, Field, Goldstein, & Perry, 1990) and lowering of anxiety and depression symptoms (Strong et al., 2005). Surprisingly, however, research on the social effects of PA in early childhood is rather scarce. The second study of this thesis will investigate how synchronous movements, similar to those observed in PA, influence pro-social behaviour. Before moving on to this study’s details, however, we will take a closer look at the children’s motor and social capabilities in the early childhood period.

The categorisation of Fundamental Movement Skills (FMS) comprises the most systematic and widely accepted grouping of children’s developing motor skills

(Gallahue & Ozmun, 2006). These movement patterns are fundamental in that they form the foundation for more complex movements displayed later in children's play, sports activities, dance and so on. (*Fundamental movement skills: Learning, teaching and assessment*, 2013). There are three categories of FMS: (1) body management skills, which relate to balancing the body; (2) locomotor skills, which relate to transporting the body from one point to another; and (3) object control skills, which relate to controlling apparatuses such as bats or balls. Assessments on FMS mostly are typically done by getting the children to live perform a particular movement and by assessing how well their performance fit some pre-determined criteria (e.g., Venetsanou & Kambas, 2011) and/or by measuring sustainment (e.g., Krombholz, 2006).

Concerning the developmental trajectory of children's motor skills, and FMS in particular, it is important to bear in mind a few points. Firstly, although proficiency in performing movements improves with age, individual and environmental factors play a significant role in the progress of motor development (Venetsanou & Kambas, 2010). Moreover, motor skills develop over a continuum rather than in a stepwise manner (Haubenstricker & Seefeldt, 1986); hence, most young children can already perform the movements that older children perform, albeit in a less proficient manner. Finally, special caution must be paid to avoid equating gender differences to sex differences. That boys start throwing and kicking balls earlier than girls and that girls start skipping and hopping earlier than boys may have to do with socio-cultural expectations and practices, and not necessarily biological differences (Malina, 2004). With these cautionary points in mind, the remainder of this section will provide information on how various determinants, mainly age, gender and environmental factors, influence the development of each one of the three categories of FMS one by one.

Body management skills have been assessed by tests asking children to balance themselves statically (i.e., on one foot, or whilst moving, to roll, bend, stretch, twist, swing or climb). At around 3½ years of age, children start to be able to maintain balance while stepping on one foot, climb stairs using one foot for each step (Frankenburg & Dodds, 1967; Dunlap, 1997) and whirl (Scott-Kassner, 1993). Research on body management skills in early childhood points to a significant difference between girls and boys. In balance skill tests that required the children to stand on one foot on a balance beam (with eyes both open and closed), walk on a straight line or walk heel-to-toe on a balance beam girls performed consistently better than boys (Chow, Henderson, & Barnett, 2001; Krombholz, 2006; McKenzie et al., 2002; Morris, Williams, Atwater & Wilmore, 1982; Venetsanou & Kambas, 2011). Balance skills also change with age. Body coordination improves from 3.5 to 6.5 years (Krombholz, 2006) and children's balancing skills can increase significantly in relatively short periods, from 4.5 to 5.5 years (Venetsanou & Kambas, 2011).

An earlier study tested children's performance on various body management tasks by utilising a pass-fail system (Gutteridge, 1939). Among a sample of 358 children, while only 50% of the 3-year-olds could climb proficiently, 75% were proficient climbers at 4 years and this proportion remained more or less stable until 6 years of age, where it eventually rose to 92%. This finding points to a clear incremental trend with age, while showing at the same time the non-linear and continuous nature of motor development. Finally, regarding environmental influences, it was reported that having older siblings, as compared to being an only child or being the first-born child, was positively associated with body management skills in 3.5- to 6.5-year-olds (Krombholz, 2006). Arguably, having siblings as play partners exposes children to contexts of interpersonal coordination, which indirectly contribute to their body management skills.

The second category of FMS, locomotor skills, refers to skills such as crawling, walking, running, hopping, jumping, leaping, skipping and galloping (*Fundamental Movement Skills*, 2013). From 3½ to 4 years of age onwards, children can skip, hop (Frankenburg & Dodds, 1967; Dunlap, 1997), gallop, slide and jump forward and up and down (Scott-Kassner, 1993). Considerable improvement in locomotor skills is observed between 3.5 and 6.5 years, however (Krombholz, 2006; Wong & Cheung, 2006). While 3-year-olds can leap a distance of 35-60 centimetres, 4-year-olds can leap distances of 60-84 centimetres (Bayley, 1936). Similarly, 5-year-old children can jump higher and farther than 3-year-olds (Cowan & Pratt, 1934; Haubenstricker, Branta, Ulrich, Brakora & E-Lotfalian, 1984). These studies make the age-wise development in individual locomotor skills evident. Yet, these movements are of limited use on their own; in real life, it is crucial to be able to combine multiple movements to produce more complex ones. To investigate children's capabilities to combine movements, one study asked 3- and 4-year-old children to clap, march and clap-and-march at the same time in their preferred rhythm. It was found that although 4-year-olds were better than 3-year-olds in clapping and marching at the same time, the combined movement was the most difficult one for both age groups (Rainbow, 1981). This indicates that there is room for improvement when it comes to performing physically coordinated actions, even when coordination is intrapersonal.

Research suggests that inter-limb coordination may not be the only issue with locomotor difficulties. It seems that children simply find some locomotor tasks harder than others. For instance, rhythmic clapping was found to be easier than rhythmic marching (Rainbow, 1981). Gutteridge's (1939) aforementioned comprehensive study also showed that while 58% of children could jump proficiently at the age of 4, only 43% could gallop, 33% could hop and 14% could skip. Importantly, these gaps among

different locomotor skills were found to disappear in the 6th year of life, when children's performance across tasks became more uniform (Gutteridge, 1939). In addition to age, another reason why children may not perform as well in certain tasks, such as in boys' skipping or girls' overhand throwing (Gutteridge, 1939), might have to do with social expectations. "Practice makes perfect" and while boys may get more opportunities to do activities like overhand throw, girl games typically involve more skipping (Malina, 2004). Finally, some social factors seem to positively influence children's locomotor skills, such as having older siblings (Krombholz, 2006) or coming from a middle-high socioeconomic background (Hardy, King, Kelly, Farrell, & Howlett, 2010). Importantly, both these factors can create a more supportive social network, with the presence of siblings contributing directly to having playmates and a higher SES increasing the parents' likelihood of valuing and encouraging the children's PA involvement (McGee et al., 2006).

The last category of FMS, object control skills, encompasses movements such as throwing, catching or kicking a ball and striking or bouncing a ball using a bat. Essentially, these movements involve manipulating objects, which requires advanced inter-limb coordination and power control. Unsurprisingly, older children are better at object control skills than younger children (Chow et al., 2001; McKenzie et al., 2002). An early study found that at the age of 3, children could target objects that are at 1.5 to 3 meters' distance from them in throwing tasks (Wild, 1937). Still another study showed that while only 20-30% of the 3-year-olds could throw or catch a ball, among 4-year olds, this number had increased to 80% and 56% for throwing and catching, respectively (Gutteridge, 1939). These studies show a clear and rapid developmental trend with increasing age. Yet, the most consistent finding from research pertaining to object control skills is the large difference between boys and girls.

All throughout the early childhood period, boys perform better than girls at various object control tasks, including throwing objects (Morris, Williams, Atwater & Wilmore, 1982), catching balls (McKenzie et al., 2002; Okely & Booth, 2004), striking a stationary ball, overhand throwing, kicking (Hardy, King, Farrell, Macniven, & Howlett, 2010; Okely & Booth, 2004), catching a beanbag and rolling a ball through a goal (Chow, Henderson & Barnett, 2001). One longitudinal study, assessing motor development across the span of ages 2 to 18, sheds further light on the emergence of these differences across sexes. By assessing children's motor performance on a 5-point stage system, where task difficulty increased at each stage, (Haubenstricker and colleagues (1999) identified the ages at which at least 60% of the children could reach any given stage. They found that there were no significant differences between the object control skills of boys and girls at the initial stages of object control tasks. Yet, from stage 3 onwards, it took girls up to 40 months longer on average than boys to perform proficiently in skills such as overhand throw, catch, strike and kick (Seefeldt & Haubenstricker, 1982). Although no studies have directly examined the causal origins of these differences between boys and girls, social factors and values encouraging boys to participate in activities that involve object throwing, catching, striking and kicking may be influential (Malina, 2004).

In line with this interpretation it was found that the general activity level in children's daily lives (i.e., their habitual PA), predicted motor skill development across all of the three FMS categories (Bürgi et al., 2011; Fisher et al., 2005; Kambas et al., 2012). Convergent findings across many studies also reveal that boys are physically more active than girls at pre-school ages (see Tucker, 2008 for a review). The links between habitual PA, gender and FMS performance might have to do with active children (especially boys) having more opportunities to try out and practise various

movements. Structured educational programmes that involve adult instruction on how to perform certain movements can also be beneficial for improving FMS (Haubenstricker & Seefeldt, 1986). A number of physical education programmes repeated regularly over a period of time (range: 8 weeks to 8 months) have been shown to improve children's performance success in all three categories of FMS (see Iivonen & Sääkslahti, 2014; Venetsanou & Kambas, 2010) for detailed reviews). Social support within the family also positively affects FMS development. In a comprehensive study investigating 535 boys and 452 girls of 4 to 6 years of age, it was found that higher parental education, higher value placed on PA and regularly cycling to school were positively associated with children's FMS performance (Cools, De Martelaer, Samaey, & Andries, 2011). Intriguingly, however, while parents' direct engagement with their children's PA was positively related with FMS performance in boys, girls' performance was negatively affected by their parents' enquiries about their performance with the preschool teacher. This suggests that what counts as 'socially supportive' may not be the same for all children. More generally, however, these findings show that leading a physically active lifestyle and receiving social support positively affect children's motor development.

Motor skills are essential for successful interpersonal coordination and synchronisation with external stimuli. The wide range of factors mentioned in this section suggests a complex web of relations between motor skills and other individual, social and environmental factors. The following section will take this investigation one step further and present the literature on children's rhythmic movement skills and their developing abilities to move in synchrony with external rhythms.

4.1.2 The development of synchronisation skills

As children dance, run, do sports and play games, they often move their bodies in a rhythmical way, often together with others. Earlier in Chapter 2, we observed the

importance of interpersonal coordination between infants and carers. Similarly, in early childhood, synchronised timing of movements, for example in PA, may yield important social effects. It enables reaching mutual outcomes and can therefore foster collaboration, joint action and social bonds among participants (Sebanz et al., 2006). How, then, do skills for synchronisation develop in early childhood years? This section will tackle with this question, with special emphasis on potential factors that influence children's synchronisation performances. The information gathered from this section will importantly inform the way the synchrony manipulation is implemented in the second study of this thesis.

As has been covered in Chapter 2, research has shown that before early childhood, children can produce rhythmic movements when they hear rhythmical beats (Zentner & Eerola, 2010) and align the start and end time of their movement with another child (Endedijk et al., 2015), but they cannot yet actively synchronise their movements with external rhythms (Endedijk et al., 2015; Provasi & Bobin-Bègue, 2003; Zentner & Eerola, 2010). During the early childhood period, however, there is considerable improvement in children's proficiency to synchronise with a beat (e.g., Christianson, 1938; Malbrán, 2002 ;van Noorden & De Bruyn, 2009). One early study, where children were asked to tap in time to clicks on a rhythm machine, illustrates the improvement in children's synchronisation accuracy with increasing age; while only 25% of the 3-year-olds could tap in time with the rhythmic clicks, this proportion increased to 44% in 4-year-olds and 75% in 5-year-olds (Williams, Sievers & Hattwick, 1933). In fact, 5-year-olds no longer needed instructions and started tapping in synchrony with the clicks spontaneously. In another exploratory study, children were not instructed to move in any particular way, but were simply asked to respond to the musical beats with their body movements (Sims, 1985). It was found that while 3- and

4-year-olds synchronised their body movements with the musical beats only around 15% of the time, 5-year-olds did so 46% of the time. Similar results were obtained in another exploratory study with 3- to 6-year-old children (Moog, 1976). In addition, Moog (1976) observed that children of all ages more readily started to dance when a partner accompanied them than when alone, be it another person or a doll/teddy bear. One drawback of these early studies, however, is the lack of statistical tests, making it hard to interpret the significance of the reported results. Nevertheless, the striking difference in percentages across age groups supports the view that skills involved in synchronisation improve between 3 and 6 years of age.

It is important to identify precisely which skills develop. Several researchers have systematically investigated and identified components of children's rhythmic ability that are thought to be important in synchronisation. It seems that 3-year-olds have much to improve whilst drumming along the beats of a musical piece: the timing of their drumming only roughly corresponds to the musical beats, their onset time is not perfectly synchronised with the beats and they find it particularly challenging to sustain synchrony throughout the duration of a piece (Malbrán, 2000). Moog (1976) reported that the latter factor improved with age, as 4-year-olds were better than 3-year-olds at sustaining synchrony for a longer amount of time.

Another important factor in synchronisation with an external rhythm is the ability to perceive external rhythms and to apply them to one's own behaviours (Phillips-Silver et al., 2010). We observed in Chapter 2 that the ability to perceive and distinguish between external rhythms is well in place by the end of infancy. Still, development in this area continues in the early childhood years as children become capable of distinguishing between more complex stimuli. It has been shown, for example, that while dancing along to music tracks during which rhythms varied, 3- and 4-year-olds

more successfully adapted their body movements to the changing rhythms than did 2- and 3-year-olds (Eerola & Luck, 2006).

These findings indicate that precision in perceiving rhythms and moving synchronously improves during early childhood years. Yet, the ability to perceive rhythms does not necessarily translate into the ability to reproduce them accurately in one's own behaviour. This has been revealed by studies in which children were asked to reproduce previously heard rhythms in singing, clapping or marching activities. Although 3- and 4-year-old children could re-produce the rhythms that they had previously heard in their singing, they could not do so as proficiently when asked to clap or march in those rhythms (Rainbow, 1981). This suggests that the modality in which children are asked to synchronise can have a huge impact on their performances. It is possible that the motor demands associated with moving body parts while keeping in time with an external beat hamper the children's rhythmic performance. Yet, significant development is observed in this area as well from age 5 to 8, as children become better able to re-produce previously heard rhythms in their clapping or stepping movements (Schleuter & Schleuter, 1989). In addition to the modality of performance, a number of other factors can be influential in children's abilities to synchronise with external stimuli. In the following subsections, these factors will be reviewed in detail. More specifically, two clusters of factors will be covered: (i) movement type; and (ii) the rhythms' closeness to the child's own spontaneous motor tempo (SMT) and the speed of the rhythms.

4.1.2.1 Effect of movement type on synchronisation

Studies assessing the development of children's synchronisation abilities have looked at a wide range of movements. Across various study designs, children have been asked to clap their hands, tap their hands on their laps, tap their fingers or hands on

tables, march, drum or sing. Given the crucial role of motor capacities in synchronisation, it is no surprise that the type of movement performed appears to affect how well children synchronise.

Several studies have investigated children's synchronisation proficiency while performing manual movements as compared with lower body movements. The general conclusion is that upper body movement synchrony is easier to perform than lower body movement synchrony and that improvement is observed in both movement types with age (e.g., Loong, 1999; Rose, 2014). Whereas clapping hands in time to a beat is something that children can perform successfully from 3 years of age onwards, more complicated tasks are difficult even for 5-year-olds (Frega, 1979). Tasks may become more complicated if they involve lower body movements (i.e., marching, pedalling); if they involve multiple body parts (e.g., clapping hands and walking at the same time); or if they require integrating information from multiple modalities (e.g., listening, performing and writing at the same time). Frega (1979) found that the percentage of children who could synchronise their walking rhythm to an external beat rose by 12% from 3 to 5 years of age. Using an instrument to keep time with the beats led to an even higher increase, of 26%, across the two age groups. Further, at 5 years, children's lower body synchronisation extended to other movement types, such as tapping with their thighs. Despite this age-related improvement in lower body synchronisation, however, the upper-lower distinction is maintained all the way until 8 years of age - children were better at synchronising while patting with their hands or clapping than while doing pedal stepping or walking (Rose, Fisher & Shewmaker, 2012; Schleuter & Schlauter, 1989).

So, what is it that causes this discrepancy between abilities in upper and lower body movement synchrony? One study reported that synchrony performance interacts

with participant sex (i.e., girls performed better than boys), and with speed (i.e., better performance was observed at faster tempi; Rose, Fisher & Shewmaker, 2012). More details on the speed effect will be presented in the next section. The sex effect, however, may be related to physical development, which is known to occur more rapidly in girls than in boys. Further, the finding that children can more easily synchronise by singing than by performing any type of movement supports the physical development hypothesis (Rainbow, 1981). In addition to the physical demands, there may be cognitive demands associated with synchronising body movements. For instance, compared to inferring the rhythms from a musical piece, receiving the rhythms as verbal instructions on which body part to move (e.g., the instructor uttering “Clap-march” in a rhythmical manner) improved success in a complicated task that involved moving multiple body parts one after the other (Jordan, 1994). Yet, responsiveness to the instructions can be variable depending on the particularities of each case. One study showed that receiving instructions had a more positive impact on synchrony performance in 5-year-olds than in 4-year-olds (Frega, 1979) and in clapping movement than in stepping (Schleuter & Schlauter, 1989). More research is needed to clarify how physical and cognitive demands influence children’s synchronisation success.

Based on the existing literature, it can be concluded that young children find it easier to synchronise when the movements involve a single body part and/or upper body parts. Still another influential factor for successful synchronisation is the tempo of the rhythms, with which children are supposed to synchronise. In what follows, the effect of different tempi on synchronisation will be examined.

4.1.2.2 Effects of Spontaneous Motor Tempo and speed on synchronisation

The concept of spontaneous motor tempo (SMT) and how it is assessed were described in detail in Chapter 2 (see Section 2.1.3). To recap briefly, SMT refers to the most comfortable tempo at which an individual can produce rhythmical movements. Studies done with various age groups have shown that SMT slows down during the lifespan. This means that younger people spontaneously produce more rapid rhythmical movements and this speed progressively decreases with age. Considering the early childhood period, the average SMT between 2.5 and 5 years of age is 300-400ms ISI (Drake, Jones, & Baruch, 2000; Provasi & Bobin-Bègue, 2003) and SMT within this age range is considered to be stable (Provasi & Bobin-Bègue, 2003). An external rhythm's closeness to one's SMT can influence synchronisation success. SMT can therefore be viewed as a safe zone within which children, regardless of their age, can more readily produce rhythmical movements proficiently. Synchronisation proficiency in cases of deviation from one's SMT are therefore insightful.

Studies investigating the tapping and drumming actions of children have shown that 2.5 years old could synchronise just as competently as 4.5-year-olds when the external rhythm was within their SMT range (Provasi & Bobin-Bègue, 2003; Kirschner & Tomasello, 2009). This indicates that there may be little age-wise variation in synchronisation ability as long as the children are given rhythms that are within their SMT range. Pronounced age-related effects can be observed, however, when children try to synchronise with beats that are beyond their range. In one study, children were asked to synchronise their tapping rhythm to 400ms, 600ms and 800ms stimuli (Provasi & Bobin-Bègue, 2003). It was found that 4-year-olds were better than 2.5-year-olds in synchronising with the 600ms and 800ms stimuli, that is, with the stimuli that were beyond their SMT range. Another interesting finding was that boys performed better

than girls. Moreover, for both genders, a significant learning effect over the course of the experiment session was found (Provasi & Bobin-Bègue, 2003). Follow-up research assessing the possible relative importance of differential physical development and prior experience is needed to understand the source of these differences.

The literature clearly shows that older children are better than younger children at synchronising beyond their SMT. Yet, their abilities have limits. One study showed that despite synchronising with a broader range of tempi than 3-year-olds, 5-year-old children still had difficulties while synchronising to beats that were out of their SMT range (Bobin-Bègue, Droit-Volet, & Provasi, 2014). Although the children adapted to a speedier rhythm by increasing their tapping tempo, they found it particularly challenging to slow down again when the external rhythms slowed down (Bobin-Bègue et al., 2014). In fact, virtually all of the literature on children's synchronisation abilities asserts that when it comes to speed, faster is better. At 3 to 4 years of age, children can synchronise better when tapping to faster metronome beats than slower ones (Fraisse, Pichot & Clairouin, 1969). With children aged 5 and above, synchronising to slower tempi is maintainable, though still harder than synchronising to fast tempi (Zimmerman, 2011). This trend seems to continue into middle childhood, as evidenced by better synchronisation performances of 5- to 8-year-old children with faster tempi (Walters, 1983). Overall, the literature shows how important SMT compatibility and speed are in children's synchronisation performances.

4.1.3 Conclusion

This section reviewed research on children's motor movements and synchronisation skills. One clear conclusion is that there is rapid and continuous development during the early childhood years. Children's understanding of complex rhythms, ability to synchronise flexibly beyond their SMT range and ability to

synchronise using various body parts all improve considerably. The findings also reveal the conditions under which children can proficiently synchronise with external beats, thereby informing the design of the second study of this thesis. As mentioned earlier in Chapter 1, Study 2 will investigate the question whether actively performing synchrony with peers facilitates pro-social behaviours. Following insights from the literature reviewed in section 4.1, the movements that the children actively perform will be basic movements that involve a single body part at a time (i.e., clapping and tapping with hands). Given the high variation in balancing skills, for example, as children march to a rhythm, the children in the current study will perform the movements while seated. Moreover, the external rhythms will be chosen according to the average SMT of this age group and it will be ensured that the rhythms do not extend beyond the children's SMT range.

4.2 PRO-SOCIALITY IN EARLY CHILDHOOD

Early childhood years are marked by an unprecedented expansion of the young child's social sphere. Children start to interact more and more with people outside of the family, including teachers and peers. Socialising within peer groups becomes more common, providing novel contexts and opportunities to relate to others, while at the same time bringing new challenges due to increased socio-cognitive demands of this new social context. Section 4.2.1 will examine some of the most important socio-cognitive skills that the children develop during this period, which relate to the development of pro-sociality. Namely, understanding others' emotional states, managing own emotions, understanding others' beliefs and thoughts and perspective taking will be covered. Taking a close look at the development in children's socio-cognitive skills, the review in Section 4.2.1 will enable a thorough understanding of the

children's peer interactions and pro-social behaviours, which will be covered in Section 4.2.2.

Specifically, Section 4.2.2 will discuss the role of peer-play in children's social life and some important antecedents and consequences of peer-play, as well as provide an overview of the most prominent types of pro-social behaviours that the children perform during early childhood (i.e., helping, sharing and comforting). This literature on children's pro-social skills and behaviours in early childhood will provide the necessary background information on children's social development and guide the measures of social bonding and pro-sociality that will be used in Study 2.

4.2.1 The development of socio-cognitive skills

4.2.1.1 Emotional development

Interacting with peers comes with emotional demands. Unlike in their interactions with adults, who carefully attend to the children for consolation and assistance, in peer-to-peer relationships, children are no longer in a predominantly recipient position. Instead, they are in a position to work actively to maintain good relations with another child who has similar emotional competence and empathy skills (Denham, 2007). Thus, the peer context provides unique opportunities for emotional development. The socio-cognitive similarities among peers makes it easier for them to understand the emotional lives of each other compared to understanding parents or children of other ages (Dunn & Hughes, 1998; Shantz, 1983). Further, the norms that the children create within their peer groups guide them on the appropriate ways of expressing their emotions (Corsaro & Eder, 1990). Avoiding and/or resolving arguments with peers requires children to be able to identify and reason about others' emotional states, to express their own emotions in socially appropriate ways and to regulate intense and negative emotions. In turn,

improvements in these skills are linked to other aspects of social and cognitive development, including pro-sociality.

Sensitivity to changes in other people's emotional states is a crucial part of peer interactions, which improves significantly between ages 3 and 6. Research examining the identification of emotions has frequently used a method where children were asked to name or interpret the emotional expressions of puppets, facial images or characters whose story was presented to the children in a vignette. From 3.5 years of age, children can name others' emotional states (Denham & Couchoud, 1990) and significant improvements in emotional state identification is observed until the age of 5-6 (Denham et al., 2013; Denham & Couchoud, 1990a; Widen & Russell, 2003). Young children are better at identifying basic emotions such as happiness, sadness and anger than more complex emotions such as fear, surprise or disgust (Denham & Couchoud, 1990a; Widen & Russell, 2003). When it comes to interpreting others' emotional states, reasoning about potential events/causes that may lead to one's own current emotional state is easier for 4- and 5-year-olds than reasoning about the consequences of others' emotional states (i.e., what someone in a particular emotional state is likely to do next; Russell, 1990). Supporting the importance of emotion understanding in interpersonal relationships, such reasoning about the causes and consequences of emotional states is facilitated when the children speculate about their own emotions and emotions of others who are closer to them (i.e., mothers versus classmates; Dunn & Hughes, 1998). Moreover, at 5 years of age, children start taking into consideration the individual positions and desires of others while identifying how they might be affected by the same event in different ways (Gove & Keating, 1979). For instance, children correctly reason that an objectively identical game outcome may cause one person -the winner- to be happy while making the other one -the loser- sad (Gove & Keating, 1979).

Children's understanding of emotions becomes even finer tuned towards the end of early childhood period, as they start to reliably distinguish between different negative emotions, such as sadness and anger (Graham, Doubleday, & Guarino, 1984; Levine, 1995) and to attribute causes to socially complex emotions such as anger and pity (Green, 1977; Weiner, Graham, Stern, & Lawson, 1982).

One challenge brought about by peer-to-peer interactions is emotional self-regulation. Expressing negative and intense emotions is likely to result in conflicts with friends, who may not be proficient in regulating their own emotions either. By the age of 4-5, children can already express basic emotions such as happiness, sadness, anger, fear, surprise and interest quite vividly. They also start to express more complex emotions such as guilt, pride and contempt (Denham et al., 2004). With the newly-acquired ability to express such a wide range of emotions, choosing socially appropriate ways of emotion expression becomes ever more important for social interactions. This may require downgrading the overt expression of negative emotions such as anger and fear (Denham, 2007). It may also require children to consider how others might be feeling (e.g., upset, embarrassed etc.) before they express their positive emotions such as happiness and pride. Yet, although children can well identify and reason about other people's emotions by the age of 5, they do not necessarily share others' feelings (e.g., feel sorry upon seeing someone get upset), until the age of 7-8 (Strayer, 1993). This may cause problems among friends, especially when one child is oblivious to the distress of another (Hartup, Laursen, Stewart, & Eastenson, 1988). For this and other reasons, conflict among friends is not rare in 4-year-old children's naturalistic play and occurs just as frequently as it occurs among neutral associates (Harput et al., 1988). Importantly, however, children are more likely to resolve conflicts with friends, suggesting that knowing each other closely may ease emotion regulation and empathy

(Harput et al., 1988). Similarly, observations of 3- to 6-year-old children within their family contexts have revealed that children can understand the complex reasons of their mothers', fathers' or siblings' emotions, express verbally how they feel about others' actions and explain why they feel that way, as well as start to give others advice on how to feel better and/or regulate their emotions (Bretherton et al., 1986). Anecdotally, a 6-year-old child's comforting response to his/her mother's upset due to missing a flight was reported as: "I don't think you should think about it. If you don't think about it, it'll get better" (Bretherton et al., 1986. p. 540).

These developments in the emotional domain are related to other aspects of social and cognitive development in a number of ways. For instance, it has been shown that children's understanding about others' emotions is correlated with role-taking skills (Green, 1977) and executive control skills (i.e., the ability to inhibit urges due to contextual demands (Denham et al., 2013). These advancements in socio-cognitive processing are particularly important for facilitating social interactions. Research suggests that children's social competence and having friends are related to their abilities to identify others' emotions (Denham et al., 2013), regulate negative emotions (Eisenberg et al., 1993; Murphy, Shepard, Eisenberg, Fabes, & Guthrie, 1999; Walden, Lemerise & Smith, 1999) and express their own emotions proficiently (Eisenberg et al., 1997; Roberts & Strayer, 1996). Thus, throughout early childhood, children start displaying behaviours that are less egocentric and, instead, more guided by sympathetic concern for others in a reciprocal and altruistic manner (Hoffman, 1975). To explore further the socio-cognitive skills that influence social interactions and pro-sociality in early childhood, the following section will turn to the children's developing abilities to take the perspective of another.

4.2.1.2 Perspective taking and Theory of Mind development

Being able to put oneself in others' shoes (i.e., perspective taking) is highly important for social interactions. The developmental literature points to three types of perspective taking, namely visual, emotional and social-cognitive (Underwood & Moore, 1982). Visual perspective taking refers to being able to guess how objects are viewed from another person's spatial position, while emotional perspective taking refers to being able to understand others' emotions and to empathise with them. The main focus of this section, however, will be on social-cognitive perspective taking, which refers to the ability to understand others' mental states (i.e., others' desires and beliefs). Also called Theory of Mind (ToM), this ability has been considered as one of the most important milestones in social and cognitive development that marks social interactions in early childhood (Sodian & Kristen, 2010).

As seen in Chapter 2, even young infants are able to infer other people's goals and discriminate between actions done purposefully and accidentally. Thus, it can be said that a preliminary understanding of others' desires and intentions is in place by toddlerhood. However, a full-blown ToM understanding requires understanding others' belief states and how these belief states may influence subsequent behaviours. The understanding that people may have beliefs that are not in line with the reality and that, if that is the case, they would act based on their false beliefs, emerges after toddlerhood (Lewis & Carpendale, 2004). To assess children's understanding of others' false beliefs, two tasks have been particularly widely used. In one task the child indicates where they think a character, Maxi, would look for an object whose place was changed from box A to box B when Maxi had left the room (Wimmer & Perner, 1983). Children who have an understanding that other people may have false beliefs would respond by pointing to box A (i.e., the box where Maxi had observed the object being put), and not to box B,

where the children know the object to be. In the second commonly used false belief task, children are shown surprising contents in a standard container (e.g., pencils in a candy box) and are asked to (i) state what they initially thought was in the box and (ii) guess what a friend of theirs would think is in the box (Gopnik & Astington, 1988; Hogrefe, Wimmer, & Perner, 1986). If the children can compare their own previous belief states to their current belief states and if they can acknowledge others' false belief states, then they should reply by saying candy instead of pencil.

A vast number of studies conducted in the past few decades using versions of these traditional false belief tasks have repeatedly shown that children can pass these false belief tasks only after the age of 4 (see Lewis & Carpendale, 2004 for a review). It appears, then, that children younger than 4 cannot put themselves in another person's shoes and predict how others would think or behave on their own terms; instead, children's current belief states seem to be imposed on others too. Some researchers have argued that the traditional false belief tasks were so high in processing demands that they did not reveal the ToM abilities of pre-verbal children (Baillargeon et al., 2010). Utilising a looking time methodology, these researchers found that infants as young as 13 months old looked longer when Maxi did not act in line with his false belief (i.e., when he looked for the toy in box B rather than in box A (Onishi & Baillargeon, 2005; Surian et al., 2007). These findings have been interpreted as demonstrating the existence of ToM in infants long before the age of 4 (Baillargeon et al., 2010). However, leaner interpretations of these findings suggest that what is shown in those infant studies is a preliminary, implicit understanding of others' perceptual perspectives and goal-directed actions, and not necessarily the understanding that others may have different belief states than one's own or reality, or that the infants "theorise" about others' mental states (e.g., Butterfill & Apperly, 2013; Perner & Roessler, 2012; Sodian & Kristen, 2010). As

this debate goes well beyond the scope of the current thesis, we will not discuss it further (but see Rakoczy, 2012 for a thorough review). The dramatic shift in false belief task performance around age 4, and potentially later in non-Western cultures (e.g. Samoa, see Mayer & Trauble, 2012) is nevertheless real, indicating, at the very least, the later emergence in early childhood of a more elaborate understanding of others' mental states. ToM ability does not seem to be an all-or-nothing phenomenon thereafter; it continues to develop and influence children's social development further throughout middle childhood (Hughes & Leekam, 2004; LeMare & Rubin, 1987).

Developing abilities to understand others' minds and mental states are reflected in the ways in which children interact with others. For instance, a dramatic increase is observed in early childhood years in the amount and extent to which children engage in joint pretend play (Hughes & Dunn, 1997) and perform tricks, jokes and subtle deceptions (Hughes & Leekam, 2004). Studies directly correlating children's ToM ability to their social interactions corroborate this. Between 3 and 6 years of age, children's ability to take the social-cognitive perspective of others predicts various aspects of social interactions, including cooperative play with peers (Lalonde & Chandler, 1995; Tan-Niam, Wood, & O'malley, 1998), sharing and helping behaviours (Underwood & Moore, 1982; Zahn-Waxler et al., 1977), referrals to playmates during naturalistic joint play sessions (Astington & Jenkins, 1995), as well as teachers' assessments of the children's social skills (Watson, Nixon, Wilson, & Capage, 1999). Further, better performance in false belief tasks was found to predict greater likelihood of being chosen as friends and of being included in peer groups (Badenes, Estevan, & Bacete, 2000; Slaughter, Dennis, & Pritchard, 2002). Similarly, within the family, it was found that children who scored better at social-cognitive perspective taking tasks were also more attentive to the emotions and thoughts of their younger siblings (Howe &

Ross, 1990). These findings show clearly that children's false belief task performance is a good indicator of their social competency in their real-life interactions.

The ability to take the perspective of another person, be it visual, emotional or social-cognitive, adds a whole new dimension to social interactions. With emerging abilities in visual perspective taking at 3 years, children become able to see the world from another person's point of view (e.g., Masangkay et al., 1974; Newcombe & Huttenlocher, 1992). As we have seen in Section 4.2.1.1, emotional perspective-taking develops considerably between 4 and 6 years of age, as children become better able to identify others' emotions and to empathise with them (Denham, 2007). Around the same time, social-cognitive perspective taking abilities also develop, whereby children come to understand the thoughts and beliefs of others as being different from those of their own (Lewis & Carpendale, 2004).

The socio-cognitive skills covered in this section, namely emotion understanding and perspective taking skills, importantly contribute to the development of social competence, peer play and pro-social behaviour, which will be covered in Section 4.2.2. Skills that influence interactions with peers are particularly important at this age group, as there is a significant shift from having teachers and parents as main interaction partners to interacting within peer groups. The following section will elaborate on how this shift takes place and the variety of pro-social behaviours displayed by this age group.

4.2.2 The development of peer-play and pro-social behaviour

4.2.2.1 Peer-play in early childhood

Peer-play characterises social interactions in the early childhood years.

Advancements in children's understanding of others' emotions and mental states plays a

crucial role in fostering interactions with peers. Further, around these ages, children are able to communicate their own thoughts, desires and feelings more efficiently.

Developments in these socio-cognitive domains enable the children to engage in mutual conversations, resolve conflicts more effectively, interact cooperatively with their peers and construct long-lasting social bonds. Being in a social environment, such as nursery schools and primary schools, also increases the time spent with peers, facilitating the opportunities to interact with peers in a way unprecedented in the children's lives (Hay, Payne, & Chadwick, 2004).

Comparisons with earlier forms of peer interactions are informative in understanding the factors that truly distinguish peer-play in early childhood. Preliminary forms of contingent interactions with peers can be observed as early as in the second half of the first year, as infants touch each other (Hay, Nash, & Pedersen, 1981), direct each other's attention to toys (Eckerman, Davis, & Didow, 1989) and engage in reciprocal imitation games (Eckerman & Peterman, 2015). During toddlerhood, children even develop preferences to spend time with certain others, which can be perceived as precursors of friendship (Howes & Phillipsen, 1992). Numerous observations have been made on toddlers' interactions with peers in day-care centres in different parts of the world, such as Japan, Norway, Italy, France and North America (see Løkken, 2000 for a review). These observations have shown an increasing amount of joint play between 1 and 3 years of age, which is characterised by the children imitating each other, taking turns during play and establishing eye contact and mutual smiles (Løkken, 2000).

Despite evidence for preliminary peer interactions in infancy and toddlerhood, however, a major transition takes place in early childhood years as children move on from one-to-one relationships to interacting in peer groups (Hay et al., 2004).

Peer groups are unique in terms of the social development opportunities they offer. Unlike in interactions with adults, negative emotions are less hidden among peers, which enables observation of others' emotional states more directly (Grusec, Davidov, & Lundell, 2002). Further, in the absence of an adult to assist or console children at times of conflict, group dynamics emerge, including coalitions and hierarchies, and children strive to resolve conflicts themselves (Grusec et al., 2002). Existing social-cognitive skills are used to deal with the complexities children encounter within the context of peer interactions. Children utilise their advanced language and communication skills to converse with their peers in various forms including telling each other stories, seeking information, negotiating or arguing with each other (Kuentay, 2001). Emotion regulation and ToM abilities (i.e., understanding of others' desires and beliefs), also has a marked impact on the way children interact with their peers. Differently from the arguments among peers in younger ages, conflicts in early childhood stem from differences in opinions rather than tussles about objects or toys (Chen, Fein & Tam, 2001). Children learn to balance their cooperative and competitive motives (LaFreniere, 1996) and to inhibit aggressive behaviours as they interact with other children (Balaraman, 2003; McDowell, O'Neil & Parke, 2000).

Cross-cultural evidence shows that a specific type of play called pretend play becomes prevalent around the age of 4 (Farver, Kim & Lee, 1995). In pretend play, children assign imaginary roles to themselves (e.g., "I am the mother and you are the father"), and imaginary affordances to objects (e.g., "This banana is our telephone"). This type of play involves sharing intentions and attention, commitment to mutually constructed rules and manifestation of ToM abilities at various levels (Rakoczy, 2008). Pretend play also provides an environment where children can freely practice their pro-social skills, as evident by extensive helping behaviour displayed in young children's

pretend play with peers (Bar-Tal, Raviv, & Goldberg, 1982). Longitudinal studies have also shown that social bonds formed during early pretend play can predict the amount and quality of friendships in later years of childhood (Dunn, Cutting & Fisher, 2002). This indicates how early-developing social and cognitive skills are important for the formation of later social bonds.

Certain characteristics of children's peer play in early childhood are also worth mentioning. Firstly, a strong gender segregation is observed, whereby girls play with girls and boys with boys (Hay et al., 2004). Notably, this trend in choosing same-sex peers as play partners holds across cultures (Hold-Cavell, Attili, & Schleidt, 1986) and continues all throughout middle childhood years (Hay et al., 2004). Moreover, the increase in group-level interactions brings about new dynamics including social status and peer acceptance/rejection. Early peer rejection can be maintained for years and impede a child's development in the long term (Coie & Dodge, 1983), and hence, vast amount of literature has focussed on the factors associated with peer rejection. Emerging dominance hierarchies can influence acceptance/rejection within the peer group with popular children more likely to be chosen as friends (Sebanc, Pierce, Cheatham, & Gunnar, 2003; Strayer & Strayer, 1976). Reports from both classmates and teachers of 3- to 6-year-olds showed that the children who were rejected from peer groups were perceived by their peers as displaying more aggressive behaviour and less pro-social behaviour (Denham, McKinley, Couchoud, & Holt, 1990) and as being more disruptive and easily angered and less cooperative (Coie, Dodge & Kupersmidt, 1990). Children like and play more with those children who act pro-socially, who can control their negative emotions (McDowell et al., 2000) and who have a good understanding of social situations and others' intentions (Yoon, Hughes, Cavell & Thompson, 2002; McElwain & Volling, 2002).

Engaging in peer-play during early childhood is important for practising a wide range of social skills, with potential long-term impact on social and cognitive development. One study found that competency in peer-play during toddlerhood predicted social competence and pro-social behaviour at preschool ages until 9 years of age (Howes & Phillipsen, 1992). In another longitudinal study, having friends and making new friends during the first year of school was found to be related with more positive perception of school, better school performance and less avoidant behaviour by the end of the school year (Ladd, 1990). It appears, then, that engaging pro-socially with peers plays an important role in many aspects of the young child's life. The following section will specifically focus on capacities for pro-social behaviour and how they are manifested in line with the developing socio-cognitive skills reviewed so far.

4.2.2.2 Pro-social behaviours in early childhood

Early childhood is an exciting period to observe some striking quantitative and qualitative changes that take place in children's pro-social behaviours. Importantly, the pace and nature of development are not uniform, but are influenced in complex ways by the social environment. A large body of observational and experimental studies suggests three types of pro-social behaviour: helping, sharing and comforting (see Dunfield, 2014 for a review). This categorisation is useful as it allows identification of the different motives and skills underlying each type of behaviour. At the same time, however, it is often hard to draw clear lines between different types of behaviour in real-life settings (Martin, Alia; Olson, 2015; Tunçgenç, 2016). For the purposes of this section, a general picture of the pro-social behaviours displayed in early childhood years is sufficient. Hence, the three proposed types will not be investigated separately. Where relevant, however, links to particular socio-cognitive skills for each type of pro-social

behaviour will be made and the differences in the occurrence of different types of pro-social behaviours will be highlighted.

Regarding the amount of pro-social behaviours observed, it has been long suggested that young children help, share, empathise and cooperate more with their peers compared to toddlers (Bar-Tal et al., 1982; Dunfield, 2010; Holmgren, Nancy, & Fabes, 1998). Yet, this incremental change is not observed the same way in all pro-social behaviours. Naturalistic observations of children's interactions with peers established that, compared to toddlers, 4- to 6-year-old children displayed more acts of helping and comforting but fewer acts of giving/sharing (Bar-Tal, et al., 1982). Other observational studies also confirmed that among 3- to 7-year-old children, helping (Radke-Yarrow et al., 1976) and comforting acts (Stockdale, Hegland, & Chiaromonte, 1989) occurred much more frequently than sharing acts. Moreover, the children's sharing and comforting behaviours correlated with each other, while helping behaviour appeared to be distinct (Radke-Yarrow et al., 1976). Arguably, the developing sense of self and property, combined with the different levels of certainty and ease in assessing the costs to self (e.g., the cost of completely losing own resources in a sharing scenario or the cost of feeling distressed while giving emotional support) contribute to the observed differences between the frequencies of helping, sharing and comforting acts (Bar-Tal, et al., 1982; Stockdale et al., 1989). It is also noteworthy that no age or sex differences have been found in these studies and that most of the observed pro-social behaviours have taken place as part of real-life interactions with peers rather than in game settings.

Social pressures involved in real-life settings seem to importantly guide children's pro-social behaviour at this age. Due to confusion about whether it is their responsibility to take action, young children can be reluctant to interfere when they see a peer in

distress, even if they acknowledge that the situation requires attention (Caplan & Hay, 1989; Radke-Yarrow et al., 1976). Adults play a pivotal role here in facilitating pro-social behaviour, by providing positive feedback (Staub, 1970), serving as a role model or merely increasing the child's confidence (Staub, 1971). Pro-social behaviours are indeed very much encouraged by adults in both school and family contexts. In schools, teachers give more positive feedback to children who help, share with or comfort their peers who are in need (Eisenberg, Cameron, Tryon, & Dodez, 1981). Home-based observations of Kenyan children showed that, across a number of different social contexts, 4- to 6-year-old children displayed most pro-social behaviours within the context of chores, suggesting the importance of increasing social demands and of being appreciated by adults (de Guzman, Edwards, & Carlo, 2005). Another study comparing 4.5-year-old white and black children's helping and comforting behaviours in an experimental setting found that black boys and white girls acted significantly more pro-socially than their black female and white male peers (Richman, Berry, Bittle, & Himan, 1988). All these studies demonstrate the many ways in which social-cultural expectations may influence children's pro-social behaviours.

Experimental studies also show how children take into account complex social dynamics in their pro-social behaviour (see Martin & Olson, 2015 for review). For instance, 5-year-olds shared more generously with their peers when the recipient could obtain information about their decisions (Engelmann, Herrmann, & Tomasello, 2012; Leimgruber, Shaw, Santos, & Olson, 2012) and when a teacher was present in the room, but not when an unfamiliar observer was present (Barton, Olszewski, & Madsen, 1979). Children also start to be more selective in their partner choices; they prefer to give more to same-sex peers (Birch & Billman, 1986; Hay & Cook, 2007); to individuals whom they like, e.g., friends rather than non-friends or acquaintances (Buhrmester, Goldfarb,

& Cantrell, 1992; Moore, 2009; Paulus et al., 2014); to individuals who are clearly in a more needy situation (Li, Spitzer, & Olson, 2014; Paulus, 2014) and to those whom they know to be nice rather than mean (Kenward & Dahl, 2011). Sharing with a nicer individual seems to be in line with children's moral construal of pro-social behaviours being good and anti-social behaviours being naughty (Hay & Cook, 2007). Another consideration that emerges is future reciprocity opportunities. When sharing resources, 3- to 4-year-old children take into consideration whether their partner had previously shared their resources with them (Birch & Billman, 1986; Warneken, Lohse, Melis, & Tomasello, 2011; Warneken & Tomasello, 2013; but see House, Henrich, Sarnecka, & Silk, 2013 for evidence of development only at 5 years of age).

The social, cognitive and emotional skills that the children develop in the first years of life contribute greatly to these qualitative and quantitative changes in pro-social behaviours. Assessments of the children's facial expressions (Eisenberg, McCreath, & Ahn, 1988) and heart rates (Holmgren et al., 1998) showed that children who helped and shared with their peers more also had better emotion knowledge (Denham et al., 2012) and expressed more sadness and concern while watching an unrelated, unpleasant video clip (Eisenberg et al., 1988; Holmgren et al., 1998). Longitudinal studies further revealed that early distress understanding, delay-of-gratification ability (Paulus et al., 2014) and mothers' talk about others' emotions and mental states (Drummond et al., 2014) predicted sharing and helping behaviour in early childhood. Moreover, an improvement towards empathic, need-oriented reasoning about others' needy situations seems to emerge between ages 4.5 and 8 (Eisenberg, Lennon, & Roth, 1983).

Another line of research has used ultimatum games to investigate children's ability to make cost-benefit analyses whilst performing potentially pro-social behaviours. In this simplified version of an ultimatum game, one child, the Proposer, is

given two options to choose from, which s/he then offers to the other child, the Responder. The options determine how resources will be distributed between the two children, e.g., 5(Proposer)/5(Responder). If the Responder accepts the offer, both children get what was offered, whereas if the Responder rejects the offer, nobody gets anything. When 5-year-old children play this game with a peer, they show a similar tendency to that observed in older children and adults in that they reject unfair offers when an equal share was possible (Wittig, Jensen, & Tomasello, 2013).

However, the children do not seem to be able to reflect their behaviour onto how others in the Responder status may behave. When the children are in the Proposer position, they choose the option that maximises their relative gain by, for instance, choosing the 7(self)/0(other) offer over the 8(self)/1(other) offer (Sheskin, Bloom & Wynn, 2014). Interestingly, the children continue to do so even after seeing the Responder reject zero offers (e.g., 4[self]/0[other]), in previous trials (Wittig et al., 2013). Yet, some early studies suggest that this tendency to distribute resources selfishly attenuates after 6 years of age (Handlon & Gross, 1959; Ugurel-Semin, 1952). Altogether, these findings suggest that children's developing social, emotional and cognitive skills contribute to pro-sociality by facilitating both sympathy with others on an emotional level and accurate reasoning about the situation. Pro-social behaviour therefore continues to increase all throughout the early childhood years and beyond.

4.2.3 Conclusion

The literature reviewed in Section 4.2 has demonstrated that throughout early childhood, children's understanding of others' mental and emotional states improve, and they start to engage in more and varied types of pro-social behaviours. We have also seen that all these developing social-cognitive skills are reflected in the way children relate to their peers, who start to occupy an increasingly greater place in the

children's social interactions. For instance, development in perspective taking contributes to the increase in pretend play engagement (Rakoczy, 2008), while developing emotion skills help children inhibit aggressive emotions as they interact with peers (Balaraman, 2003). Perspective taking and emotion understanding abilities seem to play a crucial role in pro-social behaviour too. For example, children judge the neediness of others and selectively share with those who need more (Li, Spitzer, & Olson, 2014) and share according to what they think others would think of them if others found out how much they shared (Engelmann, Herrmann, & Tomasello, 2012).

These findings inform the hypotheses and design of the second study of this thesis on synchrony and pro-sociality. For example, children's interactions with peers rather than adults will be assessed in order to create a naturalistic play context that is prevalent in this age-group. Further, due to its early emergence and stability over the course of the early childhood years, helping behaviour will be chosen to assess pro-sociality. Finally, given the strong links found between children's emotion development and pro-sociality, a potential effect of emotion understanding will be explored on facilitating helping behaviour. The details of the design and the rationale behind the measures used will be elaborated further in Chapter 5. Before that, however, the next section will tie together the literatures on children's developing motor abilities and their pro-social skills. In particular, the social and cognitive correlates and consequences of performing motor movements and of synchronising with external rhythms will be discussed.

4.3 SOCIAL AND COGNITIVE CORRELATES OF MOTOR MOVEMENTS AND SYNCHRONISATION IN EARLY CHILDHOOD

The ability to synchronise with an external rhythm or with another individual is an important indication of children's developing motor skills, though synchronisation abilities are influenced by and can influence other aspects of development too.

Exploring these inter-relations can shed light on proposed broader functions of synchronised behaviour, including how they play a role in the formation and maintenance of social bonds. Moreover, they can inform us about the underlying mechanisms of social and cognitive disorders, many of which are accompanied by motor and coordination deficits (Piek, Hands, & Licari, 2012). In two separate subsections, this section will investigate the social and cognitive correlates of children's developing synchronisation abilities in early childhood.

4.3.1 Cognitive correlates of motor and synchronisation abilities

Synchronising with an external rhythm is a sophisticated cognitive task, which, among other demands, requires one to perceive and identify rhythms (see Chapter 2); divide attention between the external rhythmical stimuli and one's own behaviour; and control, and possibly inhibit in the case of young children, the timing of one's own actions in order to respond only when it is their turn. A common way of assessing how a particular set of skills is influential in the development of another set of skills is to look at deviations (i.e., comparing typically developing populations to populations with deficiencies in the set of skills of interest). Accordingly, in this review of the cognitive correlates of synchronisation abilities, special focus will be made on how certain developmental disorders can influence development in motor and cognitive domains simultaneously. It should be noted, however, that this review is not intended to be an exhaustive one on developmental disorders. Instead, the aim here is to gain insight into the links between cognitive and motor development from studies with both typically developing populations and children with certain disorders.

Considering the complementary, reciprocal nature of synchronisation with an external rhythm, it can be said that it is very similar to a communicative interaction

between individuals. Supporting this view, research conducted with typically developing populations has revealed a strong relationship between motor and language development. One study in particular has assessed the relationship between the synchronisation success of 3- to 4-year-old children and their language skills (Carr, White-Schwoch, Tierney, Strait, & Kraus, 2014). Children who were more successful at synchronising their drum beats to an external stimulus had better perceptual and cognitive language skills (i.e., phonological awareness, naming speed and auditory short-term memory); could discriminate melodies and rhythms better; and encoded speech more precisely. The nature of this correlation is further revealed by a study showing positive effects of a rhythm-based intervention programme on 4- and 5-year-old children's language development, with a special focus on phonological, rhyme and syllable awareness (Verney, 2013). This suggests that rhythmic abilities influence language development, rather than the other way around.

Some longitudinal studies also support this idea. It has been found that 5.5-year-old children's ability to reproduce rhythms (i.e., producing the exact same rhythmical stimuli that they just heard), predicted their reading abilities at 7.5 years of age (Dellatolas, Watier, Le Normand, Lubart, & Chevrie-Muller, 2009). Similarly, rhythmic synchronisation proficiency at 6 years of age was found to predict language skills such as reading ability, phonological awareness and naming speed in subsequent years up to the age of 10 (David, Wade-Woolley, Kirby, & Smithrim, 2007). Although these findings are not sufficient to identify the direction of any causation between synchronisation and language skills, they clearly indicate an association between the two, which evolutionary account have also alluded to (Masataka, 2007).

It has been proposed that the strong link between motor and language development stems from them relying on common basic auditory processing abilities

(Goswami, 2011). If that were the case, impairment in one of these domains would be expected to co-occur with impairment in the other domain. Indeed, studies done with children with specific language impairment (SLI) show that to be the case. SLI defines a condition where the acquisition and use of language is significantly impaired in the absence of any other primary disorders such as motor dysfunction, mental disorders, intellectual disabilities, global developmental delay or hearing or sensory impairment (American Speech-Language-Hearing Association, n.d.). Yet, it appears that language impairments do not take place in isolation; motor skills in early childhood years were found to predict expressive language success of children with SLI at 7 years of age (Paul & Fountain, 1999). Further, studies with children with SLI showed correlations between the children's fine motor skill development and their proficiency in expressive language (Iverson & Braddock, 2006), articulation (Vukovic, Vukovic & Stojanovic, 2010) and communication (Webster, Majnemer, Platt & Shevell, 2005). These observed links deepen our understanding of how cognitive and motor domains interact. Additionally, from an applied perspective, identifying motor skill deficiencies can be informative for early diagnosis of otherwise hard to detect social and cognitive disorders as well as for developing intervention programmes (Leonard & Hill, 2014).

There is considerable research on the links between learning disabilities (LD) and delay and/or incompetency in children's motor performances. LD, also called specific learning disabilities, is a developmental disorder marked by significant impairment in intellectual and social functioning (The British Psychological Society, 2000). Notably, however, motor impairment does not seem to be one of the defining features of this disorder. Yet, in motor tests involving coordination of multiple body parts or synchronous finger tapping, children with LD were found to perform worse than their peers who did not have LD (Grieshaber, 1987; Woodard & Suburg, 2001). Further,

several researchers investigating typically developing populations have reported a correlation between higher nonverbal IQ scores and more accurate tapping synchrony (Corriveau & Goswami, 2009a; McAuley et al., 2006) and singing synchrony (Verney, 2013) within the early childhood period. This may suggest that the motor behavioural problems observed in children with LD can be related to their intellectual impairment. Still, more research is needed to clarify the relative contributions of cognitive and social impairment associated with LD in their relation to motor behavioural problems.

Conversely, disorders typically identified in relation to disabilities in the motor domain also seem to correlate highly with impairments in cognitive skills. One such highly studied developmental disorder is called developmental coordination disorder (DCD). DCD is defined as “a neuromotor disability in which a child’s motor coordination difficulties significantly interfere with activities of daily living or academic achievement” (Zwicker, Missiuna, Harris, & Boyd, 2012, p. 573). With an estimated occurrence in about 5-6% of school-aged children and co-occurrence with other disorders such as attention deficit hyperactivity disorder (ADHD), SLI and LD, DCD has been often related to poorer academic performance, difficulties in social interactions and increased mental health issues, such as anxiety, depression and low self-esteem (Zwicker et al., 2012). Some of the empirical studies investigating these interactions have looked at children who have not been diagnosed with DCD, but scored sufficiently low on relevant developmental tests to suspect a probability of DCD. Accordingly, this group of children were called pDCD to indicate that they have high probability (hence, “p”) of developing DCD. One such study with 4-year-old children has shown that compared to their typically developing peers, children in pDCD group scored lower on verbal IQ tests and displayed poorer language skills as expressed in the areas of auditory comprehension and expressive communication (King-Dowling, Missiuna,

Rodriguez, Greenway, & Cairney, 2015). The deficits of DCD were apparent in a more naturalistic context as well, where, during a free-play session, 4- to 7-year-old children categorised into the pDCD group performed worse in activities that involved space and material management and used language less frequently in their interactions with peers (Kennedy-Behr, Rodger, & Mickan, 2013).

At least one study has compared the performances of pDCD children to children diagnosed with DCD and found similar results across the groups, suggesting that studying pDCD populations is indeed informative about DCD (Dewey, Kaplan, Crawford, & Wilson, 2002). In that study, Dewey and colleagues (2002) found that children with DCD and pDCD scored lower than their typically developing peers on cognitive tasks measuring attention and learning. Assessing further the relationship between cognitive functioning and DCD, Alloway (2007) found that visuo-spatial working memory and IQ were separately related to the learning skills of 5- to 11-year-old children with DCD. Impairment in visuo-spatial working memory is especially important as it plays a crucial role in motor performances, especially ones involving navigation, balance and coordination (Alloway, 2007). Importantly, one longitudinal study showed that delays in meeting the motor development milestones starting from 4 months of age were predictive of poorer working memory and processing speed at the age of 4 (Piek, Dawson, Smith & Gasson, 2008). Thus, the increased strain in memory, combined with deficits in attention, language and intellectual abilities seem to account for the cognitive impairments in children with DCD. These links between cognitive and motor deficits are further evidenced by proposed common underlying mechanisms for motor and cognitive disorders as well as the high comorbidity rates in DCD. Notably, at least for the case of DCD, the disorder has started to be viewed as comprising

generalised deficits in different aspects of development rather than being a distinct, uniform disorder (Visser, 2003).

This brief review suggests a robust link between the development of cognitive and motor skills. Research shows strong correlations between rhythmical synchronisation abilities and various cognitive skills such as language and IQ scores. Both language skills and other cognitive skills mentioned in this section are actively used in social interactions with others. To explore this further, the following section will discuss how motor and rhythmic synchronisation skills link with social skills.

4.3.2 Social correlates of motor and synchronisation skills

Simply put, any physical movement that is performed in a social context is an example of the motor and social domains interacting. Research suggests that early motor skills can predict aspects of social development later in life (see Section 2.3). This section will review research conducted on the interactions between the motor and the social domain in early childhood. As in the previous section, this review will be enriched by information obtained from developmental disorders. Moreover, where available, more direct links will be formed between social development and children's growing rhythmic synchronisation skills. In addition to enabling a thorough understanding, these links drawn will inform Study 3 measures by revealing which specific social-cognitive variables are related to motor development.

Studies conducted with typically developing children reveal that the connections between motor and social domains are very strong. One study found that 4-year-olds with poor motor skills were less likely than their competent peers to successfully identify the emotions in the facial expressions of others (Piek, Bradbury, Elsley, & Tate, 2008). Further, this effect was strongly mediated by IQ, suggesting an association

among the cognitive, social and motor domains. It has been also shown that between ages 3 and 5, children's poor motor performance was associated with withdrawal from social interactions, and less engagement in social play (Bar-Haim & Bart, 2006). While causal interpretations cannot be established on the basis of such correlational research, it might reasonably be hypothesised that good motor skills serve as a gateway to social interactions with peers, in the absence of which children are more likely to experience isolation and social difficulties.

Research suggests that intervention programmes focusing on motor development can reverse the negative social conditions that children with poor motor abilities face. At least two intervention programmes have been effectively conducted with 3- to 6-year-old children. Alpert and colleagues' (1990) 8-week long programme, which required the children to perform rhythmical movements with music was found to facilitate children's self-esteem compared to a control group, who engaged in typical outdoor play for the same duration of time. Another intervention programme of 10 weeks long, in which children engaged in physical play while taking turns and imitating each other reported increases in pro-social behaviour, decreases in teachers' reports of behavioural, emotional and peer-play problems, and more importantly, a continuity in these observed effects up to 18 months after the intervention (Piek et al., 2012). These findings are telling about the psychosocial benefits of physical activities in early childhood. It is yet to be identified, however, which specific types of physical activities would be most beneficial for children's social development (Timmons et al., 2007).

Turning again to developmental disorders, DCD is known to impact children's social lives in important ways. Compared to their typically developing peers, children in pDCD groups have been found to be more likely to develop internalising disorders, such as depression and anxiety (Cairney, Veldhuizen, & Szatmari, 2010) and display

more aggressive and withdrawal behaviours in their interactions with peers (King-Dowling et al., 2015). Their behaviours in peer play settings also show marked differences to those of their typically developing peers. Children classified as pDCD showed developmental delays in social play and cooperation, used language less frequently whilst playing, engaged in fewer group play and performed more poorly in aspects of play including space and object management and participation (Kennedy-Behr et al., 2013). Similarly, for children with DCD, parental reports indicate higher levels of social problems (Dewey et al., 2002) and observations have revealed that children spend more time alone, onlooking, transiting between activities and not engaging in social activities with peers (Kennedy-Behr et al., 2013).

So, what is the nature of the co-occurrence of these motor and social problems in DCD? Is it because of some common underlying mechanisms that lead to impairments in both domains or is it rather that initial motor behavioural problems cause stress in children's social environment, which hinders their social skills? Evidence exists for both accounts. Brain studies with children in typical populations showed that the development of sensory and motor areas reach adult levels by the pre-school period (Casey, Tottenham, Liston & Durston, 2005). Yet, motor control skills rely not only on the sensory-motor areas but also on the neural connections of these areas with the areas responsible for higher cognitive functioning, such as the prefrontal cortex (Piek et al., 2012). Hence, as the prefrontal cortex continues to develop (or fails to develop, in case of certain disorders) at an incredibly high rate during early childhood (Sowell, Thompson, Leonard, Welcome, Kan, & Toga, 2004), problems in motor and social skills start to become more apparent too. Still, more research is needed to precisely address the underlying neurobiological mechanisms of co-occurring motor and social disorders.

There is also evidence that children with motor difficulties may be experiencing social issues due to the environmental stress incurred by their impairments. An interesting finding is that the children with moderate motor difficulties, but not those with poorest motor skills, engaged in more unsocial behaviour (Schoemaker & Kalverboer, 1994) and who encountered social rejection from their peers the most (Kanioglou, Tsorbatzoudis, & Barkoukis, 2005). It may be that the atypical characteristics observed in the most severely impaired children are so obvious that the other children take into consideration their condition in their interactions (Leonard & Hill, 2014). It may also be that those with moderate impairment engage in more aggressive and imprudent behaviour as they try to compensate for their difficulties, which in turn leads to difficulties in social interactions (Schoemaker & Kalverboer, 1994). Perhaps the most useful way forward in this debate would be to conduct screening projects that track performance in motor, social and cognitive domains from infancy until later in childhood (Leonard & Hill, 2014).

So far, we have looked at how social development is influenced by disorders that are marked primarily by a deficiency in motor skills. Yet, the link in the opposite direction is just as compelling; that is, how motor development is influenced by disorders that are marked primarily by a deficiency in social skills. One of the most widely researched social functioning disorders is autism spectrum disorders (ASDs). ASDs is an umbrella term that includes a number of conditions, all of which are characterised by impairments in language, communication and social behaviour as well as a restricted range of interests and repetitive behaviours (WHO, 2016). ASDs are estimated to affect 1 in 160 children worldwide and are known to co-occur with other conditions such as depression, anxiety and ADHD (WHO, 2016). The initial signs of this disorder appear as language delays and lack of eye contact in infancy and continue

to be reflected on deficiencies in emotion understanding and use of body language, gestures and facial expressions later in childhood and beyond (NHS, 2016). Motor difficulties play a strikingly small role in the diagnosis of ASDs, though they are ubiquitous in affected individuals. Research shows that the degree of motor impairment in children with ASDs is associated with children's overall cognitive skills and IQ levels and is linked to social and communicative problems (Bhat, Landa, & Galloway, 2011). Typically, motor impairments in ASDs involve poor coordination and slowed movements (Bhat et al., 2011). For instance, one study conducted with adolescents and adults showed that compared to typically developing peers, individuals with ASDs scored much lower on certain perceptual-motor tasks (Linkenauger, Lerner, Ramenzoni, & Proffitt, 2012). These tasks required the participants to estimate their own bodies' action capabilities, such as estimating whether an object is within their reach or whether their hand would fit in a hole. Moreover, in the ASDs group, the magnitude of deficiency in the perceptual-motor tasks strongly predicted the magnitude of social-communicative deficits.

Retrospective data, relying on parental reports or home videos of children who are known to have received the ASDs diagnosis is also illuminating. These data demonstrate signs of abnormalities starting from as young as 6 to 9 months of age. Often, motor milestones such as sitting and walking were delayed, atypicalities were observed in the way the children carried and moved their bodies such as arms getting caught under the chest while trying to lie or roll, and the use of reflexes and overall motor activity were reduced (Ozonoff et al., 2008; Teitelbaum, Teitelbaum, Nye, Fryman, & Maurer, 1998). Another source of evidence is longitudinal data conducted on the younger siblings of children with ASDs, who are known to be at least 20 times more likely to develop ASDs than the general population (Zwaigenbaum et al., 2007).

These sibling studies have similarly revealed motor and language delays within the first year of life in infants who were later diagnosed with ASDs at 2-3 years old (Bryson et al., 2007; Hilton et al., 2007; Landa & Garrett-Mayer, 2006). Hence, there is mounting evidence that motor skill deficiencies exist from very early ages onwards in children with ASDs.\

Yet, is there a link between the motor impairments and the social and communicative problems? Research shows a strong correlation between deficiencies in gross motor skills and problems in socialisation and non-verbal communication in 1.5- to 3-year-old children diagnosed with ASDs (Sipes, Matson, & Horovitz, 2011). These links seem to continue through the early childhood years too. It has been found that in 4- to 13-year-old children with ASDs, deficiencies in ToM development, understanding and recognition of emotions, and social communication problems correlated highly with motor coordination problems and repetitive behaviours (Dyck, Piek, Hay, & Hallmayer, 2007). Investigating these links further can be useful for early diagnosis as well as for informing treatment strategies for individuals with ASDs (Teitelbaum et al., 1998).

Interestingly, ASDs are also marked by deficiencies in rhythmic synchronisation abilities (Tordjman et al., 2015). It was found that 2- to 4-year-old children with ASDs performed worse than their typically developing peers in a drumming task that required inter-limb synchronisation in-phase (both drumsticks hitting the drum at the same time) and anti-phase (the drumsticks in each hand hitting the drum in alternating order). Moreover, children with ASDs had difficulty maintaining anti-phase and tended more to switch to the more stable in-phase pattern. Difficulties with inter-limb coordination may have important implications for inter-personal coordination also as both of them are subject to similar coordinative constraints (Isenhower et al., 2012). At least one study has provided support for this idea. It has been shown that 3- to 6-year-olds diagnosed

with ASDs failed to spontaneously synchronise their rocking rhythm with that of their parents, while their typically developing peers did so (Marsh et al., 2013). Importantly, the time spent rocking in in-phase synchrony with the parent correlated with intellectual age, pointing once again to the three-way links among the motor, cognitive and social domains. Similarly, another study on adults with ASDs showed that performing synchronous tapping movements positively influenced cognitive empathy, evident by increased understanding of the thoughts and intentions of their synchronising partners (Koehne, Hatri, Cacioppo, & Dziobek, 2016). The effects of matched movements, such as in the case of synchrony, may work through activating the so-called mirror neuron system (MNS) in the brain, which is proposed to play a role in attention sharing and empathy (Gallese, Keysers, & Rizzolatti, 2004; Lawrence et al., 2006). Given that MNS is largely dysfunctional in individuals with autism (Wan, Demaine, Zipse, Norton, & Schlaug, 2010), interventions involving rhythmic synchronisation tasks may be highly beneficial for facilitating their social skills (Srinivasan & Bhat, 2013).

There is mounting research on the positive effects of movement synchrony on social development in typically developing children. Success rates in synchronisation with an external beat increase when the children are in a social environment compared with a non-social environment. In one study, 2.5- to 4.5-year-old children were asked to drum along auditory stimuli of 400ms ISI and 600ms ISI (Kirschner & Tomasello, 2009). Both age groups performed similarly while drumming along the 400ms stimulus, which was within their SMT. Yet, while drumming along the 600ms ISI stimulus, which was harder as it was outside of the children's SMT, the younger group could synchronise their drumming when the beats were presented in a social, playful context but not when a machine played the beats in a non-social context. In fact, there was an overall effect of social context in both age groups, as all children synchronised more

accurately with the external rhythm in the social than in the non-social condition. Similarly, when 3- to 11-year-old children were asked to tap along with an external rhythm in peer groups, the younger children's tapping performance was improved if they could see their peers in the room while tapping (Noorden, 2014). Social effects that extend beyond the immediate environment seem to influence synchronisation success as well. At least one study suggests that growing up in a culture where there is high emphasis on musicality positively affects children's synchronisation performance from as young as 3.5 years of age (Kirschner & Ilari, 2013). Moreover, comparing German children to Brazilian children, Kirschner and Ilari (2013) found that being able to see their drumming partner increased synchronisation accuracy in German group but not in Brazilians. This may suggest that social context boosts synchrony performance especially in cases where the children are not yet quite proficient in synchronising.

Although social context evidently matters, not all partners seem to have a facilitatory effect on synchronisation. We know from Kirschner and Tomasello's (2009) study that 2.5-year-old children can drum synchronously with an adult when they are explicitly instructed to do so. However, when 2- and 3-year-olds were asked to drum freely in pairs, only the starting and ending times of their drumming were synchronised with each other (Endedijk et al., 2015). This suggests that explicit instruction to synchronise and having a proficient partner who can produce consistent and reliable rhythms are important. The latter point has indeed been experimentally confirmed, whereby 5-year-old children's synchronisation performances appeared to be poorest when their partners were age-matched children compared to older children or adults (Kleinspehn-Ammerlahn et al., 2011). Altogether, these findings imply that social context may facilitate rhythmic synchronisation, provided that the partners are

proficient and can produce consistent, reliable rhythmical stimuli. Yet, is the reverse also true; that is, does rhythmic synchronisation with others promote social outcomes?

To date, there is little research on this question, yet some studies suggest that moving in synchrony with another person can facilitate pro-sociality in early childhood. One relevant study in particular investigated the pro-social effects of rhythmic engagement with music in 4.5-year-old children (Kirschner & Tomasello, 2010). It was found that after performing a music-making activity, which involved synchronous singing and walking, the children helped their peers and collaborated with them more than after performing a group activity that did not involve rhythmic movements or synchrony. However, the aforementioned study comparing 3.5-year-old German and Brazilian children (Kirschner & Ilari, 2013) did not find any increase in spontaneous helping or sharing behaviours following synchronous interactions. One reason for this could be the one-year age difference between the studies; it might be that the pro-social effects of synchronous actions, at least with the measures used in Kirschner et al.'s (2013) study, emerge after the age of 3.5.

Another explanation might be related to the actions performed. Whereas Kirschner and Tomasello's (2009) study involved musical interactions including singing and walking in rhythm, Kirschner and Ilari's (2013) study involved merely drumming in time to some external beats. Hence, it is not clear which particular aspects of the musical interactions in Kirschner and Tomasello's (2009) study may have led to increased pro-social outcomes. As the authors also acknowledge, many factors may be involved, including the song's uplifting content, the ritualised context of using repeated gestures and utterances, shared intentionality among the participants and interpersonal movement synchrony resulting from group music making. One recent study with older children suggests interpersonal movement synchrony may be the key to the observed

pro-social outcomes. In this study, 8- to 9-year-old children reported increased feelings of closeness and perceived similarity towards their same-aged partners upon performing simple tapping actions in synchrony with them than upon performing the same movements non-synchronously (Rabinowitch & Knafo-Noam, 2015).

Combined with the highly social context in which children's daily PA takes place, there is reason to believe that rhythmic synchronisation of actions alone can drive the emergence of the pro-social effects observed in musical interactions. Given that movement synchrony is closely linked to social and emotional outcomes from early in development, it is possible that pro-social effects of movement synchrony occur in early childhood years too. To date, however, there has been no test of the hypothesised causal link between movement synchrony and pro-social behaviour in early childhood. To investigate this question in detail, the second study of this thesis examines whether performing movements synchronously with a peer facilitates pro-social behaviour, including spontaneous helping behaviour in young children.

5

EMPIRICAL STUDY 2: THE EFFECT OF MOVEMENT SYNCHRONY ON PRO-SOCIAL BEHAVIOUR IN EARLY CHILDHOOD

5.1 STUDY 2

The literature reviewed in Chapter 4 demonstrates how significant changes occur within early childhood years in the domains of social, motor, cognitive and emotional development. Together, these skills help children form bonds and navigate a social world that is becoming more and more complex. Their social sphere increasingly comprises peers rather than adults. The range of pro-social behaviours displayed broadens and children make complex social decisions based on their interactants' needs, desires and beliefs, and social pressures (e.g., wanting to look good to others or to do the morally right thing). Regarding children's rhythmic synchronisation abilities, research on developmental disorders and musical interactions illustrate the crucial role played by coordinated, synchronous movements in the development of cooperation and social bonding among children.

Yet, no research to date has looked specifically at the effect of movement synchrony on pro-social behaviour in young children. Given the significance of peer interactions in early childhood, it is especially important to investigate this issue in children's natural play environments with peers. In light of the literature reviewed in Chapter 4, the current study will examine children's helping behaviour in a peer-play context after the children actively perform some clapping and tapping movements synchronously with the rhythms that they hear.

Here, it is proposed that movement synchrony facilitates pro-social behaviours in children's interactions with peers. To investigate this, children first played a game in pairs, called the Clap & Tap Game, where they were asked to clap and tap on the table with both hands either in synchrony or non-synchronously with their partners. This game was designed specifically for this study to create conditions, in which children actively performed synchronous/non-synchronous movements with each other. These

clapping and tapping movements were chosen particularly due to their ease of performance, as was established during the initial pilot stage of this study. Previous research (as reviewed in Section 4.1) also shows that rhythmically clapping and tapping with both hands simultaneously were among the movements that 4- to 5-year-old children could perform most proficiently (Moog, 1976).

After playing the Clap & Tap game, the children were presented with another game, the Fish Feeding Game. This game assessed the amount of helping that the children displayed towards their partners. Precedent in the literature guided this choice of helping behaviour over sharing or comforting behaviours (see Section 4.2). It is known that helping behaviour develops fairly early in childhood; as young as 14-month-old children can hand in objects to adults who are in need (e.g., Warneken & Tomasello, 2007) and is more frequently observed than sharing or comforting behaviours in children's natural interactions with peers (e.g., Radke-Yarrow et al., 1976). Moreover, since this study aimed to build upon and extend Kirschner and Tomasello's (2010) findings with musical interactions, using the same pro-sociality measure was considered most appropriate.

Prior research on pro-sociality suggests that it can be expressed across a variety of both explicit and implicit attitudes and behaviours (Csibra & Gergely, 2009; Rubin, Bukowski, & Parker, 2006). In order to explicitly assess empathy, children were asked to report how they felt when their partner was in a needy situation in the Fish Feeding Game – for this, we created visual “Emotion Card” scales with frowny/neutral/smiley faces as scale anchors. To capture a range of implicit and emotional aspects of social bonding, this study also assessed eye contact, mutual smiling and empathy as additional measures of pro-sociality. It was hypothesised that more helping behaviour, mutual smiles, eye contact and empathy would occur following synchronous than non-

synchronous movement. Potential mediation effects of empathy, mutual smiles and eye contact on helping behaviour were also examined.

5.1.1 Method

5.1.1.1 Participants

Seventy-six children (38 girls, $M = 61$ months ± 6.6 , range: 48-76 months) participated in sex- and age-matched pairs within their schools. A priori sample size followed Kirschner and Tomasello (2010). Participants were distributed evenly and age distribution was similar across conditions (19 girls in synchrony condition, $M_{sync} = 61.81$, $M_{non-sync} = 60.68$). Assignment to the conditions was random; in cases where teachers reported a pair to be best friends, re-randomisation was done.

An additional 8 pairs (female) were tested but excluded from final analysis due to experimenter error (3), failure to coordinate with individual beat during training (1) or because the 'accident' in the helping task was unnoticed by the 'Responder' children (4). Participants came from mixed ethnicities and socio-economic backgrounds and were recruited from schools in Oxfordshire, UK. Ethics clearance was received from the University of Oxford's ethics board. Permission was obtained from the school authorities and parents prior to testing.

5.1.2 Materials and Procedure

The experiment procedure comprised of a warm-up activity (Picnic Game) and 3 main tasks (Clap & Tap Game, Fish Feeding Game and Emotion Cards). The independent variable was synchrony with two levels (synchrony versus non-synchrony). The dependent variable, pro-sociality, was measured through assessing helping behaviour and more implicit indicators of social closeness, namely mutual smiles and

eye contact within pairs. Figure 5.1 depicts the room set-up. All sessions were video recorded for coding purposes.

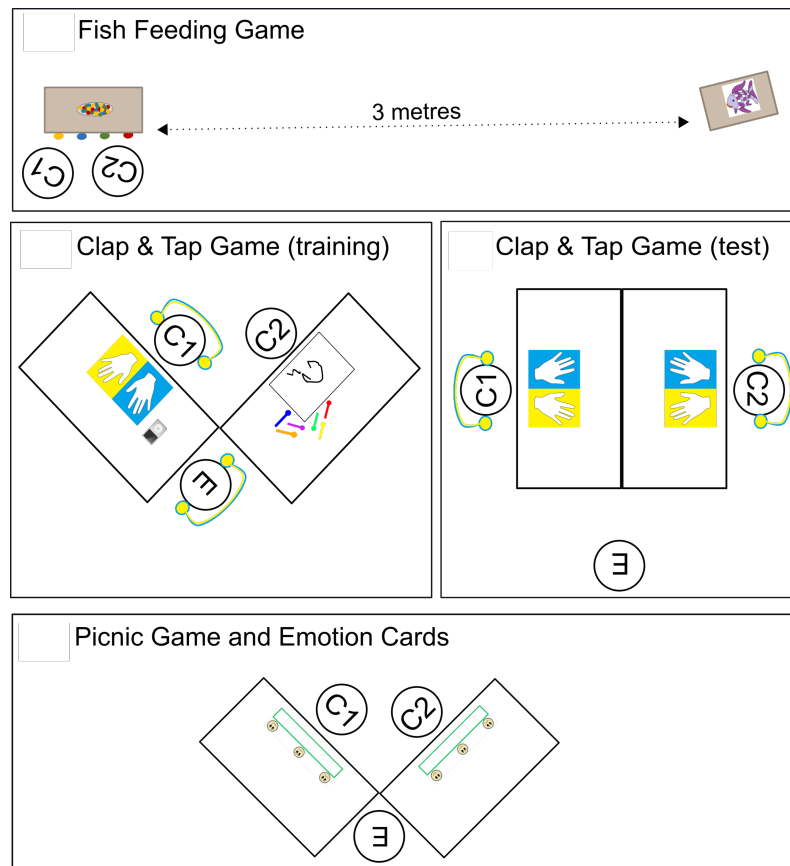


Figure 5.1. Room set-up in different phases of the study; C1: Child 1, C2: Child 2, E: Experimenter.

5.1.2.1 Picnic Game

Children engaged in a pretend picnic game with toy food items as a warm-up activity. The warm-up activity also served as training for the Emotion Cards. In the Picnic Game, everyone chose from among some toy food items that the Experimenter (E) had brought and pretended to eat them. At this stage, E showed the children how to use the Emotion Cards to indicate their liking of the food item they had chosen. The following instructions were given to explain different parts of the scale (see Figure 5.2):

“You see, there is a happy face here, a sad face there and another one in the middle. To show each other how we feel, we peel off a sticker and stick it on one of the boxes on our emotion cards. If we are feeling happy, we put our sticker here, on the

happy side [pointing at the direction of the happy face but at no specific box]. If we are feeling sad, we put our sticker here, on the sad side [pointing at the direction of the sad face but at no specific box]. If we feel just normal; that is, neither happy nor sad, we put our sticker in the middle [pointing at the direction of the neutral face but at no specific box]. If we are really really happy, we stick our sticker on this box [pointing at the square closest to the happy face, box #7]; if we are a bit less happy than that, we can stick it here [pointing at boxes #5-6]. If we are neither happy nor sad, we stick our sticker in the middle [pointing at box #4]. If we are sort of sad, we can stick our sticker here [pointing at boxes #2-3]; and if we are really really sad, then we stick our sticker on this box [pointing at box #1]. So, this is the way we can show how happy or sad we are, or if we are somewhere in between.”

Then, E demonstrated the use of the scale three times: by pretending to eat a food item that she really likes (using the happy end of the scale), one that she really does not like (using the sad end of the scale) and one that she is neutral about (using the middle of the scale). Every time before putting the sticker on the card, E confirmed that the children could infer where the sticker would be put based on E’s facial and verbal expressions as to whether she liked the food item or not. Next, E asked the children to do the same exercise three times by choosing a food item that they like, one that they do not like and one that they feel neutral about. The picnic game phase took around 5 minutes.

5.1.2.2 Clap & Tap Game

Following the warm-up, the Clap & Tap Game commenced. The game required the children to perform clapping and tapping movements in time to beats that they heard from their individual headphones. The auditory track was composed of four 10-second intervals of tick-tock sounds, during which the children alternately clapped and tapped

with both hands on the ‘hands sheet’ in front of them (see Figure 5.2). The tick-tock intervals were separated from each other by a brief *whoop* sound, during which the children quickly stood up and sat back down on their seats. The whoop sound was included to make the game more interesting and to add visual emphasis to the movement activity.

The tick-tock beats were either 300ms or 333ms; both tempi were age-appropriate to the children’s synchronisation ability range (i.e., rhythms between 300ms and 400ms ISI, see: Provasi & Bobin-Bègue, 2003). Pilot testing confirmed that these beats were easy to follow and sufficiently different from each other to establish pair-wise non-synchrony. The choice of movements was based on research showing young children’s synchronisation proficiency in clapping and tapping (Fitzpatrick, Schmidt, & Lockman, 1996; Frega, 1979; Rose, 2014).

Each child was first trained individually on how to play the game, while the other child did a drawing task at a separate table (see Figure 5.1b). During the training, both E and the trainee wore headphones and listened to the same beats via use of an audio splitter from a single audio player. This way, E could always keep track of the children’s synchronisation accuracy. First, E introduced the game to the children with the following instructions:

“You see the pictures of the two hands on this sheet? Now, we will clap and then tap with both hands on the table by putting our hands on these pictures [demonstrating how to alternately clap and tap]. Can you do it? [E places the hands sheet on the table directly in front of the child and waits until the child claps and taps a few times]. Now, while we do this, we will also listen to some ticking sounds from our headphones and try to tap according to the tick-tocks. Sometimes, the tick-tocks will stop and instead we will hear a whoop sound. When we hear that, we will stop clapping and tapping and

quickly stand up and sit down until the whoop sound finishes. And as soon the tick-tocks start again, we will continue to clap and tap. Let me show you first and then you will do it.”

E took the hands sheet in front of her and demonstrated clapping-tapping and standing up-sitting down for the whole duration of the track. When finished, E put the hands sheet in front of the child for them to practise. Where necessary, E gave instructions to the child. The training phase ended when the child could do at least one sequence of clap-tap/stand up-sit down/clap-tap without error and any instruction. All children reached this level by a maximum two repetitions of the auditory track. The training phase lasted approximately 5 minutes per child. When the training of both children was over, E told them that they would now play the game in a different way (with no explicit statement that they would play it ‘together’ or ‘facing each other’).

After training, the children sat opposite each other to perform the activity together in the test phase (see Figure 5.1c). Children in the synchrony condition heard the same beats from their individual headphones (300ms used in half of the synchrony sessions), while children in the non-synchrony condition heard beats at different tempi. All children were informed beforehand that they might hear the same or different beats and that their task was to do the moves in time to their own beats. E remained condition-blind until the test phase and moved away from the table during the test phase to avoid any potential interference.

5.1.2.3 Fish Feeding Game

Subsequently, the spontaneous helping task commenced (adopted from Kirschner & Tomasello, 2010). The whole procedure of the Fish Feeding Game, including training, followed the original implementation of the task by Kirschner and Tomasello (2010). Children were told that the aim of the game was to feed some toy fish by

carrying fish food in tubes from a table to the fish box, where, allegedly, some hungry toy fish were. By design, one of the tubes, the red tube, had a broken cap, which fell off and caused all food to spill on the floor as soon as the child lifted it. The other child in the pair (the ‘Responder’) had an intact tube and could either carry on playing the game or stop and help the other child. The Responder’s behaviours upon the red tube breaking was taken as measure of helping (more details in the Coding section). Assignment to the Responder role was done randomly prior to the session and was counterbalanced across tempi and left-right side.

The fish box and the table were located 3 metres apart from each other to allow sufficient room for the children to notice the accident and act on it. In addition, to increase the Responder’s chances of noticing the accident, the fish box was always placed on the side of the red tube. In the training phase, E showed the children how to (i) sort the fish food (wooden balls of 3cm in diameter) into tubes according to colours (e.g., blue fish food into the blue tube), (ii) lift the handlebar to retrieve the tubes and (iii) carry the tubes to the fish box and pour the food into the fish box from the tubes. The blue and green tubes were used for the training phase. By the end of the training, all children had learnt how to play the Fish Feeding Game. After the training, E told the Responder to take the red tube and the other child the yellow tube. While the children were sorting the red and yellow fish food into their tubes, E announced that she had to pop out quickly to speak with one of the teachers but that the children should continue to feed the fish by lifting the handlebar and pouring the fish food from the tubes into the fish box. To minimise potential authority and by-stander effects on children’s helping behaviour, E left the room for the test phase (duration: 2 minutes). The Responder’s behaviours only within those 2 minutes were analysed to measure helping. E returned after 2 minutes and, where there was still a problem (i.e. the food had not all been

transferred, or the child was working with the broken tube), E fixed the broken tube and proceeded with the procedure.

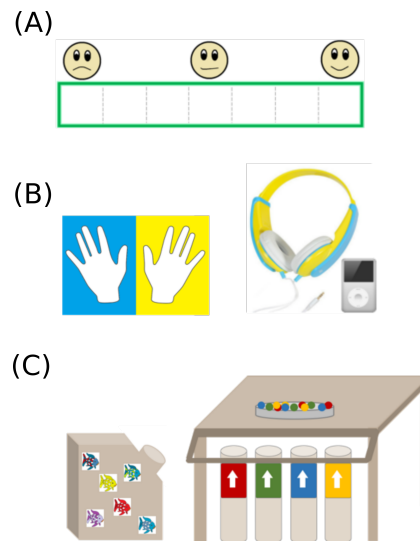


Figure 5.2. The toys used in the experiment. Top panel shows the Emotion Card, middle panel shows the Clap & Tap Game materials (the hands sheet, headphones and audio player) and the bottom panel shows Fish Feeding Game toys (fish box, table, tubes and fish food).

5.1.2.4 Emotion Cards

Following the Fish Feeding Game, the children were asked questions about their experiences with the games. Children responded by placing stickers on their Emotion Cards (for similar usage of scales, see: Chambers, Giedbrecht, Craig, Bennett & Huntsman, 1999; Denham et al., 2003). These were 7-point Likert type scales with boxes on them to indicate where to place the stickers (see Figure 5.2). The leftmost box was described orally as representing very sad, the middle box as normal, and the rightmost box as very happy (each point illustrated with corresponding frowning, neutral and smiley faces). The children were asked to rate how they felt (1) as they played the Fish Feeding Game, (2) when they noticed the broken tube, and (3) as they played the Clap & Tap Game. For each question, E first gave children their individual scales and then asked the question orally. Children did not have visual access to each other's answers while responding.

5.1.3 Coding

Synchrony Ratings

All inter-rater reliability coding was done by two individuals, both of whom were blind to the conditions and one blind to the hypothesis. Post-hoc video coding was conducted to confirm that synchrony was achieved in the synchrony condition and non-synchrony in the non-synchrony condition, and that the synchrony levels were significantly different across conditions. The coders rated participants' synchrony levels (i) by making a blind guess on which condition the pair was in, and (ii) by rating the frequency of synchronous instances in the pairs' movements on a Likert-type scale (1 = absolutely non-synchronous, 4 = sometimes synchronous, sometimes non-synchronous, 7 = absolutely synchronous). Five ratings were taken per session, corresponding to the four clap-and-tap intervals and an overall rating for the three occurrences of standing-and-sitting at the *whoop* sound.

Binomial tests revealed that the accuracy of the blind guesses was excellent for both raters ($ps < .0001$). Average synchrony ratings of the two raters confirmed that pairs in the synchrony condition were more synchronous ($M = 5.64 \pm .92$) than pairs in the non-synchrony condition ($M = 1.79 \pm .67$), Rater 1: $t(36) = 9.04, p < .0001$; Rater 2: $t(36) = 7.36, p < .0001$; inter-rater reliability: Krippendorff's $\alpha = .98$. Due to this high convergence between the ratings and the dichotomous split into synchrony and non-synchrony conditions, main analyses testing the effects of synchrony were conducted based on this dichotomous split. Future analyses that involve the synchrony ratings as a predictor involve the average of the two raters' ratings.

For exploratory purposes, the effect of level of synchrony was assessed by splitting the data four ways based on the pairs' synchrony ratings, yielding post-hoc categories of 'synchrony' (ratings between 5.5 and 7, $n = 11$ pairs), 'moderate

synchrony' (ratings between 4 and 5.5, $n = 7$ pairs), 'moderate non-synchrony' (ratings between 2.5 and 4, $n = 3$ pairs) and 'non-synchrony' (ratings between 1 and 2.5, $n = 17$ pairs). The congruence between the dichotomous and the four-way split was perfect except for one pair, which originally was in the synchrony condition (the children heard the same beats) but fell into the 'moderate non-synchrony' category as a result of the coders' ratings. The same analyses on helping behaviour that were conducted with the dichotomous split were also conducted according to the four-way split in order to assess whether gradual changes in the level of synchrony would influence pro-social behaviour differently than the dichotomous categorisation (see 5.1.3 Results section). The uneven distribution of sessions by category should be noted, however, while interpreting the results of the four-way split.

Helping Behaviour

Helping behaviour was assessed using Kirschner and Tomasello's (2010) coding scheme: The Responders' behaviours were divided into three categories according to the amount of help they provided (see Table 5.1). In addition, the number of balls picked up by the Responder (range: 0-6) was compared across conditions. Inter-rater reliability for both indices of helping behaviour was excellent; for helping categories: Krippendorff's $\alpha = .96$; for number of balls: Krippendorff's $\alpha = .98$.

Table 5.1
Coding scheme used to categorise helpers' behaviours.

Helping Categories	Category Description
Absolute help	Responder actively helps (e.g., picks up balls, holds the lid) and/or waits to play until the problem is solved
Moderate help	Responder partially helps and/or waits besides the other child showing concern and mutual commitment, but leaves to play before the problem is solved
Zero help	Responder does not help or wait for the other child, does not show concern and/or does not excuse him/herself before leaving

Smiles and Eye Contact

Clap & Tap Game phases were coded to examine children's enjoyment levels and eye contact during the task. For enjoyment levels, facial expressions were assessed by counting the number of smiles each child displayed ("individual smiles") as well as the number of times children smiled simultaneously while maintaining eye contact with each other ("mutual smiles"). Together, individual smiles and mutual smiles added up to 100% of the smiles. Following Ekman and Friesen (1982), a smile was defined as the simultaneous upward movement of the muscles around the corners of the mouth and around the eyes. For the measure of eye contact, the number of seconds the children spent actively focused on each other's eyes/faces was recorded (e.g., eyes meeting accidentally while turning the head were not included). Eye contact duration was coded for each clap-and-tap interval and stand-sit occurrences and these were summed to obtain the total duration per session. Inter-rater agreement for all of these coding categories was strong, individual smiles: Krippendorff's $\alpha = .83$; mutual smiles: Krippendorff's $\alpha = .98$; eye contact: Krippendorff's $\alpha = .99$.

5.1.4 Statistical Analyses

This study had a single independent variable with two levels: synchrony and non-synchrony. The dependent variable of helping behaviour was assessed using the aforementioned coding scheme (see Table 5.1) and the number of balls that the Responder child picked up. To assess whether children's helping differed across conditions according to the coding scheme, ordinal logistic regression analysis was conducted. This method was chosen because of the ordinal nature of the coding categories, incrementally indicating more help. Potential confounding factors (e.g., sex, tempo, side etc.) were also analysed in the ordinal logistic regression. The effect of

synchrony/non-synchrony conditions on the number of balls picked up was analysed with an independent samples t-test, as the dependent variable ranged between 0 and 7.

For exploratory purposes, the effect of condition on helping behaviour was assessed also using the four-way split described above (based on the post-hoc synchrony ratings). To examine the effect of the four degrees of synchrony conditions, Kruskal-Wallis test was conducted. Post-hoc pairwise comparisons were run with a Tukey and Kramer (Nemenyi) test to examine which of the four conditions differed from one another.

The effect of dichotomous condition (synchrony versus non-synchrony) on the 7-point Likert type Emotion Cards, frequency of individual and mutual smiles and duration of eye contact were analysed using one-way between-subjects ANOVA. To investigate whether mutual smiles and eye contact mediated the effect of condition on helping behaviour, the {lavaan} package in R was used. Finally, within-session changes in synchrony ratings, mutual smiles and eye contact were analysed by constructing four general linear models (baseline model with only random effects; model with condition as predictor; model with time points as predictor; and model with the interaction term condition * time points as predictor) and comparing them with ANOVA.

5.1.5 Results

5.1.5.1 Effect of synchrony on helping behaviour

Dichotomous Split ('synchrony' versus 'non-synchrony' conditions)

Helping categories were analysed to assess whether children in the synchrony condition displayed more helping behaviour than children in the non-synchrony condition. Ordinal logistic regression analysis on the helping categories, with condition as the predictor variable, revealed that the odds of children in the synchrony condition displaying absolute help over moderate and no help combined was 29.402 times greater

than that of children in the non-synchrony condition, 97.5% CI: 6.40 to 184.64, $Wald \chi^2(1) = 16.19, p < .0001$. Factors of Age, Sex or Tempo did not predict helping behaviour. Figure 5.3 shows the frequency of occurrence for each helping category by condition. Corroborating the findings on the effect of condition on helping categories, children in the synchrony condition picked up more balls ($M = 2.84 \pm 2.09$) than children in the non-synchrony condition ($M = 0.58 \pm .90$), $t(32) = 4.34, p = .0002$.

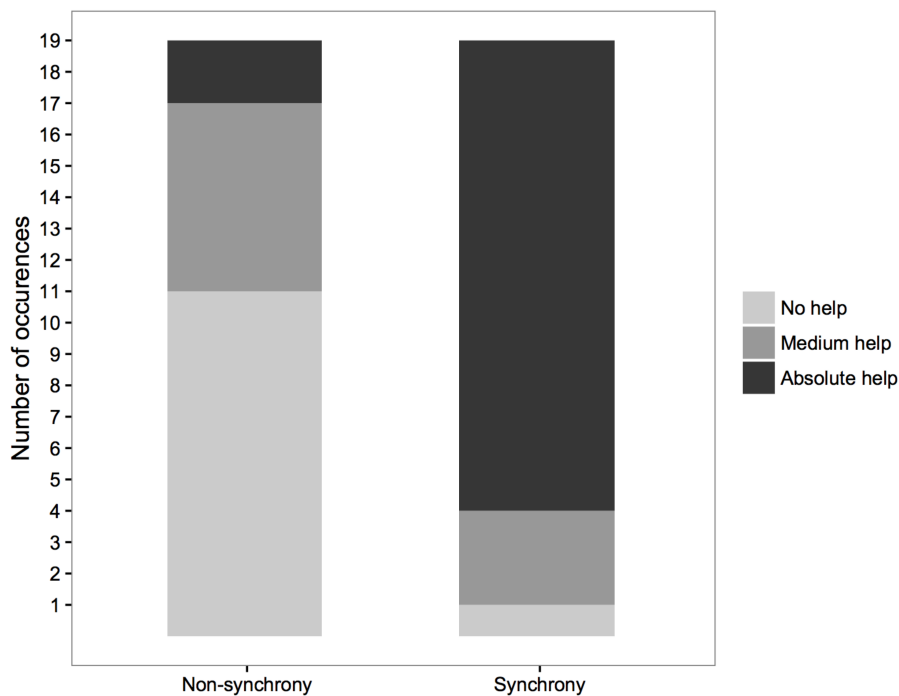


Figure 5.3. Helping categories by frequency of occurrence.

Four-way Split ('synchrony' versus 'moderate synchrony' versus 'moderate non-synchrony' versus 'non-synchrony' conditions)

A Kruskal-Wallis chi-squared test on helping categories revealed a main effect of four-way conditions, $X^2(3) = 20.22, p = .0002, \eta^2 = .55$. Tukey corrected pairwise comparisons showed that the synchrony condition was different from the moderate non-synchrony ($p = .005$) and non-synchrony conditions ($p = .003$); no difference was found between any of the other conditions, all $ps > .05$. The odds of children in the synchrony condition exhibiting absolute help compared to medium help and no help combined

were 4.28 times more than that of children in the non-synchrony condition, 95% CI: 5.70 to 908.94, $p = .0009$. This difference was not significant for synchrony versus moderate non-synchrony conditions, $OR = 1.50$, 95% CI: .19 to 106.83, $p = .42$. However, a chi-square goodness of fit test revealed that the frequency of occurrence of absolute help was significantly more in the synchrony than in the moderate non-synchrony condition, $X^2(1) = 4.9$, $p = .03$, $\phi = .7$. Figure 5.4 shows the number of occurrences of each helping category per condition.

Similarly, a main effect of condition was found on the number of balls that the Responders picked up, $F(1, 36) = 21.64$, $p < .0001$, $\eta^2 = .60$. Post-hoc Bonferroni corrected pairwise comparisons showed that children picked up significantly more balls in the synchrony condition ($M = 3.36 \pm 1.95$) than in the non-synchrony condition ($M = 0.53 \pm 1.77$) conditions ($p = .0004$); differences in the number of balls picked up were not significant across the other conditions, all $ps > .05$.

These findings are very similar to those obtained from the dichotomous split analyses, rendering the four-way split analyses rather redundant. An ANOVA test further confirmed that the average synchrony ratings as given by the two raters were significantly different across the dichotomous synchrony and non-synchrony conditions, $F(1, 36) = 216.9$, $p < .0001$. As there is high overlap between the synchrony ratings and the independent variable (synchrony versus non-synchrony conditions), all future analyses were done using the dichotomous split only.

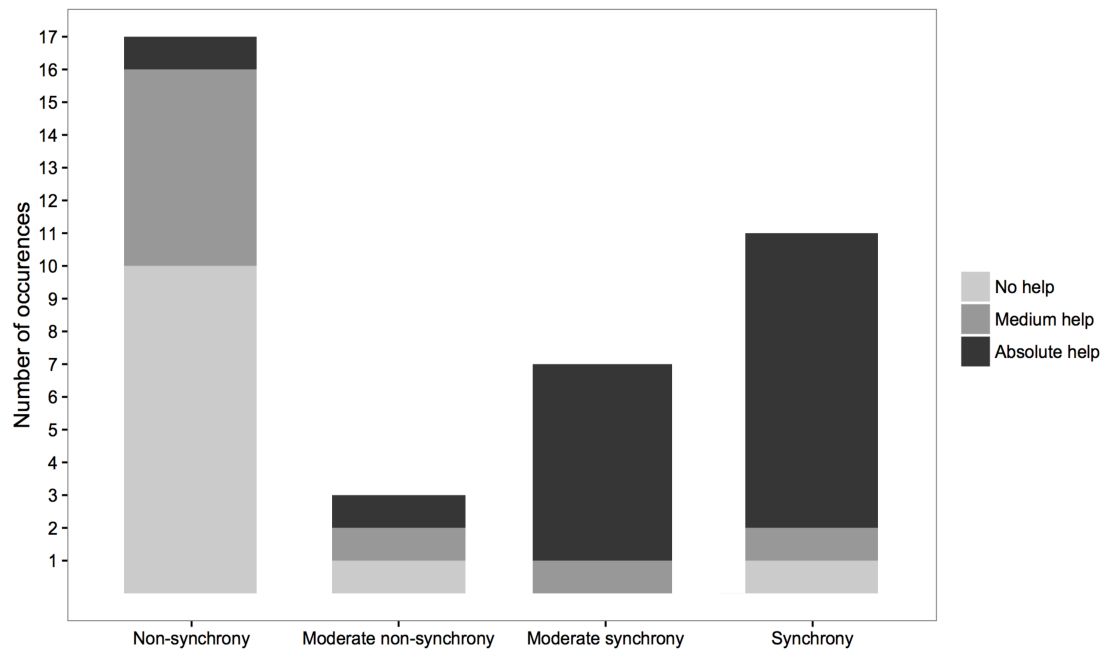


Figure 5.4. Helping categories by frequency of occurrence across 4-way conditions.

5.1.5.2 Effect of synchrony on emotion card responses, smiles and eye contact

Analyses on individual smiles, mutual smiles and eye contact while playing the Clap & Tap Game revealed significantly higher occurrence in the synchrony condition compared to the non-synchrony condition, individual smiles: $M_{sync} = 4.92 \pm 2.01$, $M_{non-sync} = 2.92 \pm 2.27$, $F(1, 74) = 76.00$, $p < .0001$, $\eta^2 = .27$; mutual smiles: $M_{sync} = 3.89 \pm 1.85$, $M_{non-sync} = 1.37 \pm 1.61$, $F(1, 36) = 20.17$, $p < .0001$, $\eta^2 = .56$; eye contact: $M_{sync} = 23.95 \text{ seconds} \pm 12.50$, $M_{non-sync} = 12.36 \text{ seconds} \pm 9.07$, $F(1, 36) = 11.42$, $p = .002$, $\eta^2 = .32$. Altogether, these findings suggest that synchronous activity was associated with more mutual enjoyment and eye contact than non-synchronous activity.

A Wilcoxon signed-rank test revealed similar levels of enjoyment during the Fish Feeding Game across conditions, $F(1, 70) = .58$, $p = .45$, $M_{sync} = 5.12 \pm 2.67$, $M_{non-sync} = 5.53 \pm 2.00$, (see Figure 5.5). Children across conditions did not report feeling any happier or sadder at the moment of the accident, $F(1, 60) = .12$, $p = .73$, $M_{sync} = 3.00 \pm 2.11$, $M_{non-sync} = 2.80 \pm 1.33$; for Responders only: , $F(1, 29) = .74$, $p = .40$, $M_{sync} = 2.88$

± 2.42 , $M_{non-sync} = 2.20 \pm 1.90$. This indicates that how happy or sad the children felt during the accident did not influence their helping behaviour. However, enjoyment levels during the Clap & Tap Game trended towards significance in the hypothesised direction: $F(1, 70) = 3.26$, $p = .08$, $M_{sync} = 6.68 \pm 1.58$, $M_{non-sync} = 6.03 \pm 0.69$.

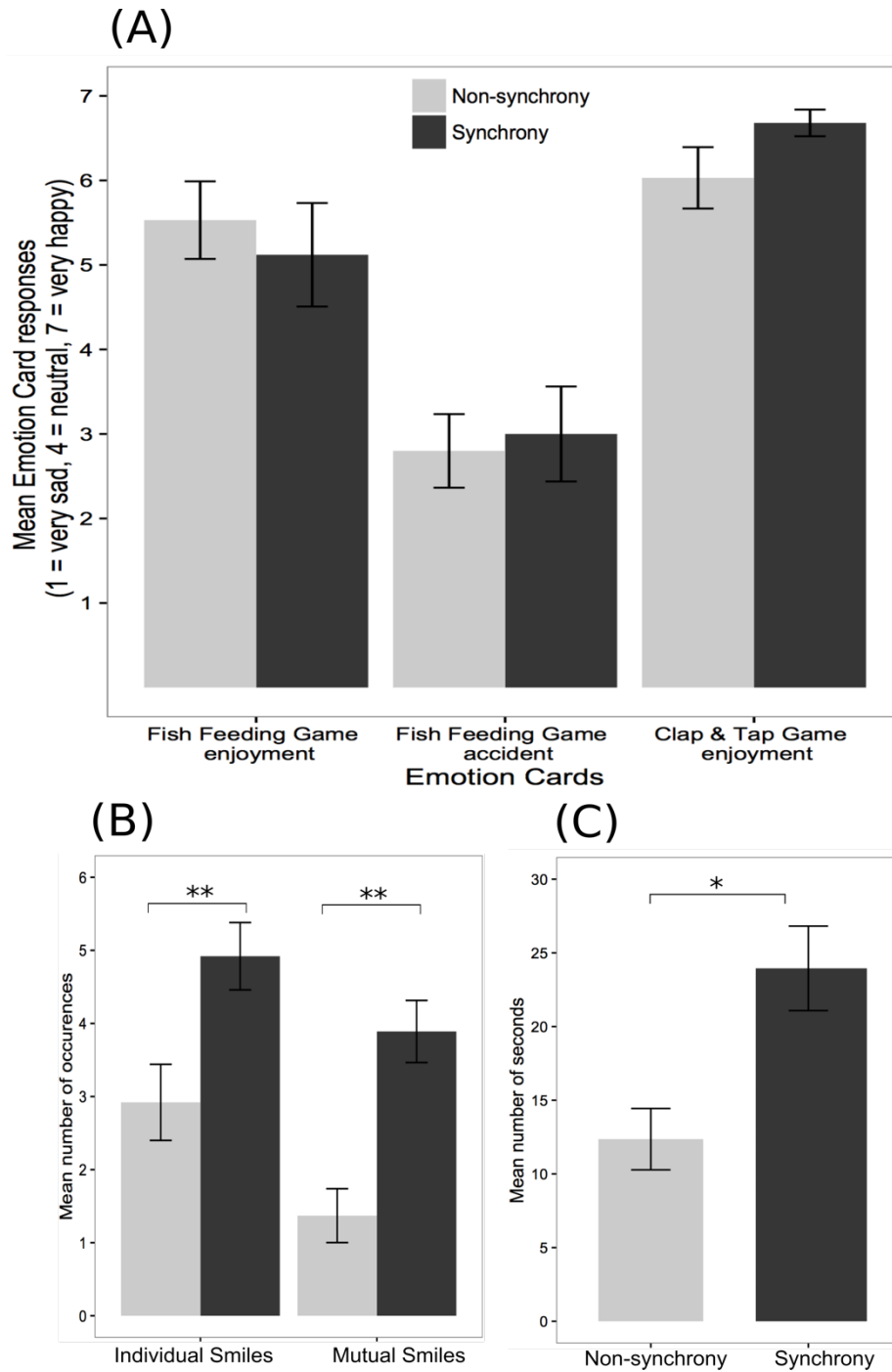


Figure 5.5. (a) Effect of condition on emotion card responses; (b) individual and mutual smiles; and (c) eye contact (bottom right panel); where * $p < .01$ and ** $p < .0001$.

5.1.5.3 Mediation effects of emotion card responses, smiles and eye contact

Children's self-reported emotional states, smiles (individual and mutual) and eye contact during the Clap & Tap Game were examined for potential associations with helping behaviour. Ordinal logistic regression analyses on helping categories with Responders' emotion card responses as the predictor variable did not reveal any significant associations, all $ps > .05$, nor did the number of individual smiles predict helping behaviour, 97.5% CI [0.93, 1.62]; $Wald \chi^2(1) = 1.94, p = .16$. However, the frequency of mutual smiles and the duration of eye contact predicted subsequent helping behaviour (absolute helping compared with medium helping and no helping combined); mutual smiles: $OR = 1.60$, 97.5% CI [1.16, 2.31], $Wald \chi^2(1) = 7.32, p = .007$; eye contact: $OR = 1.06$, 97.5% CI [1.01, 1.12], $Wald \chi^2(1) = 4.94, p = .03$.

This link was further explored by assessing whether mutual smiles and eye contact mediated the relationship between synchrony and helping behaviour. No indirect effects were found and the main effects of the mediators on helping behaviour disappeared when the effect of condition was controlled for, indirect effect of eye contact: $Z = .21, SE = .22$, 97.5% CI [-.34, .31], $p = .84$; indirect effect of mutual smiles: $Z = .64, SE = .23$, 97.5% CI [-.28, .44], $p = .53$ (see Figure 5.6). Thus, it can be concluded that performing the movements synchronously led to an increase in eye contact, mutual smiles and helping behaviour independently.

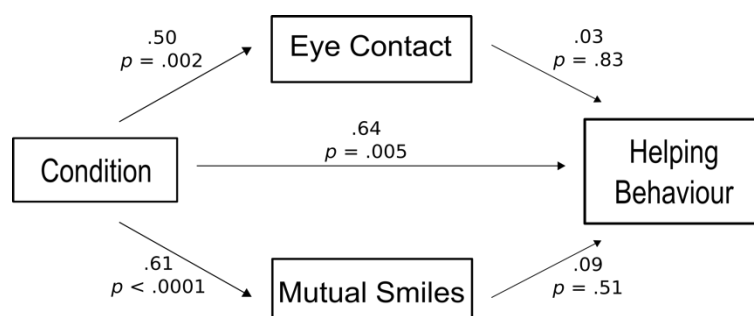


Figure 5.6. Standardised regression coefficients for the mediation of eye contact and mutual smiles on the relation between condition and helping categories. Condition is dummy coded, with higher value indicating synchrony condition.

5.1.5.4 Within-session changes in synchrony ratings, mutual smiles and eye contact

In order to investigate any changes in implicit measures during the 45-second sessions, further analyses were conducted using the post-hoc coding of synchrony ratings, mutual smiles and eye contact on each time point of the session. The sessions comprised of 7 time points of 4 Clap & Tap intervals, each separated by 3 Stand & Sit occurrences.

First, the synchrony ratings were assessed to see whether the children were progressively more successful at moving synchronously/non-synchronously with each other. Since a single, overall rating for the three occurrences of Stand & Sit were given during the post-hoc coding, those time points were excluded from this analysis (see Figure 5.7). Using the {nlme} package in R, four models were compared in an ANOVA to assess the main effects of time points (the four Clap & Tap intervals) and condition (synchrony versus non-synchrony) and their interaction on the average synchrony ratings given by the two raters. The first model (baseline) was a single parameter mean model, where the synchrony ratings were predicted by their overall mean only. Subsequent models accumulatively included time points ('time points model'), condition ('condition model') and the interaction term for condition * time points ('interaction model') as their predictor variables.

The ANOVA revealed no significant difference between the baseline model and the time points model, $X^2(7) = 2.55, p = .47$, suggesting no main effect of time points. However, the condition model, $X^2(8) = 36.49, p < .0001$, and the interaction model were significantly different from the baseline model, $X^2(11) = 11.04, p = .01$. The condition model confirms the previously reported main effect that children in the synchrony condition were rated as more synchronous than children in the non-synchrony condition. The interaction effect was further analysed in post-hoc tests using the first

time point (Clap & Tap 1) as the baseline for comparisons. Synchrony ratings given for Clap & Tap 1 compared to the ratings given for Clap & Tap 2 were not significantly different in synchrony and non-synchrony conditions, $b = .45 \pm .53$, $t(108) = .84$, $p = .40$. However, compared to the first time point, Clap & Tap 3 and Clap & Tap 4 were rated significantly higher in the synchrony than in the non-synchrony condition, Clap & Tap 1 versus 3: $b = 1.13 \pm .53$, $t(108) = 2.12$, $p = .04$, Clap & Tap 1 versus 4: $b = 1.63 \pm .53$, $t(108) = 3.06$, $p = .003$.

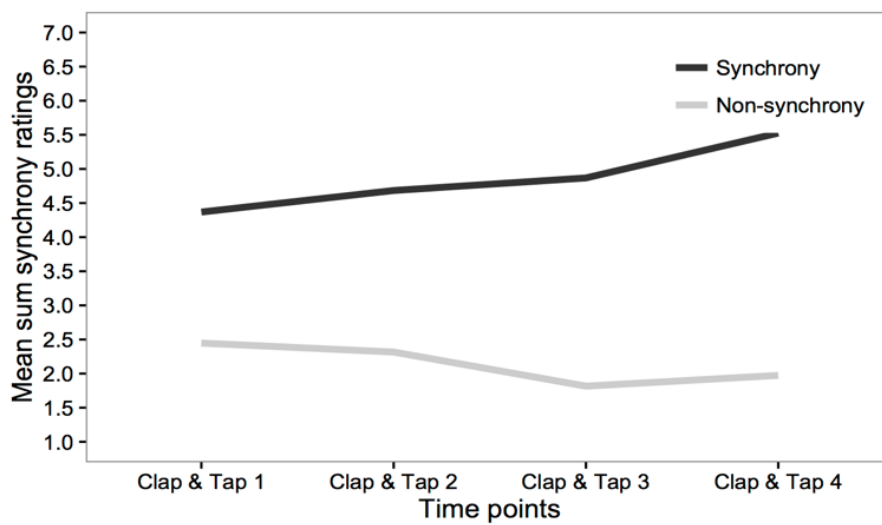


Figure 5.7. Within-session change in synchrony ratings by condition.

Next, mutual smiles and eye contact were examined in a similar way by comparing four models for each one of the dependent variables separately. These models were identical to the ones constructed for synchrony ratings, with the exception that all seven time points (4 Clap & Tap intervals and 3 Stand & Sit occurrences) were included in the analyses. For mutual smiles, there was a main effect of time points, $X^2(10) = 19.21$, $p = .004$, and condition, $X^2(11) = 17.69$, $p < .0001$. However, no significant interaction effect was revealed, $X^2(17) = 7.25$, $p = .30$. The main effect of time points shows that overall, children smiled at each other increasingly more frequently during the course of the game. The main effect of condition confirms the previously reported findings that children in the synchrony condition engaged in more

mutual smiles than children in the non-synchrony condition (see Figure 5.8). The lack of any obvious interaction effect indicates that the change in mutual smiles over time was similar in synchrony and non-synchrony conditions.

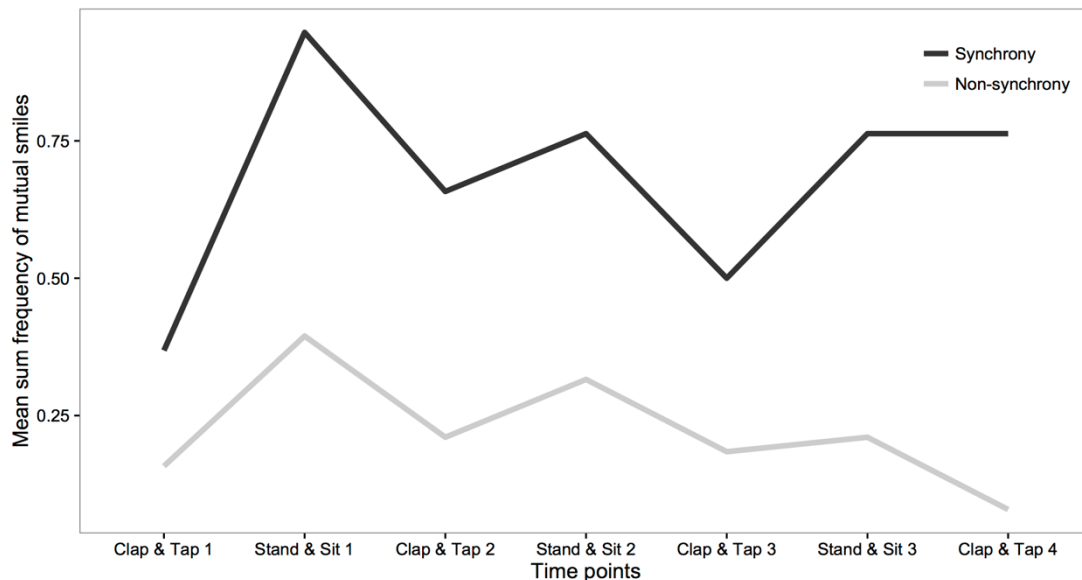


Figure 5.8. Within-session change in mutual smiles by condition.

Analysis of within-session changes in amount of eye contact revealed a main effect of time points, $X^2(10) = 24.87, p = .0004$, a main effect of condition, $X^2(11) = 19.20, p < .0001$, and an interaction effect, $X^2(17) = 15.54, p = .02$. The main effect of time points shows an overall increase in the amount of eye contact during the course of the Clap & Tap Game, though it should be noted that the increase was not linear across the seven time points (see Figure 5.9). The main effect of condition mirrors the previously reported finding that children in the synchrony condition engaged in more eye contact with each other compared to children in the non-synchrony condition.

In order to explain the interaction effect of condition and time points on eye contact, post-hoc tests were conducted similar to the way done with synchrony ratings. Using the first Clap & Tap interval as the baseline for comparisons did not yield any significant differences across time points, all $ps > .05$. Therefore, time point 3, in which

overall eye contact was highest (i.e., Clap & Tap 2, $M = 2.68 \pm 2.19$), was used as the baseline comparison point. This analysis revealed that the increase in eye contact duration between time points 2 and 3 (i.e., Stand & Sit 1 versus Clap & Tap 2) was higher in the synchrony condition than in the non-synchrony condition, $b = -1.68 \pm .59$, $t(216) = -2.85$, $p = .005$. Similarly, the decrease in eye contact duration between time points 3 and 4 (i.e., Clap & Tap 2 versus Stand & Sit 2) was higher in the synchrony condition than in the non-synchrony condition, $b = -1.55 \pm .59$, $t(216) = -2.62$, $p = .009$. No other differences between time points reached significance, all $ps > .05$.

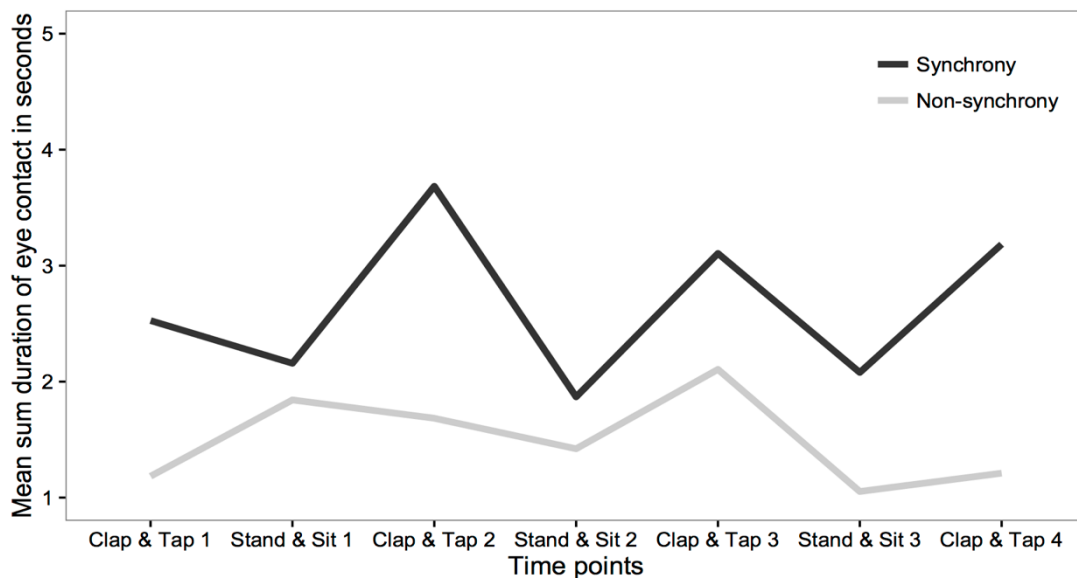


Figure 5.9. Within-session change in eye contact by condition.

5.1.6 Discussion

This study found that, compared to non-synchronous movement, performing movements in synchrony with a peer led to more spontaneous helping among young children. Further, we found that synchronous movement was associated with increases in enjoyment, eye contact and mutual smiles between the partners. The findings extend our understanding of the effects of synchronous movement on pro-social behaviour in children and begin to reveal the broad range of social effects of movement synchrony in children's peer-play interactions.

A number of previously unexplored aspects of the synchrony-pro-sociality link were investigated in the current research. Studies by Cirelli and colleagues (Cirelli, Einarson, et al., 2014; Cirelli et al., 2016; Cirelli, Wan, et al., 2014) assessed helping behaviour of infants, who were moved to certain rhythms synchronously/non-synchronously with another adult. However, from infancy onwards, self-propelled actions signal animacy, agency and communicative intent (Gergely & Csibra, 2003) and are imitated more by infants (Elsner, 2007). Recently, Rabinowitch and Knafo-Noam (2015) demonstrated positive effects of active movement synchrony on feelings of similarity and closeness among 8- to 9-year-old children. The current study extends the findings of these previous studies by (i) testing the effects of synchrony in a younger population and (ii) including an active behavioural measure of pro-sociality (i.e., helping task), as well as implicit interactional measures (i.e., mutual smiling and eye contact).

The findings also shed light on how musical interactions may lead to pro-social outcomes. In their study revealing increased helping behaviour following a music-making activity, Kirschner and Tomasello (2010) discuss the factors entailed by music that may underpin this effect, including synchrony. In the current study, subtle manipulation of this factor alone yielded levels of helping comparable to those attained following musical interactions. The significant difference between our synchrony and non-synchrony conditions and the large effect sizes found demonstrate that movement synchrony influences pro-social behaviour in young children. Differently from Kirschner and Tomasello, we did not find any sex differences in helping behaviour. This is in line with some previous synchrony studies with children (Rabinowitch & Knafo-Noam, 2015; Tunçgenç & Cohen, 2016). One recent study showed that rhythmic movement activities levelled out baseline sex differences observed in negative feelings

towards out-group members (Study 3 of this thesis: Tunçgenç & Cohen, 2016). It may thus be that our Clap & Tap Game similarly diminished sex differences in helping behaviour. Further research is required to corroborate and understand these results.

The present study also assessed enjoyment levels, mutual smiling and eye contact between the partners. Children's self-reports trended towards more enjoyment while playing the Clap & Tap Game in the synchrony condition, which was corroborated by the significant difference in individual smiles across conditions. This is in line with previous research showing a positive association between infants' frequency of smiles and rhythmic coordination with auditory stimuli (Zentner & Eerola, 2010). Neither self-reported enjoyment levels nor individual smiles predicted subsequent helping behaviour. However, analyses of eye contact and mutual smiles revealed higher occurrences of both in the synchrony than in the non-synchrony condition and that both predicted helping behaviour.

Previous research has shown that eye contact occurring during synchrony enhances memory for partners' physical features and utterances, which may positively impact future interactions (Macrae et al., 2008; Woolhouse, Tidhar, & Cross, 2016). Mutual smiling and eye contact also characterise children's initial interactions with their carers (Trevvarthen, 1993) and their friendships in early childhood years (Goldman & Buysse, 2007). In the current study, these variables may have acted as markers of affiliation and shared positive affect, leading to a greater degree of pro-sociality (Kleinke, 1986). However, mutual smiles and eye contact did not mediate the effect of condition on helping behaviour, suggesting that synchronous movement independently affected the changes in mutual smiles, eye contact and helping behaviour.

Positive social outcomes following synchronous movement may stem from a number of factors. Previous studies have found that participants perceived themselves

as more similar to their partners in traits such as appearance, personality and artistic taste following synchronous movement (Rabinowitch & Knafo-Noam, 2015; Valdesolo & DeSteno, 2011; Valdesolo, Ouyang & DeSteno, 2010; Wiltermuth & Heath, 2009). Conversely, individuals moving non-synchronously may need to divert their attention away from each other due to increased demands for inhibition (i.e., to not copy the other person's rhythm but to follow one's own instead), potentially creating social distance and dissimilarity. Research also shows that people generally prefer to interact and cooperate with those who are more similar to themselves (Haun & Over, 2015). No direct measure of similarity was taken in the current study. Still, it may be that synchronous movements fostered perceptions of similarity, which, in turn, led to higher amounts of helping behaviour, mutual smiling and eye contact.

Another mechanism that could explain the synchrony-pro-sociality link is empathic concern (Valdesolo & DeSteno, 2011). Responders' ratings of how they felt at the moment of the accident did not support this possibility. Yet, it may be that children had difficulty expressing their emotions retrospectively. Their responses might have been influenced by their interactions during the time period between the moment of the accident and the administration of the emotion scale and/or by concerns of social correctness, such as appearing sorry for others' misfortunes. Coding the children's emotional expressions at the moment of the accident could therefore have provided valuable supplementary evidence; however, this was not possible due to restricted camera angle. Based on previous research, coding of facial expressions could yield more tacit cognitive processes of emotional processing (Ekman, 1993; Gross & John, 1997; Izard, 1992). To assess the role of empathy, future research should include multiple measures of emotion expression.

Future research can also address some other limitations of the current study. Firstly, to better substantiate and understand the links between synchrony and pro-sociality, it is important to examine the directionality of the observed outcomes. Does synchrony facilitate social closeness, interactivity and pro-sociality and/or does non-synchrony engender perceptions of low-level antagonism, dissonance and dissimilarity? The proposal that synchrony facilitated pro-sociality, rather than non-synchrony reducing it, would be in line with Rabinowitch & Knafo-Noam's (2015) findings showing no differences in perceptions of similarity and closeness between non-synchrony and solo conditions, but significantly higher ratings in both in the synchrony condition. Future studies should use baseline measures to systematically investigate how synchrony and non-synchrony contribute to pro-sociality.

Another limitation of this study concerns the possibility of a minimal group effect, rather than synchrony effect. The information given to children prior to the Clap & Tap Game that they might hear the same or different beats might have created the conditions for perceptions of groupishness. Following this instruction, intended to avoid interference of confounds (e.g., about partners' competence), children were told to follow their individual beat played through their personal headphones. Minimal group manipulations typically involve a group identity-building element in addition to the announcement of assignment to different groups, such as wearing group-coloured vests or doing a group activity (e.g., Dunham et al., 2011). Therefore, the observed effects are unlikely to be caused by a minimal group effect. Still, future research should explore ways of eliminating this possibility.

Extending the growing literature on the importance of coordinated movements for cognitive and social development, this study found that children helped each other more after a synchronous activity that resembles typical playground games. Investigations in

this area hold great promise for illuminating the connections among motor, social and cognitive development, ultimately expanding our understanding of the ontogenetic and evolutionary roots of human social behaviour. If future research finds evidence for long-term effects of movement synchrony, the findings may also potentially identify a subtle, effective and economical method to facilitate children's pro-social behaviour that may also helpfully inform clinical, educational and socio-political interventions. At the same time, the current findings raise questions with far-reaching scientific and applied import. How does the observed link between movement synchrony and pro-sociality manifest itself in older ages, as children's motor and social skills both improve to enable more intricacy in their social interactions? Can movement synchrony affect other aspects of social bonding and pro-sociality than just helping behaviour? To what extent can movement synchrony facilitate social bonding and pro-sociality?

Study 2 and some prior research (e.g., Rabinowitch & Knafo-Noam, 2015) showed an increase in pro-sociality following synchronous interactions. Notably, however, there was no friction or competition in the interaction contexts of these studies; in other words, there was no reason for the children to not socially bond with each other, provided that some affiliative cues were present. From an evolutionary perspective, however, it is important to find out how movement synchrony would influence bonding and pro-sociality when the children started off with negative and/or antagonistic feelings towards each other. Can synchrony forge bonds and pro-sociality in more challenging contexts like these as well? We know that as children get older, they start to structure the world based on social categories and group divides. Does movement synchrony contribute to how children structure their social worlds? Given its effects on facilitating pro-sociality, can movement synchrony help decrease the distance

between individuals from different groups and forge interpersonal bonds above and beyond already-existing group divides?

Answers to these questions contribute rich new insights on the links between social, cognitive and motor development. Moreover, they would have important implications for educational and social intervention programmes aiming to facilitate bonding across groups, such as among individuals coming from distant, unfamiliar cultures and backgrounds. The final study of this thesis investigates specifically whether and how movement synchrony forges social bonds across group divides. The following chapter will set the ground for the third study of this thesis by providing a comprehensive review of the literature on children's developing motor synchronisation, social and cognitive abilities, with special focus on the developing understanding of groupishness in middle childhood.

6

INTERPERSONAL MOVEMENT SYNCHRONY, COORDINATION AND PRO-SOCIALITY IN MIDDLE CHILDHOOD

In most industrialised countries, children in middle childhood, that is, between ages 6 and 11, go to primary school. This brings about huge changes in their lives. Children's social lives are increasingly dominated by interactions with peers in classroom settings, academic performance becomes a prominent issue, while at the same time the children are introduced to extracurricular activities such as music groups/choirs, sports teams or art clubs. This new, vibrant environment creates new opportunities for both motor and social development. With an increasing interest in sports, children engage in physical activities in peer groups, which involve a considerable amount of interpersonal coordination.

The children's improved fine and gross motor skills further enable them to move their bodies rhythmically and in synchrony with external beats. Social skills thrive also. Children's perspective taking skills are well developed by now, which enables them to understand better how others feel, what they want and to form and strive towards mutual goals with others. One marked change from earlier ages is the proliferation of groupishness; children not only perceive of their social world in terms of categories but also start forming their own identity on the basis of the groups that they belong to. This chapter will review the motor and social developmental changes that take place during middle childhood years. Similar to the structure followed in the preceding two literature review chapters, the current chapter will be divided into three sections and the findings will inform how the third study of this thesis will be conducted.

Study 3 aims to find out whether movement synchrony can foster bonds beyond existing group divides. Evolutionary theories assert the importance of synchrony for bonding across (genetically distant) groups (see Chapter 1). Therefore, it is important to test whether the positive social outcomes observed in Study 2 would hold when children start off with rather negative sentiment towards each other, possibly representing large

groups in the real-world more closely. In Study 3, the negative sentiment is incurred via use of an inter-group setting and bonding towards out-group members is assessed. Moreover, children perform full body movements rather than smaller movements such as clapping and tapping in order to avoid motor competency to interfere with the performance (Volman & Geuze, 2000) and to maximise children's perception of synchronisation.

Section 6.1 will start with a review of the various types of physical activities that the children perform between ages 7 and 12. Having constructed this ecologically valid framework, the section will continue to review more specifically how well children in this age group can perform synchronous movements in time to external rhythms. The synchronous movement manipulation of Study 3 will be implemented in line with the findings that emerge from this review. It is equally important to understand the range of social-cognitive skills that the children develop at these ages and how these developments influence social bonding and pro-social behaviour.

Section 6.2 will elaborate on the different types of pro-social behaviours (namely sharing, helping and comforting) that the children perform and the remarkable changes that occur in the children's peer relationships. The development of groupishness will be explained in more detail in a separate section and the importance of being part of a peer group, together with the potential consequences of social exclusion for social and cognitive development will be discussed. Again, the insights gained from the existing literature on children's social development will help shape the kinds of measures that will be used in Study 3 to assess bonding across group divides. Finally, in Section 6.3, the separately investigated domains of motor, social, cognitive and development will be investigated in relation with each other. Existing research on the effect of synchrony on

social bonding and pro-sociality as well as insights from some of the developmental disorders will be presented.

6.1 PHYSICAL ACTIVITY AND RHYTHMIC SYNCHRONISATION ABILITIES IN MIDDLE CHILDHOOD

In middle childhood, children's motor abilities develop in such a way as to enable them to perform physical activities in many different forms. Many of these physical activities take place in group settings and require the children to move rhythmically and to coordinate their movements with others. Physical activity (PA) therefore provides important opportunities for children to share, collaborate and emotionally engage with other children. Interactions during PA significantly influence children's friendships, social development and mental health (Smith, 2003). Differently from younger ages, children's motor development in middle childhood occurs mainly in organised physical activity contexts such as involvement with sports teams or dance. This section will first demonstrate the links between PA, social development and socio-cultural factors that influence PA. Next, the development of specific motor skills will be covered and finally, literature on children's growing abilities to synchronise movements with external rhythms will be reviewed.

6.1.1 Physical activity in real-life settings

The wide variety of PAs that children perform in middle childhood have been revealed by several longitudinal studies, which measured children's activity levels by examining their heart rate, self-reports and parental reports. The converging finding from these studies is that children in middle childhood are at least as physically active in early childhood but that activity levels decline as they approach adolescence (Malina, 2001; McGee, Williams, Howden-Chapman, Martin, & Kawachi, 2006). One distinguishing factor of children's PA patterns in middle childhood is the abundance of

organised PA, such as in team sports or dance clubs. Yet, children still engage in free play too, which is known to create affiliative bonds among peers (Pellegrini, 1988); in fact, it appears that rough and tumble play occurs more often in middle childhood than it does in early childhood or early adolescence (Pellegrini, Dupuis, & Smith, 2007). Several biological, social and environmental factors can influence the PA levels of children, including age, gender, social support, socio-economic status, availability of the facilities and cultural context (Findlay, Garner, & Kohen, 2009).

Across a number of cultures, it was consistently found that boys engage in more vigorous activity than girls (McMurray, Harrell & Bangdiwala, 1994; Whiting & Edwards, 1973). A survey investigating how children spend their free time reveals that boys participate in significantly more team sports than girls in all ages between 7 and 11 (Jacobs & Vernon, 2009). On the other hand, girls engage with individual sports more and also try out a larger variety of activities such as arts, drama and joining social clubs (Jacobs & Vernon, 2009). Arguably, much of this difference between team sport engagement of boys and girls has to do with social norms. At least in the specific cultural contexts in which these surveys are based, boys are often encouraged to join sports teams, whereas girls are encouraged to do more arts, craft and music related activities (Eccles, Wigfield & Schiefele, 1998; McHale, Crouter, & Tucker, 1999).

Cross-cultural studies show how cultural norms can strikingly influence the types of activities that children do. In non-literate, unindustrialised populations, play is often replaced by labour, as children need to work to earn money and/or do house chores such as taking care of younger siblings or the elderly (Larson & Verma, 1999). In post-industrial Western societies, however, play is conceived as the norm for children and on average, a 10-year-old child in the US spends around 3 hours a day playing, while this figure is around 2 hours for Japanese children and 1.2 hours for the Taiwanese

(Stevenson & Lee, 1990). In addition to influencing the PA engagement of children, culture can influence the meanings attributed to PA as well. One study conducted with 9- to 11-year-old children found that children from different ethnic backgrounds rated the importance of sports differently on peer acceptance and social status. More specifically, non-Hispanic Caucasians placed more importance on being good at sports than their African-American and multiracial peers (Chase & Machida, 2011). These findings clearly demonstrate that the social and cultural environment children are raised in can hugely influence the PA amount, type and its potential impact on social relationships.

Family-related factors are also important. For example, parents' overall interest in social, cultural, recreational and intellectual activities can predict 7- to 9-year-old children's participation in PA (McGee et al., 2006). It might be that parents who give importance to such activities pursue the opportunities for PA and encourage their children to participate more. In fact, it has been shown that parental monitoring and encouragement facilitates PA in both boys and girls of 9 years of age (Bradley, McRitchie, Houts, Nader, & O'Brien, 2011). Socio-economic status (SES) also reliably predicts children's PA involvement (McGee et al., 2006). While SES may be related to the parents having a pro-PA attitude as described above, on a more basic level, it allows children access to structured physical activities, such as joining sports clubs. In the absence of such facilities, the children spend more time playing at home (Ziviani et al., 2008); missing out on opportunities for adult supervision, trying out different types of activities and finding the one that suits their temperament and abilities the best (Findlay et al., 2009).

Research shows that there may be a complex network of factors that hamper organised PA involvement, including personal, social, financial, environmental and

policy-related factors (Beighle & Morrow, 2014). Although much of these factors might be relevant for attending organised sports clubs, an affordable PA setting with adult supervision can be integrated in the schools' physical education curriculum (Beighle & Morrow, 2014; Castelli & Ward, 2012) and/or constructed as part of before- and after-school clubs (Beighle & Moore, 2012). Given the importance of PA on children's health, it is of crucial importance that children be provided with opportunities for sufficient physical play in schools and in common play areas in their neighbourhoods (Castelli & Ward, 2012; McGee et al., 2006; Ziviani et al., 2008).

One feature that is immediately apparent in children's physical activities, be it within the context of organised sport, physical education in schools or children's free play on the streets, is that they occur in the company of other children (McHale, Crouter, & Tucker, 2001). A cross-national survey conducted by WHO on over 39,000 children aged between 11 and 16 years supports this by showing that children's engagement with PA was largely influenced by the activity levels of their best friends (Anderssen & Wold, 1992). Moreover, a 9-month long physical activity programme has shown that pairing up children with a peer encouraged cooperative learning and teaching of the physical activities and helping behaviour in 11-year-old children (Polvi & Telama, 2000). In another study, where 10- to 13-year-olds were asked about their opinions on friendship whilst thinking of their best 'tennis friend', the children reported companionship and enjoyment of the play as the most important factors (Weiss & Smith, 2002). All these findings indicate a strong association between bonded social relationships and PA involvement.

A comprehensive meta-analysis of the social benefits of sports in children and adolescents revealed that PA engagement, especially team sports, was associated with improved self-esteem and social interactions (Eime, Young, Harvey, Charity, & Payne,

2013). Parents and teachers also seem to view PA as correlated with social benefits. It has been found that parents of children aged 5 to 10 believe that in addition to obvious positive effects on physical health, their children's self-esteem and social interactions with friends improved as a result of engaging in sports activities (Neely & Holt, 2014; Wiersma & Fifer, 2008). Another study demonstrated that teachers' assessments of 9-year-olds were more positive if the children were engaged in sports activities than if they did not (Fletcher, Nickerson, & Wright, 2003; but see: Metsäpelto & Pulkkinen, 2012).

Studies have also revealed mental health benefits of PA. Performing team sports, rather than individual sports, was associated with fewer symptoms of depression (Eime et al., 2013) and social anxiety (Dimech & Seiler, 2010) in children. Further, engaging in sports activities reduced stress in adults (Sothorn, Loftin, Suskind & Blecker, 1999) and was negatively correlated with depression symptoms at 10 and 12 years of age (McHale et al., 2001). All these findings reveal a relation between PA and children's friendships and social development. Future research should investigate specifically which types of activities can help facilitate aspects of social development directly.

The most widely researched benefits of sports and PA are, however, on physical health. In adults, being physically inactive has been associated with various problems including obesity, cardiovascular diseases, hypertension, diabetes, osteoporosis and colon cancer (Pate et al., 1996; Haskell, 1996; Katzmarzyk, Malina & Bouchard, 1999). Similarly, in children aged between 6 and 9, body fat accumulation was found to be related to decreased PA, especially in boys, which suggests a risk for obesity in children who are not physically active (Ball et al., 2001; Malina, 1986). Importantly, there seems to be a continuity in people's PA patterns across the lifespan; both physical activity levels and sedentary behaviour style in early childhood were found to correlate highly

with PA in middle childhood (Jones, Hinkley, Okely, & Salmon, 2013), which then correlated with PA in young adulthood (Malina, 2001). Thus, promoting PA at early ages is important. With regards to the physical health benefits of PA, it has been recommended that children perform moderate to vigorous activity for 30 minutes, at least 3-4 times a week (Sothorn et al., 1999). However, due to the scarcity of research, no such recommendation exists in relation to the social and mental health benefits of PA (Poulsen & Ziviani, 2004).

Another type of PA that is frequently observed in middle childhood is dance. Dance can be defined as movement to music, where the spatial patterns of participants' motor movements temporally match the auditory stimuli coming from the music (Naveda & Leman, 2010). Widespread benefits of dance are proposed for the development of motor skills, social interactions, cognition and physical health. For instance, it has been shown that 8- to 11-year-old children's body-mass index significantly improved following attendance to a 10-week long dance programme (Huang, Hogg, Zandieh, & Bostwick, 2012). Another study showed that a 6-week long dance programme could enhance children's self-esteem, perceived body image and their ability to verbally express others' actions and emotions (Riley, 1987). A number of observational studies have been conducted in schools that adopt special arts and dance programmes in their curriculums. These observations have revealed that dancing enhanced the community feeling within the school and improved the children's academic achievement, confidence, sympathy and negotiation skills during social interactions with peers, reading and writing skills and understanding of mathematics concepts (Bradley, Bonbright, & Dooling, 2013; Soto, 2001). It seems thus that, similar to sports, dance offers a wide range of social and cognitive benefits.

The social context and the complex cognitive processing involved in dance appear to be instrumental in producing such diverse effects. We know that when teaching dance, instructors make use of a number of cognitive skills such as mental imagery, planning, decision making, memory and abstract thinking, e.g., metaphoric thinking about the choreography and the dance moves (Overby & Bradley, 2003). Several controlled studies with 8- to 10-year-old children have further shown that being taught a subject matter with a dance-like performance improved learning in topics ranging from history and bicycle safety to anatomy and physical science concepts (Overby & Bradley, 2003; Overby & Durr, 1993). For example, in the performance on physical science concepts, the performers demonstrated gravity, friction and kinetic energy principles with their dance moves and songs that were embedded in an age-appropriate, theatrical plot (Overby, 2015). The embodiment of abstract ideas in rhythmic, repetitive visualisations may have helped children to grasp and remember concepts better. However, despite the known positive effects of dance, unlike sports, dance has not been part of the educational curriculum in most countries (Gilbert, 2005). Even in places where dance courses are offered in some of the schools, such as the United Kingdom, Denmark or Canada, the courses have not become a regular part of the curriculum and are generally taught under the umbrella of physical education lessons (Gilbert, 2005). More experimental studies are needed in order to examine directly how dance yields these, and possibly other, effects.

The existing research on children's daily PAs suggests that PA, in the form of sports or dance, can foster children's self-esteem, mental health, aspects of cognition and social interactions. Given that PA often takes place in a social context with peers, it can offer invaluable opportunities for children's social development, including opportunities to work together with others, to see themselves in comparison to their

peers and to develop friendships (Smith, 2003). More research is needed to find out the whole range of benefits of PA and the particular features of PA that give rise to those positive outcomes. For the purposes of the current thesis, however, it is important to view PA and its effects within the context of coordinated motor behaviour influencing social and pro-social development. The following two sections will expand on this view by revealing the specific motor skills that children develop at this age and their growing abilities to synchronise movements with external rhythms and with others.

6.1.2 The development of motor skills

The wide range of physical activities mentioned in the preceding section are possible thanks to the developing motor abilities of children. It has been even suggested that having the required motor skills is essential for enjoying the physical activities and for the positive outcomes of PA to follow (Poulsen & Ziviani, 2004). In middle childhood, both boys and girls go through significant physical changes; their height and weight increase, limbs and muscle systems grow and functioning of certain brain areas improve (for a review see Malina, 2004). All these influence the action capacities of the children and hence, are related both to PA and to the children's coordination and synchronisation skills. The current section will provide a review of how children's motor abilities develop including consideration of various factors that influence them, such as gender and cultural context.

While examining motor development in early childhood, we have looked at movements that have been classified as fundamental motor skills (FMS). Moving on from there, in middle childhood, children start to acquire skills to perform specific movements demanded by the organised physical activities they increasingly engage with, including skills for hiking, rugby, volleyball, diving, gymnastics, wrestling, canoeing and so on (Haubenstricker & Seefeldt, 1986). Thus, while early childhood

ages have been categorised as the “Fundamental Movement Phase”, ages 7 to 14 have been categorised by different researchers as the “Sport-related Movement Phase” (Seefeldt & Haubenstricker 1982), “Specialised Movement Skill Phase” (Gallahue, Ozmun & Goodway, 2012) or “Skilfulness”(Clark & Metcalfe, 2002). The middle childhood ages, subsumed within this group, are thought to serve as a transitional period from FMS towards skill specialisation. Based on the existing research, several general principles can be extracted about the nature of the development of motor skills: Motor changes with age (i) are marked by being qualitatively different from the actions performed at younger ages, (ii) follow a similar developmental sequence in all children, (iii) build upon previous experiences and capabilities, (iv) are directional; that is, going towards advancing or declining the performance of a particular type of motor movement, (v) interact with other personal, social and environmental factors, and (vi) can occur at different rates in different children (Goodway, Ozmun & Gallahue, 2013). Thus, the specialisation stage that children in middle childhood go through is closely related to their FMS development. Skills specialisation, then, essentially relies on further development of children’s already-existing FMS from early childhood years; thus, FMS development in middle childhood will be explored further in the remainder of this section

To recapitulate, FMS consists of three categories: body management skills (e.g., balancing and coordination of body parts), locomotor skills (e.g., running, jumping, skipping) and object control skills (e.g., throwing, kicking, striking using a bat) (*Fundamental movement skills: Learning, teaching and assessment*, 2013). Compared to younger ages, children in middle childhood perform better in all areas of FMS; still, the development of FMS continues within the middle childhood period as well. Between ages 7 and 11, children run faster (e.g., Curtis, 1975; Keogh, 1969; Vincent,

1968), do longer standing jumps and jump and reach further (Branta et al., 1984), with minor differences observed between boys and girls (Reuschlein & Haubenstricker, 1985). For example, within those 4 years, children manage to run about 80 cm more per second and do standing jumps 50 cm longer (Haubenstricker & Seefeldt, 1986). Similarly, for the object control skills, by age 11, children can kick a ball much further (Keogh, 1969), strike objects with greater precision and velocity (Williams & Breihan, 1979) and throw objects more than double the distance 7-year-olds can do (Hardin & Garcia, 1982). As was the case in early childhood, however, boys perform better than girls at object control skills, including kicking a ball (DeOreo & Keogh, 1980), striking an object with another object (e.g., hitting a ball with a bat or throwing an object from a distance), with the gender gap increasing even further from 7 to 11 years (Haubenstricker & Seefeldt, 1986). These gender differences in certain motor skills are likely a combination of physiological differences (Eckert, 1973) and social norms promoting certain types of physical activity among boys more than girls, such as kicking, striking or throwing (Malina, 2004).

Studies conducted in different countries corroborate further the idea that the cultural context in which the children grow up may influence the development of their FMS. One tool frequently used to assess motor development is the Test of Gross Motor Development 2 (TGMD 2; Ulrich 2000). This test assesses the children's locomotor and object control skills in a variety of tasks and was standardised in a large sample of US children representative of the US population in terms of age, gender, race, parental education, rural versus urban background and so on. Administration of this test in other countries than the USA has provided insights on the cross-cultural variation that exist in motor development. Those studies have shown that compared to their American peers, Belgian (Bardid et al., 2016) and Brazilian children (Valentini, Spessato & Rudisill,

2007) performed more poorly in object control skills, while Chinese children scored significantly better in both locomotor and object control skills (Pang & Fong, 2009). The authors suggested that the differences in physical education programmes that the children are exposed to in their schools and the cultural meaning and importance attributed to PA may account for these variations from the US samples. Another study examining motor competence of 7- to 8-year-old Australian children, using a different assessment method than TGMD 2, also reported a mismatch between the Australian children's performances and the US-based norms (Okely & Booth, 2004).

Investigating such contextual differences is important for understanding the factors that influence PA and for making recommendations on the optimum PA levels. Importantly, however, regardless of the differences in specific measures, such as on how fast American children can run compared to their Belgian peers, a cross-cultural trend of age-related improvement in FMS is observed. This supports the aforementioned general principle that while cultural values and experiences may affect FMS, it nevertheless follows a general sequential and directional developmental pattern (Goodway, Ozmun & Gallahue, 2013).

The development of motor skills, and FMS in particular can importantly guide children's PA levels. In fact, there seems to be a dynamic, relation between FMS and PA (Stodden & Goodway, 2007). More specifically, children who have developed FMS in early ages tend to engage in more sophisticated PA types later in life and those who engage in PA get more opportunities for neuro-motor development and thus, have more improved FMS (Holfelder & Schott, 2014). It is likely that other factors such as cultural context, socio-economic status, education, and psychological traits influence this relation between FMS and PA. More research is thus needed to identify the role played by each of these factors before a direct cause-effect relationship can be established

between FMS and PA (Kambas et al., 2012). The literature reviewed in this section has shown that a complex set of factors contributes to the children's developing motor skills in middle childhood. Importantly, for the aim of the current thesis, the proficiency gained in performing motor movements also transfers into the children's rhythmic and synchronised movement abilities. This will be the focus of the following section.

6.1.3 The development of rhythmic and synchronised movements

Improvements in movement skills are reflected on the children's abilities to move rhythmically and synchronously. In Chapter 4, we have seen that children become more proficient in matching the timing of their movements to external rhythms in middle childhood. Still, certain restrictions apply, such as the external rhythm having to be within the children's SMT range and/or slightly faster, but not slower. In middle childhood, children become able to synchronise much more flexibly. Arguably, the many rhythmic physical activities that the children perform as part of their sports or dance involvement (see Section 5.1.1) help them acquire better interpersonal coordination and synchronisation skills.

Research suggests that the developments in motor abilities largely account for the children's improved synchronisation performance. Firstly, it is only at around 6-7 years of age that children start to master control over their posture and body scheme (Assaiante, 2012). Importantly, middle childhood may be a critical period in this respect, as children's control over their body parts decreases again in adolescents, due to unpredictably quick changes in limb growth (Assaiante, 2012). Moreover, studies on children with DCD, a neuromotor disorder marked by impairments in motor coordination difficulties, have illuminated the role of motor capacities for synchronisation. For example, 8- to 13-year-old children with DCD performed worse

than their typically developing peers in a finger flexion synchronisation task, a pattern of performance that was not related to attentional problems (de Castelnau, Albaret, Chaix, & Zanone, 2007). To determine what specifically was underlying the DCD group's difficulties, a follow-up study focussed on the brain networks involved. EEG scans of 8-to 9-year-old children with DCD taken whilst performing a rhythmic finger flexion task in synchrony revealed that the children did extensive motor planning prior to performing the movements in order to compensate for their deficits in maintaining synchrony (de Castelnau, Albaret, Chaix, & Zanone, 2008). Thus, lacking skills to perform and process motor information seems to directly impact on children's synchronisation performances.

Abilities to synchronise movements with external rhythms improves significantly from early childhood to middle childhood ages and onwards (Kuhlman & Schweinhart, 1999). In Chapter 4, we observed that young children's synchronisation success was highly dependent on the external rhythm's compatibility with the children's SMT and simplicity of the movements (i.e., single, upper body movements were easier). In middle childhood, children synchronise with external rhythms with increasing proficiency. For instance, when asked to move a lever or tap their fingers in time to some external beats, children between ages 6 and 12 were able to tap increasingly closer to the beat (i.e., asynchronies declined with age; Smoll, 1974). Across ages 7 to 11, not only does children's in-phase and anti-phase tapping synchrony precision increase, but also their synchronisation patterns become more stable (Volman & Geuze, 2000).

From early adolescence onwards, however, children's synchronisation abilities start to stabilise and approach near-adult levels (Thompson et al., 2015), with not much difference observed between ages 12 and 16 (Wolff & Hurwitz, 1976). However, it would be misleading to interpret these findings as implying that only from adolescence

onwards can children reliably synchronise with external rhythms. While the incremental developmental pattern until adolescence is clear, we know from research on early and middle childhood that by age 7, children are able to synchronise their movements provided that certain conditions are met, e.g., that the external rhythm is close to their SMT range (Drake et al., 2000; McAuley et al., 2006; Petzold, 1966).

Research shows that children aged 8 to 11 do not significantly differ in their abilities to perform dual motor rhythmic movement tasks, e.g., clapping hands and walking at the same time (Getchell, 2006) and in synchronising their tapping rhythm with an external beat (Drewing, 2006), suggesting that stabilisation of synchronisation abilities begin around these ages. Also, the type of movement may influence synchronisation performance. For example, whereas performing fine motor movements, such as finger tapping, may be more challenging than gross motor tasks in middle childhood, the speedy changes in limb length can make it harder for adolescents to proficiently perform whole limb movements as they are at fine motor movements (Assaiante, 2011). It is thus safe to conclude that synchronisation tasks involving certain movements and rhythms can be reliably applied to children in middle childhood. Bearing all these considerations in mind, as well as the milestones in social development, the final study of this thesis will investigate a sample of 7- to 11-year-old children (described in Section 7.1.1.1).

Studies have also examined factors besides age that influence children's synchronisation abilities. For instance, it was found that across all ages between 5 and 16, girls synchronised better than boys in a finger tapping task (Wolff & Hurwitz, 1976). Although the reasons for this have not been investigated in particular, the authors speculated that it may have to do with the earlier development of left hemisphere in girls, which is known to aid controlling the serial organisation of repetitive motor

movements. Another study showed that 10- to 12-year-old children displayed mirror-neuron activation (i.e., mu desynchronisation) while watching visual rhythmical stimuli but not while listening to auditory rhythmical stimuli (Hilderman, 2015). This may suggest that children's synchronisation performances can be facilitated by presenting them with visual rhythmical stimuli, such as another person performing the same rhythmical movements. Experience with rhythms seems to influence synchronisation performance also. One recent study revealed a positive relationship between proportion of life spent playing music and finger tapping performance in all ages starting from middle childhood (age 8-14) through to late adulthood (age 51-80) (Thompson et al., 2015). This finding is in line with Kirschner and Ilari's (2013) findings described in Chapter 4, which demonstrated the positive effects of growing up in a culture where music and rhythms are prominent, on young children's synchronisation performances. This supports an important role for cultural factors in the development of synchronisation abilities.

Another clear trend in children's synchronisation performances in early childhood was the facilitatory impact of social context. A similar effect seems to occur in middle childhood as well. For example, one study found that when presented with a musical piece and asked to move their bodies in synchrony with the musical rhythms, 9-year-old children moved their bodies more intensely when in groups of 4 than when they were on their own (De Bruyn, Leman, & Moelants, 2008). Applying the same methodology with adolescents, it was also found that participants synchronised better with the rhythm of the music in the group context than in the individual context (Leen, Marc, Michiel, Frank, & Dirk, 2009). Further, a comparison between within-condition correlations of 'group' and 'individual' conditions revealed better synchronisation among participants in the group than in the individual condition. Numerous factors may play a role here;

being in a group setting may feel more natural, alleviate social embarrassment, allow for showing off and facilitate rhythmic movement intensity. It may also be that seeing others move their bodies rhythmically and synchronously facilitates one's own movements due to increased mirror neuron activation (Hilderman, 2015). Only future research can disentangle which of these factors, and possibly others, account for the positive effects of social context on stimulating participants' movement intensity and rhythmic synchronisation.

6.1.4 Conclusion

The existing research on motor development shows that important improvements in synchronisation abilities occur in middle childhood years. Children's increased capacity to perform fine and gross motor movements more proficiently and experience more rhythmic and coordinated movements in their daily lives contribute to this development. Similar to what has been observed in early childhood, however, children at these ages still synchronise better in the presence of other individuals. This lends support to the idea of a relationship between synchronous movements and social interactions in middle childhood. To investigate this point further, the final study of this thesis will look at how movement synchrony influences social bonding within and across groups of children. Before moving on to the details of this study, however, the following two sections will review the literature on social and pro-social development in middle childhood (Section 5.2) and the links between movement synchrony and coordination and children's social-cognitive development (Section 5.3).

6.2 PRO-SOCIALITY IN MIDDLE CHILDHOOD

By the age of 7, children have already acquired a wealthy repertoire of social-cognitive skills and pro-social behaviours. Importantly, there is continuity between children's pro-sociality in early childhood and middle childhood (Malti, Gummerum,

Keller, & Buchmann, 2009). In middle childhood, children are much more proficient in understanding the emotional and mental states of others and responding to them accordingly. In Section 6.2.1, we will thus review the continuation of the development of socio-cognitive skills and pro-social behaviours. This review will provide a foundation for the measures of social closeness and bonding that will be used in Study 3.

The biggest change that marks the developments in this age group is observed in their integration into the society. Children come to internalise the moral values and social norms of their society and apply them as they reason about and respond to others. Perhaps the best indication of children's social integration is the immense demonstration of groupishness in their own social interactions. Children not only hang out with peers, but also start to identify themselves in reference to their groups. To capture the changes in groupishness, Section 6.2.2 will provide a review of the development of peer relations and inter-group behaviour.

6.2.1 The development of socio-cognitive abilities and pro-social behaviour

Previously, we have seen that children start being able to identify their own and other people's emotions and reason about the causes and consequences of certain emotional states around ages 4 to 6. Importantly, these abilities contribute to how children express their own emotions and regulate them during interactions with others, for example by suppressing an urge to react physically when feeling angry at a peer. Understanding other people's intentions and beliefs further facilitates social interactions and pro-social behaviour, and development in these areas continues in middle childhood ages as well. In addition to evaluating others' actions on basis of their individual mental

states, however, a new dimension now comes into play, which considers moral, societal values. All these, in turn, are reflected in children's pro-social behaviour.

Research shows increased sophistication in children's abilities to understand others' emotional and mental states in middle childhood years. For instance, in one study, 8-year-old children were shown video clips depicting distressing scenes, while their heart rates and facial expressions were recorded (Gurthrie et al., 1997). In addition, children's emotion regulation abilities were assessed with a test and self-reports were obtained on their experiences of watching the video clips. It was found that those children who had greater emotion regulation abilities sympathised more with others' distress, as evidenced by their facial expressions, heart rate changes and self-reports. Approaching middle childhood, children also begin to acknowledge continuity in others' mental states across time points and contexts. For instance, the children understand that others' pre-existing beliefs may influence their future food preferences (Carpendale & Chandler, 1996) and how they approach morally challenging situations (Chandler, Sokol & Hallett, 2001). These findings show that children start to use their socio-cognitive skills effectively in evaluating social situations and interactions with others. It was shown that social and affective perspective taking abilities correlate significantly with sociability with peers (LeMare & Rubin, 1987). In other studies with typically developing, deaf children and children with autism spectrum disorders (ASDs), theory of mind (ToM) understanding predicted peer social skills as assessed by the children's teachers (Peterson, Slaughter, Moore, & Wellman, 2016). Importantly, however, in children with ASDs, this relation between socio-cognitive abilities and sociability with peers is not direct but instead is mediated by language ability. It seems, then, that fostering the development of social-cognitive and communicative skills at

early ages can greatly improve children's social functioning later in childhood and possibly beyond.

Another socio-cognitive area that shows marked development in middle childhood is morality. Children assign moral values to actions as being right or wrong and prefer those who act morally, e.g., distribute resources fairly (Mulvey, Hitti, Rutland, Abrams, & Killen, 2014b). They can distinguish between moral judgments, i.e., rules pertaining to harm, fairness and rights, and social conventions, i.e., rules pertaining to organising the social life such as etiquettes (Helwig & Turiel, 2004). Children's moral judgments and pro-social behaviour seem to significantly affect each other too. Between ages 5 and 9, correlations have been found between the amount of pro-social behaviour that the children display and the following moral domains: how much punishment the children believe moral transgressors deserve, how much emotion they attribute to moral transgressors (Malti, Gasser, & Gutzwiller-Helfenfinger, 2010), how much sympathy the children feel towards those who are affected by immoral acts and how morally motivated the children are to act pro-socially (Malti et al., 2009).

With increasing age, other aspects of social interactions, such as reputation concerns, start guiding moral behaviour. For example, when asked whether they would help and share with another individual, 7- to 12-year-old children's responses corresponded to their opinions not only on the moral value they attributed on pro-social behaviour, but also on how much they would be bothered if their peers evaluated them as being mean for not acting pro-socially (Jackson & Tisak, 2001). A survey conducted with 8- to 11-year-old children provides further insight on children's conceptions of morality and pro-social behaviour. In the survey, children were asked what they thought other children would do if they wanted to be nice to others. The most frequently reported behaviours were affiliative behaviours such as making friends with others, and

sharing and caring for others (Greener & Crick, 1999). This suggests that children place positive moral values on pro-social behaviour.

Considering the different types of pro-social behaviour, namely helping, sharing and comforting, striking changes occur in sharing behaviour in middle childhood, while helping behaviour remains intact and comforting continues to increase gradually (Jackson & Tisak, 2001). To experimentally assess children's sharing behaviour, researchers created a task in which the children were asked to distribute resources between themselves and a friend in three different conditions: Prosocial, Envy and Costly Sharing. Within each condition, children chose one of the two options provided to them, which determined how resources (e.g., sweets) would be distributed. The options were as follows, where the first number corresponds to what the participant child gets and the latter number to what the recipient gets: Prosocial (1/1 versus 1/0), Envy (1/1 versus 1/2) and Costly Sharing (1/1 versus 2/0). This means that, in the Prosocial condition, the child can choose Option 1 (1/1) and distribute resources equally, or choose Option 2 (1/0) and take 1 for self and give 0 to the recipient.

The studies revealed that children at 8 years of age, but not 4- to 7-year-olds, preferred to share equally over options of both advantageous (1/0) and disadvantageous (1/2) inequity (Blake & McAuliffe, 2011; Fehr, Bernhard, & Rockenbach, 2008). In fact, this developmental trend continues throughout middle childhood, with 8- and 10-year-old children choosing the option that benefits the recipient more often than do 6-year-olds (McGuigan, Fisher, & Glasgow, 2016). These findings support the widely accepted idea of a positive association between age and pro-social behaviour. Yet, what is even more striking than the incremental change in pro-social sharing behaviour is the increasing intricacies involved in it.

Children's sharing behaviour appears to be very selective, with social context and particular conditions of the recipient being taken into consideration. For instance, in the Costly Sharing condition (1/1 versus 2/0), where the children have to sacrifice part of their share if they are to share resources equally, children were pro-social only towards the recipient whom they liked (McGuigan et al., 2016; but see Berndt, 1985). On the other hand, in the Envy condition, where the pro-social sharing option was costly only relative to the recipient (1/1 versus 1/2), children chose to share equally with individuals who had a higher social hierarchical status, such as the head teacher but not the caretaker, in the school (McGuigan et al., 2016).

Selectivity based on the recipient's conditions was shown with a different sharing task as well, where 8-year-old children were given the opportunity to freely share or not share their own resources with another (hypothetical) child (Malti et al., 2015). The children shared more with those who were presented as needier (i.e., sad and lacking the resource being distributed), and as morally deserving (i.e., those with a record of sharing with and not pushing other children). Moreover, the children chose to share more with a neutral individual (e.g., neither needy nor not needy), than with a recipient who was depicted as not needy or morally undeserving. In a similar sharing task paradigm, children were also shown to share more with those who speak the same accent as themselves only if the children lived in regions where they were exposed to multiple accents (Cohen & Haun, 2013). These findings indicate that a number of social variables shape children's sharing behaviour. Before deciding to share their resources, the children factor in the social context, reputational concerns and the deservingness of the recipient by considering moral values as well as the recipients' unique circumstances, such as their neediness or similarity of accent.

Still other environmental factors, such as competency, conceptions about responsibility, parenting style and culture, seem to play a role in the manifestation of helping and comforting behaviours. In one study, 4-, 7- and 11-year-olds were presented with helping tasks that required novel skills that the children had gained within the context of the study, such as how to open a particular type of box (Peterson, 1983). Children across all ages helped equally when they witnessed someone unsuccessfully trying to open the box. However, when the tasks required real-world experience, such as how to wrap a package, older children helped significantly more than younger children. In addition, in both learning-based and experience-based tasks, children's helping behaviour increased based on their competency, which depended on training received at time of the study or on age-related real-world experience, respectively.

Another study, where the recipient of the pro-social act was either a toddler or an age-matched peer further showed that perceived competency and responsibility influence 6- and 9-year-old children's pro-sociality (Midlarsky & Hannah, 1985). The children participating in the study witnessed an accident in which another child tripped over and fell on the floor in pain. More help and comforting was provided by the older children, when the confederate child was younger, (i.e., a toddler), and when they expressed more pain. The participants in this study were also interviewed afterwards about their decisions on whether to provide help. The responses suggest that fear of inadequacy and uncertainty as to whether it was the children's responsibility to interfere with the incident played an important role in their decisions to help.

Being largely dominated by studies conducted in Europe and the USA, the existing literature offers few opportunities to assess culture-related factors that may affect pro-social behaviour. However, at least one study aimed to capture this variation and investigated 7- and 8-year-old children's sharing behaviour with a classmate by

examining a range of factors, such as race, parenting style and children's moral reasoning (Stewart & McBride-Chang, 2000). Compared with their Caucasian peers (from Australia, England, America, South Africa and Canada), Asian children (from China, Thailand, India and Japan) gave more of their resources to a classmate. Parenting styles that emphasise other people's needs and training of the child by parents were positively correlated with children's giving behaviour. Integrating other-oriented motivations into one's own moral reasoning further increased children's likelihood of sharing, compared to those who had a self-oriented focus (Stewart & McBride-Chang, 2000).

Overall, we have seen in this section that the dynamic relationship between children's developing socio-cognitive skills and pro-social behaviour continues in middle childhood. Cultural and moral values, parenting style, context-specific considerations such as sense of responsibility and competency in performing the pro-social act or the recipients' conditions are some of the known factors that influence this dynamic relationship. One aspect of development that shapes children's social life and behaviour considerably at these ages is the emerging idea of the group. The next section will take a closer look at how group memberships affect self identification and social interactions with peers.

6.2.2 Peer relations and the development of groupishness

Human children form categories to make sense of their social world from very early ages onwards. In his seminal work, Bruner (1957) explains in detail how readiness to perceive stimuli in terms of categories occurs and that such readiness in cognitive processing is a "necessity for smooth adjustment" to changing situations (p. 149). As children grow, their categories start to be shaped according to the social environment

and cultural values to which they are exposed. Their construal of social groups start to change from mere perceptual categories into categories that meaningfully and crucially shape the children's own identity and behaviours (Bruner & Haste, 1987).

In middle childhood, there is an incremental change in children's peer group interactions, which maps on to a growing sense of groupishness. Following Brown (2000), I use the term groupishness to refer to group-based self identification, marked positivity, affiliation and cooperation with in-group members and derogation and/or discriminatory attitude towards out-group members. Middle childhood ages are optimal for groupishness to flourish, as children's socio-cognitive abilities allow them to engage with others at the group level better than in early childhood and the quest for autonomy, which characterises adolescence, has not yet emerged. Children at these ages identify themselves based on their group memberships, believe that group norms should be abided by and that those who transgress from the norms can be excluded from the group.

Daily life experiences of engaging with multiple groups and better social perspective taking skills can contribute to understanding the group norms and to group cohesion (Abrams, Rutland, Pelletier, & Ferrell, 2009). Similar to adults, children view family, sports teams and best friends as highly cohesive groups and list the most important defining characteristics of groupishness as working towards common outcomes, reciprocal interaction and interdependence among group members (Svirydzenka, Sani, & Bennett, 2010). This understanding is apparent in children's own interactions too. In group settings, children display an increasing amount of inter-subjectivity, attention sharing, complementarity in conversations and collective decision making (Gummerum, Leman, & Hollins, 2014). This section will present a review of

the research on the importance of groups in children's daily interactions with peers, on how groupishness manifests itself in attitudes towards in-group and out-group members and finally on ways to alleviate inter-group biases and facilitate social bonding.

Similar to early childhood, status within the peer group and acceptance by others continue to be prominent features of children's interactions. Importantly, a child's status within one group may determine his/her status in another group, making peer acceptance/rejection of broad relevance and an indicator of overall social functioning (Coie & Dodge, 1983; Coie & Kupersmidt, 1983). Popularity and peer acceptance correlates positively with helpfulness, cooperative behaviour and compliance to group norms and negatively with aggressive and withdrawal behaviours (Coie, Dodge & Kupersmidt, 1990; Newcomb, Bukowski, & Pattee, 1993). Inter-group dynamics are sharpened with the emergence of competing peer groups. Group norms define which behaviours are un/acceptable and what the group's stance would be towards individuals who perform them (DeRosier, Cillessen, Coie & Dodge, 1994). Accordingly, children may become subtler in the way they express approval and resentment. For instance, rather than arguing or fighting with others, children may consult other group members and decide to isolate a child who does not seem to be a good fit to the group (Younger, Schwartzman & Ledingham, 1986). In that sense, excluding others from the group may even have a social bonding effect for the remaining group members (Bukowski & Sippola, 2001). So, how do group dynamics come to play such an important role in children's social interactions?

Numerous theories have been put forth in order to explain the development of groupishness. Notwithstanding the differences among these theories, several developmental patterns emerge: Firstly, with age, a transition is observed from

favouring self (early childhood) to favouring the in-group (middle childhood) to finally acknowledging the mutual existence of multiple group identities (Aboud, 1988). The peaking of groupishness in middle childhood occurs as children progress from a mere awareness of the existence of different categories to internalising the group values (Bennett & Sani, 2011). For example, even though infants as young as 3 months of age may have a preference to look longer at own-race faces (Kelly et al., 2005), it is only after 5-6 years of age that race is perceived as a socially meaningful category (Kinzler et al., 2010). A common way of evaluating the intensity of groupishness is via examining differential attitudes towards the in-group and the out-group. Following Tajfel (1970), groupishness has been assessed via intergroup biases, namely increased likelihood of displaying positive sentiment and prosocial behaviour towards members of the in-group on the one hand, and discriminatory attitude and anti-social behaviour towards out-group members on the other. In research with children, preferences for the in-group and prejudices against the out-group members (Nesdale, Durkin, Maass, & Griffiths, 2004), differential evaluations about norm transgressors, and decisions to include/exclude others from the group (Abrams & Rutland, 2008) have been examined as ways to measure intergroup biases.

In order to test these proposed effects of groupishness, it is essential that appropriate methods be used. Seemingly subtle differences in methodology can importantly affect the outcomes in groupishness research. One recent study showed, for example, that when group labels were not provided, children younger than 7 years of age failed to establish a social category only based on visual cues shared between the group members, such as having similar skin colour or wearing an accessory (Baron, Dunham, Banaji, & Carey, 2014). Another methodological consideration receiving increased attention is on the benefits of using implicit measures. While explicit

measures simply ask the participants about their opinions of the in- and out-group, (e.g., with questions such as “How much do you like the in-/out-group?”), implicit measures aim to detect intergroup biases without the participants having to say them explicitly.

A classical implicit measure used with adults and recently adopted for use with children is the computerised Implicit Association Test (IAT) (Baron & Banaji, 2006; Rutland et al., 2014). This test assesses how quickly participants allocate positive and negative traits to in- versus out-group members. Longer delay in assigning positive attributes to an out-group member, for example, is taken as an indicator of implicit out-group bias. Sole reliance on explicit measures becomes a concern especially in older ages, as children learn that discrimination and hostile attitudes are socially unacceptable and hence refrain from expressing them overtly (Banaji, Baron, Dunham, & Olson, 2008). A series of studies have provided support for this point by examining children’s race-based intergroup attitudes. While explicit self-report measures revealed a decline in out-group bias around middle childhood, the use of IAT demonstrated stable in-group favouritism and out-group derogation across 6- year-olds, 10-year-olds and adults (Baron & Banaji, 2006; Dunham, Baron, & Banaji, 2006; Rutland et al., 2014). This suggests that intergroup biases are observed widely all throughout childhood and implicit (but not explicit) measures are able to capture this.

One of the earliest forms of groupishness to emerge is gender-based social categorisation. A series of studies using self-identity measures adopted from social psychology research investigated 5- to 10-year-old children’s level of self identification with gender groups. For instance, children were asked to evaluate the suitability of certain gender-stereotypical traits to self (e.g., clean and polite for girls and strong and brave for boys). It was found that children more often attributed those adjectives to

themselves that were typical of their gender group (Bennett & Sani, 2008c). Expanding on these findings, two other studies have given children certain adjectives and asked them how well each adjective suited to self, the in-group and some neutral groups such as animals (Bennett & Sani, 2008b; Sani & Bennett, 2009). The in-groups were constructed based on gender, family and age. When asked later to recall which traits belonged to whom, children confused self-related adjectives more with in-group-related adjectives compared to the neutral categories (Sani & Bennett, 2009). Moreover, children remembered the traits describing the in-group just as much as those describing self (Bennett & Sani, 2008b). Self stereotyping and similarities in cognitive processing (e.g., memory recall) when dealing with tasks related to self and the in-group have been interpreted as suggesting an overlap between the self and the in-group. These findings thus indicate that from 5 years of age, there is considerable blurring of the boundaries between self and the in-group at least as far as groups based on gender, family and age are concerned.

Another salient social category that has been widely investigated is race (i.e., skin colour). As mentioned earlier, intergroup biases on the basis of race can be observed early in childhood, starting around 3-4 years of age, and peak at middle childhood. A comprehensive study investigated 10-year-old children's explicit judgments about exclusion of girls and Black children from one-to-one friendships, peer groups and schools (Killen, Lee-Kim, McGlothlin, Stangor, & Helwig, 2002). Children thought that excluding others based on race was more wrong than exclusion based on gender. Moreover, while a quarter of the participants evaluated exclusion as okay in friendship and peer group contexts, almost all of the participants (98%) reckoned it was unacceptable to exclude children from the school. This indicates that children's

intergroup biases are particularly reflected on their judgments about their own relationships.

Other studies with 6- to 10-year-old White children have shown that children were more likely to attribute negative traits to a Black than a White child (Rutland, Cameron, Milne, & McGeorge, 2014) and to an Asian than a White person (Dunham, Chen, & Banaji, 2013) and to rate a norm transgressor more negatively, and as more likely to continue behaving negatively in the future and less likely to be friends with others if the transgressor was Black than White (McGlothlin & Killen, 2006). Implicit assessments using IAT also corroborate these findings by revealing quicker attribution of positive traits to the in-group than to the out-group (Baron & Banaji, 2006; Rutland et al., 2014). Notably, however, these tendencies were not observed when the participants belonged to disadvantaged social groups; Black children did not favour their in-group but instead favoured Whites (Dunham et al., 2013). These findings are especially insightful in understanding how children's peer relationships work and what kinds of measures can be taken to alleviate discriminatory intergroup biases.

Interestingly, however, intergroup biases can emerge even in the absence of real-world divides such as gender or race. Research within the 'minimal group paradigm' has demonstrated that, in both adults and children, arbitrary group memberships can be sufficient to induce group-related stereotyping and preferences (Tajfel, Billig, Bundy, & Flament, 1971). In a minimal group paradigm, people are randomly assigned to groups based on trivial criteria (e.g., the toss of a coin) and their behaviours and attitudes towards in-group and out-group members are assessed afterwards. Developmental research shows that from around 5 years of age, children start displaying intergroup biases by overlooking the positive features of the out-group while at the same time

selectively encoding positive information about the in-group in minimally constructed groups (Schug, Shusterman, Barth, & Patalano, 2013). After the age of 6, children start to adopt a normative attitude to intergroup biases and expect others to behave in a biased way as well. It was found that children who expressed intergroup biases expected other in-group members to agree with them while they expected out-group members to disagree (Abrams, 2011). We have already seen that towards middle childhood, not only attitudes but also children's behaviours and moral evaluations start to be influenced by group membership. Therefore, although minimal group allocation is random, it can have sufficiently strong effects to be socially divisive.

Minimal group paradigm research in middle childhood reveals that children exhibit intergroup biases in a variety of domains. When split into minimal groups, children like the in-group more, rate them as being more similar to self (Abrams, Rutland, & Cameron, 2003; Nesdale & Flessner, 2001; Nesdale, Maass, Griffiths, & Durkin, 2003) and evaluate an antisocial act as morally more wrong when an in-group than an out-group member is affected by it (Rhodes & Chalik, 2013). Intergroup biases seem to become even more stark when minimal group membership is coupled with social categories that define real-world divides. It was found that, when the minimal in-group member was of the same ethnicity as the participant and the minimal out-group member was of a different ethnicity, children rated their in-group even more favourably than if ethnicity did not match with minimal group membership (Nesdale et al., 2003; Nesdale, Griffiths, Durkin, & Maass, 2007).

Interestingly, the social status effect previously mentioned in reference to race-based intergroup biases, comes into play here as well. In minimally constructed groups, where the in-/out-group's ethnic identity was similar to/different from that of the

child's, children who belonged to the ethnic group with lower social status reported a higher desire to change groups (Nesdale et al., 2004). This suggests that while minimally constructed groups are sufficient to evoke intergroup biases, children's attitudes are further qualified by social meanings that the groups carry.

Minimal group assignments can impact on not only relational attitudes, such as liking, but also behaviours. For instance, starting from 4 years of age, children trust and learn new information more from in-group members, even if the in-group informant has proven to be unreliable and the out-group informant has an established reputation of being reliable (MacDonald, Schug, Chase, & Barth, 2013). However, this in-group favouritism diminishes after 6-7 years of age, as children start to consider the reliability of the informant too, and not just their group membership (Elashi & Mills, 2014). Still, 6-year-olds discriminate against out-group members in other domains, such as when they apply costly punishment. If an out-group member allocates resources selfishly and thereby puts an in-group member at a disadvantage, children punish them more than if the perpetrator is from the in-group and the victim is an out-group member (Jordan, Mcauliffe, & Warneken, 2014). Support for other members of the in-group in this way implies that children acknowledge the importance of intersubjectivity and sticking together as a group. This is also evident in 7-year-olds' attributing responsibility to self for transgressions done by other in-group members (Bennett & Sani, 2011), although, interestingly, no embarrassment seems to occur (Bennett & Sani, 2008a). This lack of emotional involvement suggests that the sense of responsibility for others' misdoings stems from a normative assumption that group members should stick together as a cohesive unit.

A growing understanding of group norms also promotes endorsement of group coherence. Research has examined children's differential evaluations of norm transgressions depending on who has done it and whether the resulting act benefits or harms the group. One study showed that whereas 6- and 7-year-old children may favour in-group members regardless of their deviant behaviour, 9-year-olds are more sensitive about sustaining in-group norms and are more likely to include other individuals based on their compliance to group norms rather than based merely on their group membership (Abrams, Rutland, Cameron, & Marques, 2003). In another study, 5- to 11-year-old children, split into minimal groups, were presented with scenarios depicting deviant individuals (in-group or out-group members), whose deviant behaviour always benefited the opposing group. When asked about their preferences to include either one of those deviant individuals in their in-group, the children preferred normative in-group members to deviant in-group members and deviant out-group members to normative out-group members (Abrams, Rutland, & Cameron, 2003). This shows that children are very selective in their inclusion/exclusion evaluations, choosing those individuals who are likely to maximise the group benefit. This consideration also develops with age, as, in one study, children between 9 and 16 years of age even evaluated out-group members' transgressive actions as more favourable than those of in-group members', because the latter case incurred a threat to the group norms and group identity (Rutland, Hitti, Mulvey, Abrams, & Killen, 2015).

Children's group attitudes are also affected by their growing understanding of morality. For example, 9-year-old children stated that it was okay to exclude an in-group member who violated social-conventional norms (e.g., the dress code of the group) and moral norms (e.g., splitting resources unequally among group members), and include an out-group member who conforms to norms instead (Killen, Rutland,

Abrams, Mulvey, & Hitti, 2013). Yet, children can also distinguish between moral and social-conventional norms and weight their importance while making decisions about inclusion/exclusion. Children understand that a moral transgressor's actions are essentially unfair, while a social-conventional transgressor may ruin the routine functioning of the group (Hitti, Mulvey, Rutland, Abrams, & Killen, 2014). Accordingly, when presented with transgressors of a social-conventional versus a moral norm, 9- to 13-year-old children found it was more okay to exclude the moral transgressor compared to the social-conventional transgressor (Hitti et al., 2014).

Considerations of morality and fairness may thus influence, and sometimes trump, children's intergroup biases. When the group norm clashes with moral values (i.e., when the group norm is to split resources unequally), children prefer pro-equality transgressors over pro-inequality conformers even when the transgressor is an out-group member (Mulvey, Hitti, Rutland, Abrams, & Killen, 2014a). Similarly, in their own sharing behaviour, children tend to distribute resources equally between in- and out-group members from around 8 years of age (Fehr et al., 2008) and punish those who distribute unequally, regardless of their group membership (Jordan et al., 2014). It seems, therefore, that children do not blindly demonstrate intergroup biases but rather that their behaviours are qualified by moral concerns.

The research reviewed so far reveals an incremental pattern of groupishness such that children in middle childhood ages display a strong positive bias towards their in-groups and negative bias towards their out-groups. This is true irrespective of the basis on which the groups are formed, be it for gender, race or arbitrarily constructed groups. Importantly, however, children, like adults, conceal their negative attitudes towards out-group members when asked explicitly; yet, implicit measures confirm that the biases

persist all throughout childhood. These biases may be observed in children's reported liking of others, in their evaluations about others' deviant behaviours and in their tendencies to share with or include/exclude others. Importantly, children's understanding of moral values interacts with groupishness in determining their intergroup attitudes.

At the beginning of section 5.2, we have seen how groupishness is manifested in children's day-to-day interactions with peers. Peer groups serve as reference points for self-identification and socially acceptable behaviour and rejection by peers can have long-term negative consequences for children's social functioning. In fact, rejection can be so powerful that ostracism experienced during a brief online game session of Cyberball can temporarily hamper 8- to 9-year-old children's self-esteem (Abrams, Weick, Thomas, Colbe, & Franklin, 2011). Thus, it is important to tackle rejection and group discrimination early on in childhood. A vast amount of research has been done to identify the factors that contribute to rejection and group discrimination as well as to develop programmes in order to overcome their negative effects.

One group that stands out as being the target of peer rejection is children with attention deficit hyperactivity disorders (ADHD), a life-long condition whose prevalence is on the rise. ADHD is characterised by inability to maintain attention, fidgety behaviours and difficulty in organising and completing tasks without interruption (American Psychological Association, 2013). Such behaviours can cause serious problems in schools and organised activity settings, with children with ADHD failing to follow the rules in a group game or disrupting the progress of a class. Research has shown that ADHD-related behaviour patterns can lead to fewer friendships and an increased likelihood of being excluded from peer groups (Mrug et

al., 2012). Interviews reveal that children with ADHD report less involved interactions with friends starting from early childhood and persisting into early adolescence (Bagwell, Molina, Pelham, & Hoza, 2001). ADHD symptoms and social functioning seem to mutually influence one another all throughout childhood. It was found that experiencing peer rejection at 4 and 6 years of age predicted ADHD symptoms at ages 6 and 8, respectively (Stenseng, Belsky, Skalicka, & Wichstrøm, 2015). Further, a longitudinal study which followed up children diagnosed with ADHD for up to 8 years revealed that ADHD symptoms at 7-10 years of age were predictive of delinquent behaviour, depression symptoms, alcohol, cigarette and drug use and general impairment in social, emotional and interactional functioning in early adolescence (Mrug et al., 2012). The potential for such serious consequences call for effective treatment of ADHD and, crucially, increasing awareness in society to prevent exclusion of affected individuals from social life.

Intervention programmes applied in a variety of settings provide insights into how existing group divides can be dissolved. It has been shown that giving children the opportunity to obtain unbiased information about the other group through direct contact can effectively reduce race-, sex- and ethnicity-based intergroup biases (Gaertner et al., 2008; Hitti, Mully & Killen, 2011). Increased opportunities for communication among groups, such as is the case in racially heterogeneous schools (McGlothlin & Killen, 2006) or merely making children imagine themselves together with a member of the other group in a fun play setting (Cameron, Rutland, Turner, Holman-Nicolas, & Powell, 2011), can decrease negative out-group biases.

Given the importance of self-identification in driving groupishness, offering a new identity that encompasses the opposing groups' values can also alleviate negative

out-group biases. One intervention programme with 6- and 7-year-olds, for example, has successfully increased children's likelihood of preferring other-race and opposite-sex children as their favourite playmates, by emphasising that children of all groups were members of the same family (Houlette et al., 2004). Notably, however, the endurance of the effects of intervention programmes rely highly on broader environmental factors, such as parental attitudes. For example, one study on 9- to 16-year-old Spanish children's attitudes towards Africans and Gypsies revealed that, although children believed that excluding others was wrong, they could nevertheless do so out of conformity to their parents' views (Enesco, Navarro, Paradela & Callejas, 2002). Thus, although intervention programmes can help alleviate group discrimination in children, comprehensive programmes are needed to achieve long-term effects (Killen, McGlothlin, & Henning, 2008).

6.2.3 Conclusion

This section has reviewed research on social development in middle childhood years. We have seen that children's abilities to understand others' emotions and mental states improves; pro-social behaviour, especially sharing behaviour, increases; and groupishness, whereby children show a positive preference for the in-group and negative attitudes towards the out-group, proliferates. Moreover, all these developments in children's social behaviour are qualified by a growing understanding of morality. Groupishness is apparent in peer relationships as well and can result in exclusion of some children from peer groups and/or discriminatory attitudes towards out-groups altogether. All these findings suggest that a wide range of factors influence children's pro-social behaviour in middle childhood. The previous sections of this chapter have also shown the increasing trend in children's engagement with PA in schools, sports teams and dance clubs, all significant incubators for the emergence of friendships and

social bonding. In order to tie these two domains of development together, namely motor and social-cognitive domains, the following section will now examine the relations between them.

6.3 SOCIAL AND COGNITIVE CORRELATES OF MOVEMENT SYNCHRONY AND PRO-SOCIALITY

So far, the developments in motor and social-cognitive domains that take place in middle childhood have been examined separately. Yet, there are important two-way relations between those domains. For example, in children's everyday PA, which often involves playing in groups, certain socio-cognitive skills become crucial, such as following another person's attention, developing an action plan that requires remembering previous conditions of self and others, considering others' spatial and mental perspectives or anticipating others' future actions (Thomas & Gallagher, 1986). Hence, it should not be surprising to discover that improvements and impairments in socio-cognitive skills follow and precede improvements and impairments in movement skills. To investigate this further, the current section will focus on these interlinks and differential development patterns in children with certain motor, social or cognitive impairments. Direct links to rhythmic and synchronised movements will be made where possible. Finally, insights will be gathered from successful intervention programmes, whereby children's social-cognitive skills show improvements via rhythmic, motor performances.

A strong link has been found between cognitive deficits, namely learning disabilities and language impairments, and children's rhythmic, motor movement abilities. Compared to the typically developing population, as many as 6 times more children with learning disabilities experience motor problems (Woodard & Surburg, 2001). These problems include impairments in locomotor and object-control skills,

which are positively correlated with the children's disabilities in reading skills and mathematics skills (Westendorp, Hartman, Houwen, Smith, & Visscher, 2011).

Learning disabilities seem to specifically influence rhythmic production and synchronisation abilities as well. Several studies have found that children with learning disabilities performed less accurately and had more variation in the timing of their tapping while synchronising to external rhythmic beats (Brunt et al., 1983; Gilbert, 1983) and while reproducing them, although no differences were found in children's abilities to perceive the rhythms (Atterbury, 1983). Thus, it may be that the factors that contribute to children's learning disabilities also lead to motor problems without influencing perceptual processes.

Similar connections between cognitive and motor synchronisation skills can be seen in children with language impairments, namely dyslexia and Specific Language Impairment (SLI). Those children seem to have difficulties distinguishing between rhythms (e.g., Alcock, Passingham, Watkins, & Vargha-Khadem, 2000; Thomson & Goswami, 2008) and synchronising their tapping to external rhythms (Corriveau & Goswami, 2009b; Wolff, 2002). This indicates possible interference in both perceiving the external beats and integrating them with the timing of one's own movements. Importantly, the deficiencies in motor skills and synchronisation success were found to predict language and literacy outcomes concurrently (Corriveau & Goswami, 2009b) and prospectively between 2 and 7 years of age (Paul & Fountain, 1999).

Conversely, children with marked deficits in motor functioning can experience social and cognitive problems also. As was mentioned earlier in Chapter 4 (Section 4.3), developmental coordination disorder (DCD), a mainly motor problem, affects the social lives of a considerable number of children. In middle childhood also, associations have been found between DCD and internalising problems such as depression and anxiety,

externalising problems such as aggression and delinquency and lower perceptions of self-worth, social competency and social support (Piek, Baynam, & Barrett, 2006; Skinner & Piek, 2001). Importantly, undiagnosed children with motor problems, who were grouped as pDCD, also expressed low self-efficacy (Hay & Missiuna, 1998). Therefore, the established links between motor and socio-cognitive domains most possibly occur in a continuum. In fact, in groups of typically developing children, correlations have been found between muscular fitness and mathematics scores (Eveland- Sayers, Farley, Fuller, Morgan, & Caputo, 2009) and between the children's synchronisation performance with metronome beats and academic achievement, as assessed by lower scores on standardised tests of language, mathematics and reading abilities (Kuhlman & Schweinhart, 1999). Moreover, motor abilities at 6-7 years were found to be related to social status in peer groups at 9-10 years (Ommundsen, Gunderson, & Mjaavatn, 2010). Thus, facilitating motor development and providing extra social support to those who perform poorly can help decrease the negative psychological, social and cognitive effects that are observed (Cairney et al., 2010).

Several educational and social policy intervention programmes have implemented tasks involving music making and sports and reached positive outcomes in not only motor but also social and cognitive domains. For instance, physical education programmes at schools can positively influence balance (Thomas et al., 1975), coordination (Shephard, 1980b) and fundamental motor skills (Vogel, 1986) as well as knowledge about a healthy lifestyle (Ansorge et al., 1985). Programmes with a focus on PA have had a positive impact also on mental health, social inclusion and aspects of cognitive functioning (Bailey, 2005), although evidence for a direct effect on academic achievement is limited (Thomas & Thomas, 1986).

Regarding musical intervention programmes, one study has found that year-long music courses in the classroom, which involved music making, singing and rhythm reproduction, improved 6- to 9-year-old children's synchronisation accuracy in a basic finger-tapping task (Slater, Tierney, & Kraus, 2013; see also Bhide, Power, & Goswami, 2013). Similar music making activities have yielded positive results on the reading abilities of children with poor language and cognitive skills (Bhide et al., 2013), on sympathy and social competence in children with poor pro-social skills (Schellenberg, Corrigan, Dye, & Malti, 2015), and empathy, pro-social attitudes and a sense of collective identity in the general population (Dillon, 2006; Marsh, 2012; Rabinowitch, Cross, & Burnard, 2012; Schellenberg et al., 2015).

Overall, these studies point to a strong link between motor abilities and PA and socio-cognitive development. Children's language abilities seem to highly correlate with their motor abilities and synchronisation success. Deficiency in motor skills can affect children's self-esteem, social competency and emotional well-being. All these are important factors influencing human social interactions, thereby supporting the hypothesis that performing coordinated movements with others can facilitate social interactions and bonding.

Research investigating such a causal relation at middle childhood ages is scarce, however. To date, the most direct evidence comes from a study conducted by Rabinowitch and Knafo-Noam (2015). In that study, 8- to 9-year-old children were paired up and were each given a computer game to play, where they were instructed to tap a button as soon as they saw a visual stimulus appear on their individual screens. Children's button pressing times were arranged such that they were either in synchrony or not with each other. Subsequently, a short questionnaire on perceived similarity of self to their partners and the widely used social closeness measure of Inclusion of Other

in Self (IOS) Scale (Aron, Aron, & Smollan, 1992) were administered. An increase was found on both measures in the synchrony condition compared to the non-synchrony condition. These results are similar to those found with younger children in Study 2 of this thesis. Rabinowitch and Knafo-Noam's (2015) study shows that, at least in self-reports, a social bonding effect of movement synchrony in peer pairs is observed in middle childhood as well.

Yet, data that rely solely on brief questionnaire reports do not capture the effects on behaviour that can emerge from IMS. Children's natural social interactions and conception of the social world at these ages is particularly marked by groupishness. Children make friends, and foes, in group contexts, identify themselves according to their group memberships and behave according to group norms, be they moral or social-conventional norms. As the above review shows, the effects of groupishness can extend to negative intergroup biases, with potentially serious consequences for group-based peer rejection and social discrimination.

At the same time, research on intervention programmes shows that performing music and sports can increase cohesion among the participants and erase previously existing negative biases towards the out-group. Among other things, these intervention programmes involve movement synchronisation among participants, which may contribute to the social closeness outcomes. Although evidence from intervention programmes is only tangentially related to this proposal, some experimental studies provide more direct support. One study with adults, for instance, has shown that participants, who were split into minimally constructed groups, spontaneously synchronised their movements with out-group members more than they did so with in-group members (Miles et al., 2011). Movement synchrony in this case may be representative of an unconscious attempt to reduce intergroup differences and decrease

social distance. The final study of this thesis will investigate this question more directly and examine how rhythmical, synchronised movements can influence social bonding and intergroup biases across groups of children.

7

EMPIRICAL STUDY 3: THE EFFECT OF MOVEMENT SYNCHRONY ON SOCIAL BONDING ACROSS EXISTING GROUP DIVIDES

7.1 STUDY 3

This study is inspired by a number of findings collated from separate areas of research on middle childhood: (i) engagement with PA in the forms of sport and dance becomes a prominent part of children's daily lives; (ii) a growing understanding of groupishness guides children's relationships with peers; (iii) intervention programmes involving music making and rhythmic movement show that it is possible to alleviate negative inter-group biases; and (iv) previous research on early childhood –including Study 2 of this thesis- and adults show that pro-social behaviour increases following movement synchrony. Moreover, evolutionary theories propose synchrony as a mechanism for facilitating group bonding among genetically unrelated individuals (Dunbar & Shultz, 2010). If that is the case, then we would expect to observe the positive social effects of movement synchrony also in situations where there may initially be some negative sentiment among the individuals. Building on all this literature, the current study investigated specifically the effect of movement synchrony on facilitating social bonds in a group setting, where prior inter-group biases had been established.

Children were taken into the study in groups of 6 and were split into two minimal groups of 3 individuals (number of girls and boys are matched across the two minimal groups) and engaged in group activities to foster group membership. Children's bonding levels for the in-group and the out-group were measured with a brief questionnaire at baseline. Following this, the movement phase took place, where each group learnt to perform a set of movements in time to certain rhythms. Previous research shows that this age group still has difficulties maintaining anti-phase synchrony while performing fine motor movements, such as finger tapping (Volman & Geuze, 2000). In order to eliminate noise that might stem from such differences in motor competency and to

amplify the perception of synchrony, full-body movements were chosen and both the types of movements and the timing of the rhythms were altered in the manipulation of movement synchrony. The two minimally constructed groups within each session learnt and performed the same set of moves in time to the same rhythms in the synchrony condition, and different sets of moves in time to two different rhythms in the non-synchrony condition. Thus, the potential effect of performing matched movements, in addition to the effect of matched rhythms, in the synchrony condition should be considered while interpreting the results.

Following the movement phase, children were given another questionnaire assessing in- and out-group bonding, which included and expanded on the brief questionnaire that the children had answered at baseline. The questionnaire items were adapted from well-established questionnaires that assessed aspects of social bonding (Aron, Aron, & Smollan, 1992; Glass & Benshoff, 2002; Martin, Carron, Eys, & Loughhead, 2012; Wiltermuth & Heath, 2009). The rationale behind administering this questionnaire was to assess multiple facets of social bonding, such as perceptions of similarity, connectedness, liking and pro-social attitude. Following Rabinowitch and Knafo-Noam (2015), a child-appropriate version of the Inclusion of Other in Self (IOS) Scale was used to examine perceived social closeness towards the in- and the out-group.

It must be remembered, however, that with an increasing awareness of social acceptability norms at these ages, children's explicit responses may conceal their negative out-group attitudes. It was thus important to measure group bonding using an implicit measure as well. However, the practical difficulties incurred by a set-up with 6 children made it impossible to administer the computerised IAT. Instead, a new game (i.e., the Island Game) was developed and implemented to measure group bondedness implicitly. The Island Game was a behavioural measure, where physical closeness was

used as an indicator of social closeness. Physical proximity and approach behaviour have long been used as indications of social closeness and bonding in comparative animal research (e.g., Clay & de Waal, 2013). Social psychology studies conducted with adults have also reported strong positive associations between physical proximity and social closeness (Halberstadt et al., 2016; IJzerman & Semin, 2010). Following these approaches, the Island Game assessed the children's willingness to be in close proximity to the in-group versus the out-group (more details in the Methods section).

It was expected that upon performing the same movements synchronously, the children would be more likely to stay close to the out-group in the Island Game than after performing the movements in the non-synchrony condition. Similarly, for the questionnaires, it was hypothesised that following the movement phase, children in the synchrony condition would report feeling closer to the out-group than children in the non-synchrony condition. Finally, if movement synchrony has an effect on alleviating existing inter-group biases, the difference between pre- and post-movement phase questionnaire results should be more positive and higher in the synchrony condition than in the non-synchrony condition.

7.1.1 Method

7.1.1.1 Participants

One hundred and two participants (53 females, $M_{\text{age}} = 8; 9$, range: 7; 1 – 11; 6; $M_{\text{sync}} = 8; 9$, $M_{\text{non-sync}} = 8; 9$) took part in the study. The choice of this age range took account of children's developing motor capabilities. Previous studies have shown that it is only after 7–8 years of age that children can move in synchrony with a rhythm and with other individuals at levels comparable to those of adults (Drake et al., 2000; McAuley et al., 2006). The participants were recruited from local primary schools in Oxford, United Kingdom and came predominantly from middle-class, mixed ethnic

backgrounds. All of the children were proficient in English, which was the language used during testing, although 6 children (3 girls) needed the Experimenter’s (E) help in completing the questionnaires due to reading difficulties. The study received ethics approval from the University of Oxford’s ethics board and written permission was obtained from the teachers and the parents of the participants prior to testing.

There were six participants in each session (either 4 boys and 2 girls or 2 boys and 4 girls), split into two arbitrary groups (either 2 boys and 1 girl or 1 boy and 2 girls in both groups). Groups therefore resembled real-life mixed-sex groups, without sex being introduced as another grouping factor as neither group nor session consisted exclusively of girls or boys. The within-session age difference among children ranged between 6 months 4 days and 12 months 16 days, a statistically insignificant difference, $F(1, 15) = 0.003, p = 0.96$. More detailed descriptive statistics on the number of participants by condition are provided in Table 7.1.

Table 7.1
Descriptive statistics of the sample by condition and in total

		Synchrony	Non-synchrony	Total
Sex (number of participants)	Female	27	26	53
	Male	21	28	49
Tempo (number of sessions)	585ms	8	9	17
	555ms	8	9	17
Movement Set (number of sessions)	Set 1	8	9	17
	Set 2	8	9	17

7.1.1.2 Materials and Procedure

General Set-up and Procedure

Each session consisted of 5 phases: (1) minimal group formation, (2) pre-test questionnaires, (3) Moves Task, (4) Island Game, and (5) post-test (long) questionnaire. Three separate areas were created in the experiment room to accommodate the different tasks (see Figure 7.1).

Upon arrival, children were first assigned to one of two groups: the orange group or the green group. Once the groups were formed, children wore vests that matched their group's colour and were directed to their group's area. In the Group Areas, there were 3 mats (of matching colour to the group's colour) with individual shapes printed on them. The shapes were used to identify the children individually. Cards with these shapes printed on them were used throughout the experiment to indicate each child's spot in a task or game. The Group Areas were used for a warm-up activity and for the children to complete the questionnaires. The Moves Task took place in an area adjacent to the Group Areas. A tall room divider that occluded visual access separated the Moves Task Areas of the two groups during the training phase. The children learned and practised the Moves Task within their groups with the room divider present. For the test phase, E removed the divider and the children performed the Moves Task while facing the other group. Following the Moves Task phase, the children were taken to the Island Game Area, where they played the Island Game. Finally, children returned to their Group Areas to complete the post-test questionnaires.

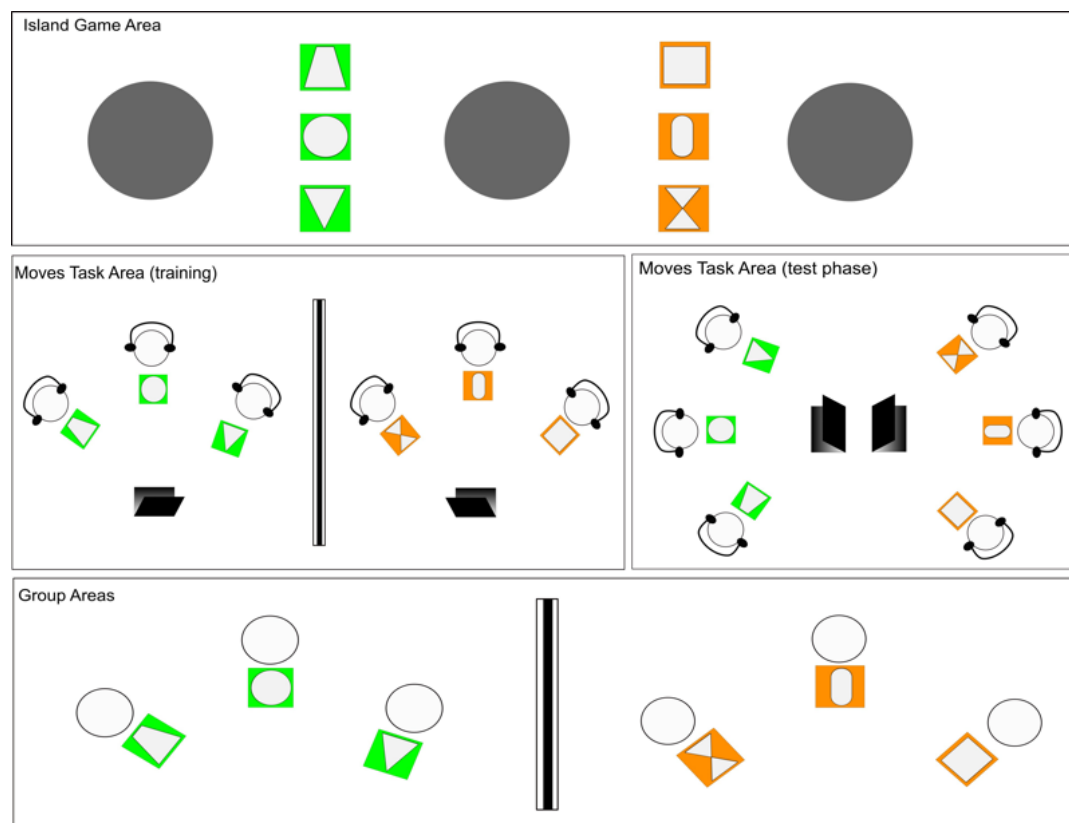


Figure 7.1. Summary of the study phases according to order and locations of occurrence.

Phase 1- Minimal Group Formation

The sessions commenced with E telling the children that: “Today, we will play some games together. You will play these games in groups, so let’s first form two groups. There will be an orange group and a green group. Here, I have 6 cards with different shapes on them. I’ll put them in this box now and everybody will draw one card out of the box, which will determine the group you are in. Pay attention to the shapes on your card – you’ll need to remember them later as you play the games!”

Although the drawing of cards seemed random, in reality, the cards were assorted in such a way to ensure the correct male-female ratio in each group. Specifically, the children always drew the card that was on top of the pile; the order of cards in the box and the children’s order of drawing were fixed so as to ensure that the groups had the same male-to-female ratio and were mixed-sex. Each card was coloured either orange or

green and had certain shapes on them, which were used to identify the children individually (colours and shapes counterbalanced, see Figure 7.2a for an example set). To further establish identification with group, children were asked to put on their group's vests (see Figure 7.2b) and the study commenced in the Group Areas. In the Group Areas, there were 3 mats (matching the group's colour) with individual shapes printed on them. The children found their shapes and sat on their mats to do a warm-up activity. The warm-up activity required the children to work together with their group to draw a group flag, which was then hung on the board in their Group Area.

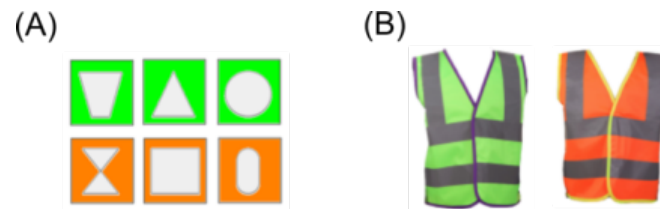


Figure 7.2. Materials used for minimal group assignment: (a) Shape cards that identified children individually; (b) Colour-matched vests for the groups.

Phase 2- Pre-test Questionnaires

At their individual positions in their Group Areas, children were asked to complete two brief questionnaires to assess how bonded they were to their in-group and to the out-group; the in-group bonding ($IB_{pre-test}$) and out-group bonding ($OB_{pre-test}$) questionnaires, respectively. Both $IB_{pre-test}$ and $OB_{pre-test}$ consisted of three 5-point Likert type questions each (for a list of the questionnaire items, see Table 7.2). Brief instruction on how to use the Likert scale was given at the beginning. Children completed the questionnaires individually and privately in their own time.

Table 7.2.

Pre-test questionnaire items. Questions 1-4 were used for identification purposes. All of the items were answered by circling around one of the options on a 5-point Likert type scale, where the labels were indicated as “Strongly disagree, Disagree, Don’t agree or disagree, Agree, Strongly agree”.

Asterisks indicate the resource from which the item was adapted from: *Glass & Benshoff, 2002; **Martin, Carron, Eys & Loughhead, 2012.

1. Your Name	
2. Your Shape	
3. Your Group’s Colour	
4. The Other Group’s Colour	
5. I like my group*	8. I like the other group*
6. I would enjoy helping my group**	9. I would enjoy helping the other group**
7. My group is cool**	10. The other group is cool**

Phase 3- Moves Task

On completion of the pre-test questionnaires, children were brought to the Moves Task Area. This task required the children to perform full-body moves in time to beats that they heard from their headphones.

For the Moves Task phase, E created training videos, which included instructions and demonstrations on how to perform the moves in time to the beat. Two movement sets were created, each comprised of 3 moves (2 arm movements and 1 leg movement). All of the moves were basic leg and arm movements such as stepping to the sides and stretching or swinging the arms. None required any prior experience and they were selected so as to avoid evoking a particular meaning (e.g., such as in clapping, marching etc.). For a sample of the move sequences that were used in the study, see Figure 7.3.

For the beats, two auditory tracks of drumbeats (585ms and 555ms) were created using Garageband software. Using Silent Disco technology, each group’s computer was connected to a separate audio channel, from which the drumbeats were presented to the children’s individual wireless headphones. This way, the two groups in each session could receive their own visual (instruction videos for the moves) and auditory stimuli (the beats presented through the two audio channels) simultaneously without knowing

what stimuli the other group was receiving. In the synchrony condition, both groups were presented with the same movement set and the same beats (half of the sessions presented with 585ms beats; see Table 7.1). In the non-synchrony condition different movement sets and different tempi beats were presented to the two groups. To increase the contrast across conditions, not only the rhythms but also the movement types were altered in the non-synchrony condition.

Videos were shown to the children on 13” computer screens, a separate one for each group. During training of the Moves Task, the two groups were separated by a tall room divider that completely occluded visual access between them, and the auditory beats were presented through individual headphones. The training videos lasted for just under 6 minutes. In the videos, the instructor first demonstrated the moves in a step-wise fashion one by one (see Figure 7.3). Following each demonstration, she asked the children to join her in doing the move in time to the beats. When individual training for all three moves was completed, the moves were practised for one last time for the whole duration of the auditory track, which was later presented in the test phase. E observed the children during training; all of the children could proficiently perform the moves in time to the beats by the end of the training.

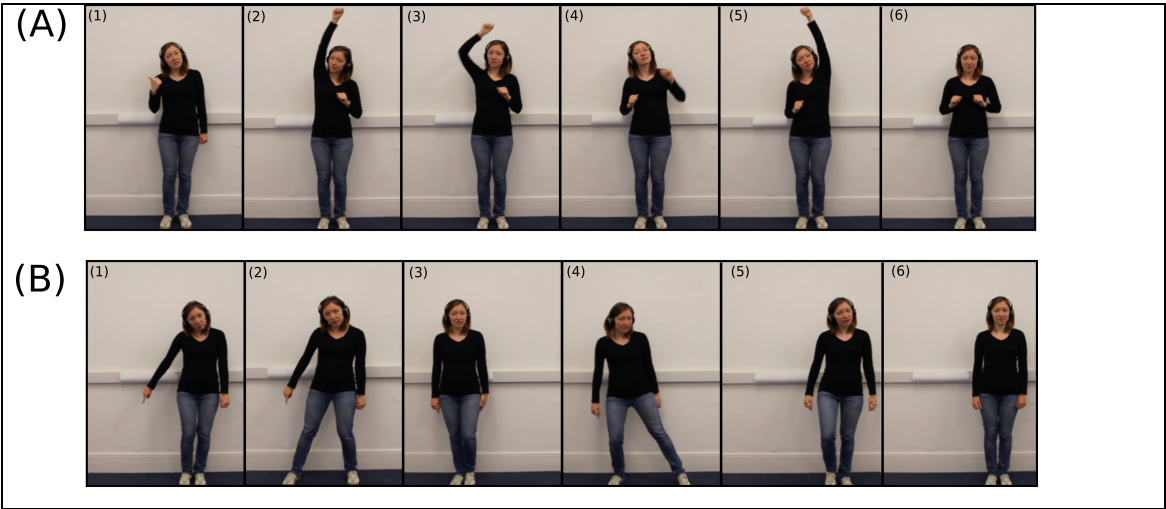


Figure 7.3. Figure 7.3. Screenshots from the training video, depicting examples of (a) an arm movement; and (b) a leg movement step by step.

After the training was over, E instructed the children that they would do the moves once more, this time facing the other group. She removed the room divider between the groups and positioned the children in a crescent shape around the computer screen, so that all children could see all members of the other group, their own group members and their video at the same time (see Figure 7.1 for a depiction of the configuration). In order to eliminate potential memory demands, an instruction-free video of E performing the moves was provided during the test phase too. The test phase lasted for approximately 3 minutes.

Phase 4- Island Game

The Island Game took place immediately after the Moves Task test. In this game, three islands (charcoal coloured mats of 100cm diameter) were placed on the floor with each spaced approximately 2 meters from the adjacent island. One group of children (orange or green) was positioned in the space between two of the islands and the other group of children was positioned in the space between the other two islands. Two of the islands were therefore closer to either one of the groups and one island in the middle was equally close to both groups (see Figure 7.1 for a depiction of the configuration). Similar to previous phases, the children's individual positions were determined via the shape cards on the floor.

The game required the children to start from a crouching position, facing the Experimenter and to quickly run to an island of their choice on the experimenter's signal. At the start of each trial, the children were told to crouch on their dedicated spots with eyes closed and their face to the floor. This was done in order to minimise children's choices being influenced by others' choices. The children maintained this position until E counted down from 3, at which point E announced, "Go!" and the children jumped up and ran to the island that they chose. Choosing to go to an island

that was closer to one's own group versus the other group was taken as a reflection of social closeness to one's own group versus the other group. The Island Game was repeated 6 times and children's starting positions within their group 'zone' were shuffled each time. After the Island Game was finished, children went back to their Group Area and completed the post-test questionnaire.

Phase 5- Post-test Questionnaire

The post-test questionnaire comprised of four parts. Unless otherwise stated, all questions were answered on a 5-point Likert type scale (1 = Strongly disagree, 2 = Disagree, 3 = Don't agree or disagree, 4 = Agree, 5 = Strongly agree). A list of the questionnaire items is provided in Table 7.3.

The first set of questions concerned children's experiences of the activities that they had just done (i.e., perceived difficulty, success and enjoyment: Questions 15-19). The second set of questions was similar to the pre-test questionnaires; items assessed how bonded children felt towards their in-group and the out-group. These questionnaires were called IB_{long} and OB_{long} . Within both IB_{long} and OB_{long} , 3 of the items were identical to those in the pre-test questionnaires, $IB_{pre-test}$ and $OB_{pre-test}$ and were called $IB_{post-test}$ and $OB_{post-test}$ (Questions 30-32 and 44-46, respectively). These 3 items ($IB_{post-test}$ and $OB_{post-test}$) were analysed separately in order to directly compare how children's bonding levels changed before and after the Moves Task (more details follow in the Results section).

The third part of the post-test questionnaires was a 5-point, child-adapted version of the IOS scale, used to assess perceived relationship to the in-group and to the out-group (Cameron, Rutland, Douch, & Brown, 2006). In this scale, two circles representing the participant and the group were displayed with increasing degrees of overlap (from entirely separated to entirely overlapping), yielding five response options.

Circles were annotated with stickman figures representing the child (labelled “YOU”) and the group (labelled “YOUR GROUP” or “OTHER GROUP”). Participants indicated the option that best represented how close or how distant they felt towards the group under question. Instructions on how to interpret the IOS scale were provided to all children at the beginning of the post-test questionnaire phase.

The post-test questionnaires ended with one question (Question 48), which asked the children whom they would like to choose as playmates if they were to do some more activities later. Children indicated their response by choosing one of the four multiple choice answers: (a) 2 people from my group, (b) 2 people from the other group, (c) 1 person from my group and 1 person from the other group, and (d) Any 2 people- I don’t mind.

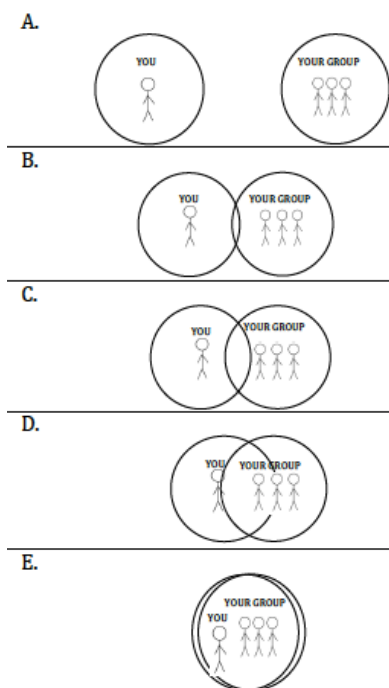
When finished, the children were thanked and dismissed from the study. The Moves Task and the Island Game phases of all sessions were video recorded for coding purposes.

Table 7.3.
Post-test questionnaire items. Questions 11-14 were used for identification purposes. Questions 33 and 47 were IOS Scales, answered by choosing one of the five pictorial options. Question 48 was answered using one of the four options provided in the question itself. The rest of the items were answered by circling around one of the options on a 5-point Likert type scale, where the labels were indicated as “Strongly disagree, Disagree, Don’t agree or disagree, Agree, Strongly agree”.
Asterisks indicate the resource from which the item was adapted from: *Glass & Benshoff, 2002; **Martin, Carron, Eys & Loughhead, 2012; *Wiltermuth & Heath, 2009.**

-
- 11. Your Name
 - 12. Your Shape
 - 13. Your Group’s Colour
 - 14. The Other Group’s Colour
 - 15. Performing the moves was easy for me.
 - 16. I enjoyed doing the moves.
 - 17. I think my group was successful in doing the moves.
 - 18. I think the other group was successful in doing the moves.
 - 19. I enjoyed playing the Island Game.

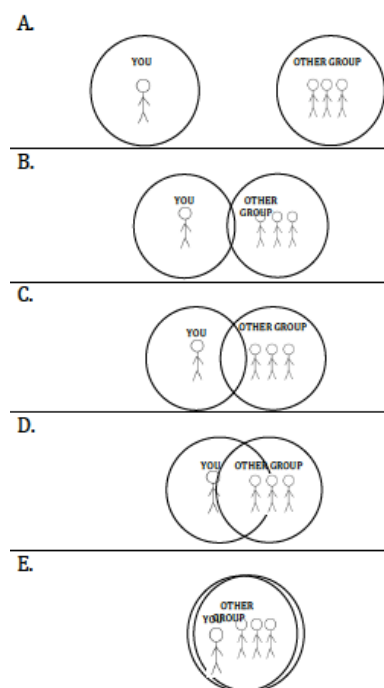
20. I feel connected to my group^{***}
 21. I feel on the same team with my group^{***}
 22. I feel good about my group^{**}
 23. I think I am similar to my group in general^{***}
 24. I share the same goals as my group^{*}
 25. I feel bad about my group^{**}
 26. I work well together with my group^{*}
 27. I am united with my group^{*}
 28. I don't like my group^{*}
 29. I would stick together with my group during challenges^{**}
 30. I like my group^{*}
 31. I would enjoy helping my group^{**}
 32. My group is cool^{**}

33. Think about yourself and your feelings for your OWN GROUP (the one that shares your colour). How close or distant do you feel to your own group? Choose from below ONE picture (A - E) that best represents how close or distant you feel to your own group. Put a cross next to it.



34. I feel connected to the other group^{***}
 35. I feel on the same team with the other group^{***}
 36. I feel good about the other group^{**}
 37. I think I am similar to the other group in general^{***}
 38. I share the same goals as the other group^{*}
 39. I feel bad about the other group^{**}
 40. I work well together with the other group^{*}
 41. I am united with the other group^{*}
 42. I don't like the other group^{*}
 43. I would stick together with the other group during challenges^{**}
 44. I like the other group^{*}
 45. I would enjoy helping the other group^{**}
 46. The other group is cool^{**}

47. Think about yourself and your feelings for the OTHER GROUP (the one that does not share your colour). How close or distant do you feel to the other group? Choose from below ONE picture (A - E) that best represents how close or distant you feel to the other group. Put a cross next to it.



48. If we came back to do more activities another day, who would you choose to do them with? Pick ONE option below.

- ☐ 2 people from my group
☐ 2 people from the other group
☐ 1 person from my group and 1 person from the other group
☐ Any 2 people - I don't mind

7.1.2 Coding and Data Preparation

7.1.2.1 Moves Task

Two coders, one blind to the hypotheses and both blind to the conditions, watched all of the Moves Task test phases of the videos and rated them for synchrony. First, the coders assessed how synchronously the two groups moved within a session by giving that session a rating from 1 to 7, based on the frequency of synchronous movement occurrences, where 1 = not at all synchronous and 7 = perfectly synchronous. Next, the coders made a blind guess as to which condition the video belonged to. Inter-rater reliability was very good, for ratings: Krippendorff's $\alpha = .94$, for blind guesses: Krippendorff's $\alpha = 1$. Both raters' guessing accuracies were 100%, binomial $p < .0001$. Using the average of the two raters' ratings, it was observed that the synchrony condition was rated as being significantly higher ($M_{sync} = 5.94$) than the non-synchrony condition ($M_{non-sync} = 2.78$), $t(10) = -10.53$, $p < .0001$.

7.1.2.2 Bonding Questionnaires

Principal Component Analysis (PCA) was conducted for the six Likert type questionnaires: IB_{pre-test}, OB_{pre-test}, IB_{post-test}, OB_{post-test}, IB_{long} and OB_{long}. Preliminary tests and correlational analyses confirmed that the questionnaires were suitable for PCA (for inter-item correlations see Appendix Figures S1- S3; for the other tests see Table S1). Oblimin rotation was used as no strong predictions were made about the orthogonal relations among the questionnaire items.

From the results of the PCA, only one component was extracted from each questionnaire, which can be interpreted as a single, composite construct of social bonding. Only items with a factor loading of $>.4$ were retained. Consequently, two items were dropped from the IB_{long} questionnaire, namely the reverse items "I don't like my group" and "I feel bad about my group". For all other questionnaires, all of the

items were retained. The detailed results of the PCAs and internal consistency values of each questionnaire can be found in Appendix Tables S2 and S3. Given the high internal consistencies of the questionnaires, responses across items for each questionnaire were averaged for each participant and these mean scores were used in subsequent analyses.

7.1.2.3 IOS Scales

For the IOS scales, children received a score ranging from 1 to 5 depending on the option chosen, with higher scores indicating higher self-group overlap.

7.1.2.4 Island Game

Participants' island choices were categorically coded as 0, 1 or 2, where higher scores indicated more willingness to be close to the other group. More specifically, a score of 0 = the island closest to the participant's own group and furthest from the other group ("Own Group Island"), a score of 1 = the island equidistant from the group islands and to participants from each group ("Middle Island"), and a score of 2 = the island closest to the other group and furthest from the participant's own group ("Other Group Island"). In cases in which children ran to more than one island in sequence (13% of cases, $n = 13$), only their first choices were counted, as these are taken to most accurately reflect their initial decision and preference. Reliability analysis on children's Island Game choices, conducted with two coders who were blind to the conditions and one who was blind to the hypotheses revealed very good agreement, Krippendorff's $\alpha = .88$.

Recognising the potential for island choices to be influenced by the other participants in this group task, Intra-class Correlations (ICC) were analysed for the Island Game data. When all six trials of the game were included in the analysis, average intra-session variance differed from the overall variance, $ICC = .24$, $CI [0.526, 0.720]$,

$F(1,100) = 4.27, p = .03$, indicating inter-dependence among children's responses within sessions. In other words, children's island choices seemed to be influenced by other children's choices and/or their previous choices. Therefore, ICC only for the first trial was assessed. Since this was the children's initial island choices, no interdependence was expected here. Results confirmed that the interdependence in children's responses disappeared when only the first trial responses were analysed, $ICC = .009$, $CI [-0.014, 0.967]$, $F(1,100) = 1.16, p = .28$. Hence, to avoid problems of group-level interdependence in subsequent main analyses, only first trial responses were used.

All analyses were done using R software (R Core Team, 2015) and following the recommendations of Field, Miles and Field (2002).

7.1.3 Statistical Analyses

This study had one independent variable with two levels: synchrony and non-synchrony. A number of dependent variables were used to investigate different aspects of bonding to the in-group and to the out-group. The 5-point Likert type questionnaires were analysed with one-way between-subjects ANOVA to assess the effect of condition (synchrony versus non-synchrony) on in-group and out-group bonding before the Moves Task (Section 7.1.4.1) and after the Moves Task (Section 7.1.4.2, Bonding Questionnaires). To examine the change in in-group and out-group bonding before versus after the Moves Task, a 2 (synchrony versus non-synchrony) * 2 (before Moves Task versus after Moves task) a mixed ANOVA was conducted on the questionnaire items that were administered in both time points (Section 1.4.2, Bonding Questionnaires).

The IOS Scales were analysed using ordinal logistic regression, due to the ordinal nature of the 5 options, which assessed increasing levels of closeness between the participants and the in-group/out-group. The final question on the bonding

questionnaire, which examined children's future playmate choices was analysed with a chi-square test, as the options comprised of distinct categories.

In analysing the Island Game, the three response options (own group island, middle island and other group island) were treated as distinct categories, without necessarily being ordinal. Since the assumptions for multinomial regression analysis were not met (see Section 7.1.4.2, Island Game for more details), chi-square analysis was conducted.

7.1.4 Results

7.1.4.1 Minimal Group Bias

A manipulation check for the minimal group effect confirmed that, at baseline (i.e., before performing the Moves Task), children overall reported higher bonding towards their in-group ($M_{IB} = 4.37 \pm .53$) than towards the out-group ($M_{OB} = 3.22 \pm 1.13$), $F(1, 95) = 73.41, p < .0001, \eta^2 = .44$. Children who were assigned to the synchrony and to the non-synchrony condition had similar scores on the pre-test questionnaires, $IB_{pre-test}: F(1, 94) = 0.22, p = .64$, or on $OB_{pre-test}: F(1, 94) = 0.01, p = .99$ (see Table 7.4). Within both synchrony and non-synchrony conditions, boys scored lower on out-group bonding questions than girls, $M_{boys} = 2.89 \pm 1.21$, $M_{girls} = 3.52 \pm .96$, $F(1, 94) = 8.04, p = 0.006$. No differences in in-group bonding were found between boys and girls. Further, a main effect of age was found on both in-group and out-group questionnaires, in-group: $F(1, 94) = 4.65, p = 0.03$; out-group: $F(1, 94) = 3.66, p = 0.06$. With increasing age, a gradual decrease was observed in inter-group biases. However, Bonferroni-adjusted pairwise comparisons revealed no significant differences between any of the age groups between 7 and 11, all $ps > .05$. No effect of group colour was found in any of the pre-test bonding questionnaires.

7.1.4.2 Synchrony Effects

Bonding Questionnaires

First, data were checked for any differences across conditions in children's experiences with the games. Children in the synchrony and non-synchrony conditions found the Moves Task similarly easy, $M_{sync} = 4.58 \pm .58$, $M_{non-sync} = 4.32 \pm 1.01$, $F(1, 100) = 2.64$, $p = 0.11$. Enjoyment ratings were also similarly high across conditions for the Moves Task, $M_{sync} = 4.25 \pm 1.02$, $M_{non-sync} = 4.24 \pm .99$, $F(1, 100) = 0.002$, $p = 0.96$, and the Island Game, $M_{sync} = 4.46 \pm .77$, $M_{non-sync} = 4.37 \pm 1.00$, $F(1, 100) = 0.24$, $p = 0.62$. Neither short or long post-test questionnaires were significantly influenced by children's age, sex, group colour, tempo or movement set, all $ps > .05$.

Next, the effect of the Moves Task on children's in-group and out-group bonding in the pre-test and post-test short questionnaires and the long post-test questionnaires was examined. For the short questionnaires, the change in children's in-group and out-group bonding was calculated with a 2 (synchrony versus non-synchrony) * 2 (before Moves Task versus after Moves task) mixed ANOVA. The means and standard deviations of children's IB and OB scores before and after the Moves Task are provided in Table 7.4.

Table 7.4.
Means and standard deviations (in parantheses) of the short versions of the pre-test and post-test questionnaires, IB and OB, by condition.

	In-group (IB)		Out-group (OB)	
	Pre-test	Post-test	Pre-test	Post-test
Synchrony	4.40 (.46)	4.27 (.81)	3.21 (.97)	4.04 (.71)
Non-synchrony	4.35 (.59)	4.20 (.94)	3.22 (1.24)	3.46 (1.34)

For the in-group bonding questionnaires ($IB_{pre-test}$ and $IB_{post-test}$), there was no main effect of condition, $F(1, 99) = .21$, $p = .65$, no main effect of time, $F(1, 94) = 1.22$, $p = .27$, or an interaction effect, $F(1, 94) = 2.02$, $p = .16$. This indicates that the change in

in-group bonding after the Moves Task was similar across the synchrony and non-synchrony conditions. However, as predicted, analysis of the out-group bonding questionnaires ($OB_{pre-test}$ and $OB_{post-test}$) revealed a main effect of time, $F(1, 94) = 27.08$, $p < .0001$, $\eta^2 = .29$, and an interaction effect of time and condition, $F(1, 94) = 9.16$, $p = .003$, $\eta^2 = .10$, but no main effect of condition, $F(1, 99) = 2.46$, $p = .12$. This shows that, although children in general reported higher bonding to the out-group after the Moves Task, this increase was significantly higher in the synchrony than in the non-synchrony condition (see Figure 7.4).

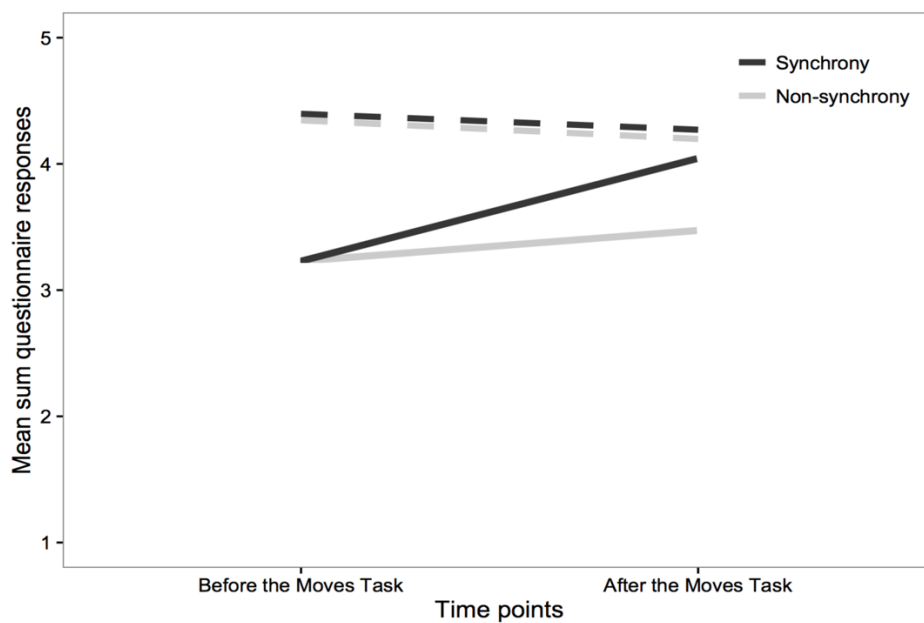


Figure 7.4. Changes in in-group (dashed lines) and out-group (solid lines) bonding before and after the Moves Task.

Similar results were obtained for the long post-test questionnaires: paired t-tests revealed that there was no significant effect of condition on in-group bonding (IB_{long}), $M_{sync} = 3.73 \pm .57$, $M_{non-sync} = 3.66 \pm .65$, $F(1, 100) = 0.36$, $p = .55$, but bonding to the out-group (OB_{long}) was significantly higher in the synchrony than in the non-synchrony condition, $M_{sync} = 3.81 \pm .58$, $M_{non-sync} = 3.32 \pm 1.12$, $F(1, 100) = 6.76$, $p = .01$, $\eta^2 = .06$, (see Figure 7.5). Further, following the movements in the synchrony condition, levels of bonding to the in-group (IB_{long}) and to the out-group (OB_{long}) were indistinguishable,

$M_{IB} = 3.73 \pm .57$, $M_{OB} = 3.81 \pm .58$, $t(47) = -.71$, $p = .48$. In the non-synchrony condition, the difference between in-group bonding (IB_{long}) and out-group bonding (OB_{long}) trended towards significance, $M_{IB} = 3.66 \pm .65$, $M_{OB} = 3.32 \pm 1.12$, $t(53) = 1.72$, $p = .09$, $d = .23$.

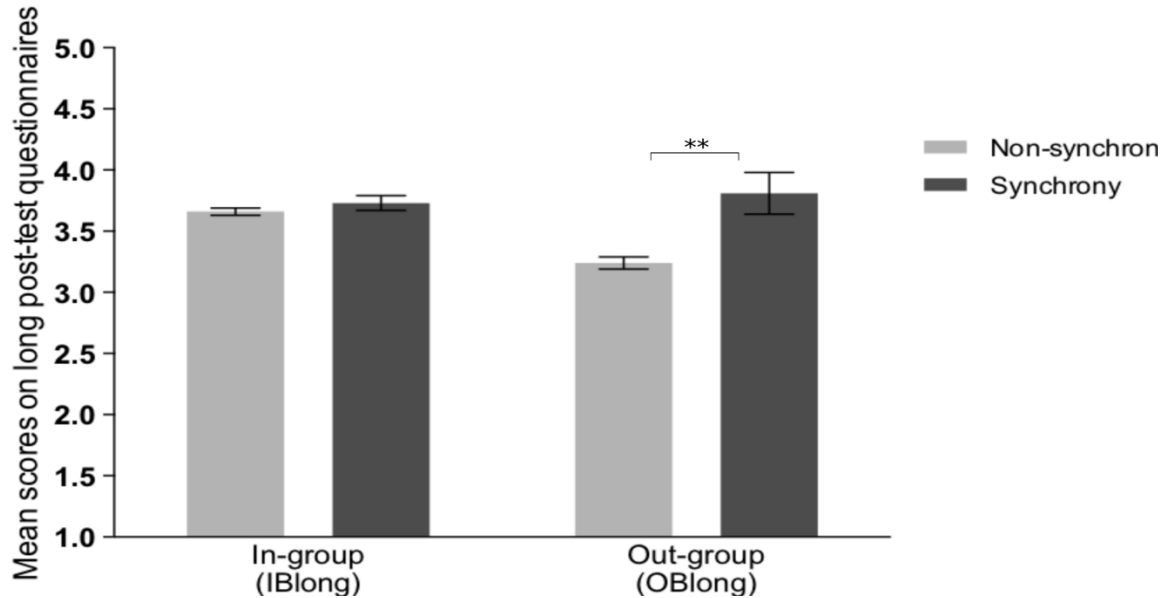


Figure 7.5. Mean scores of the long post-test questionnaires, IB_{long} and OB_{long} , by condition.

These results support the hypothesis that, compared to non-synchronous movement, performing matched, synchronous movements increases out-group bonding among participants. Results are further corroborated by condition-wise differences in the reported success of the in-group and out-group Moves Task performances. Ratings for how successful children thought their own group was in performing the Moves Task did not differ significantly between the conditions, $M_{sync} = 4.38 \pm .79$, $M_{non-sync} = 4.28 \pm 1.05$, $F(1, 100) = 0.27$, $p = 0.60$. However, children in the synchrony condition rated the other group as more successful in the Moves Task ($M_{sync} = 4.15 \pm .87$) than did children in the non-synchrony condition ($M_{non-sync} = 3.56 \pm 1.40$), $F(1, 100) = 6.36$, $p = 0.01$, $\eta^2 = .06$.

IOS Scales

IOS scale responses were analysed using ordinal logistic regression to test the prediction that scores for the out-group would be higher in the synchrony condition than in the non-synchrony condition. Data were checked for the proportional odds assumption; no violation was found for either the in-group IOS scale, $X^2(3) = 5.95, p = .11$, or the out-group IOS scale, $X^2(3) = 3.35, p = .34$. Hence, ordinal logistic regression analysis with condition, age, sex, tempo and movement set as predictors was conducted. None of the predictors were found to have an effect on children's responses for the in-group IOS scale, all $ps > .05$. This indicates that condition did not influence how close children felt towards their in-group following the Moves Task, which is in line with the questionnaire findings mentioned previously. For the out-group IOS scale, however, only condition significantly predicted responses; the odds of children in the synchrony condition scoring higher on the out-group IOS scale was 3.98 times that of children in the non-synchrony condition, $X^2(1) = 13.52, p < .0001$, 97.5% CI, 1.93 to 8.43. Moreover, within both the synchrony and the non-synchrony conditions, the differences between in-group and out-group IOS scores were significant, suggesting that even after synchronous movement performance, some in-group favouritism remained, synchrony condition: $t(47) = 3.90, p < .001, d = .56$; non-synchrony condition, $t(53) = 7.83, p < .0001, d = 1.07$; (see Figure 7.6).

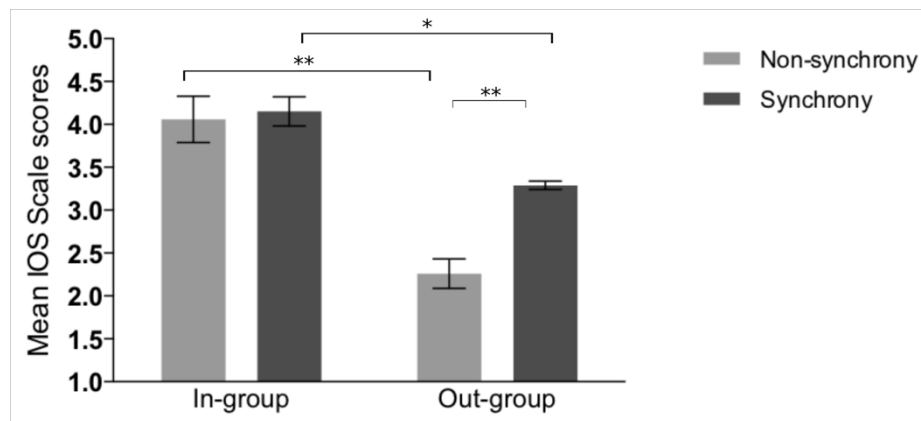


Figure 7.6. Mean scores on in-group IOS and out-group IOS scales by condition, * $p < .001$, ** $p < .0001$.

Finally, children's responses to the last item on the post-test questionnaire (Question 48) were assessed. This item asked whether the children would choose in-group or out-group members as playmates for a hypothetical future encounter. No difference was found across conditions, $X^2(3) = 5.02, p = 0.17$. Table 7.5 shows the descriptive statistics of children's responses to this question.

Table 7.5
Frequencies (n) of children's responses to Question 48 by condition. Column percentages are provided in parentheses next to the frequencies.

Options for Q48	Synchrony	Non-synchrony	Total
2 people from my group	9 (19%)	9 (17%)	18 (18%)
1 person from my group and 1 person from the other group	10 (21%)	6 (11%)	16 (16%)
2 people from the other group	11 (23%)	23 (43%)	34 (33%)
Any 2 people - I don't mind	18 (37%)	16 (29%)	34 (33%)

Island Game

Island Game analyses assessed whether children in the synchrony condition were more likely than children in the non-synchrony condition to choose the "Other Group Island". Table 7.6 shows the descriptive statistics of children's Island Game responses by condition. The data did not meet the assumptions of multinomial logistic regression. Specifically, the high leverage assumption of multinomial logistic regression was violated (i.e., zero cases in the Non-synchronous/ the "Other Group Island" cell, as can be seen in Table 7.6). Hence, a chi-square test was run to analyse the effects of condition (synchrony versus non-synchrony) on children's island choices. The result showed a significant effect of condition with a large effect size, $X^2(2) = 13.29, p = 0.001, \phi = .36$. Children in the non-synchrony condition were 1.69 times more likely to go to the "Own Group Island" than children in the synchrony condition. Moreover, while no child in the non-synchrony condition chose to go to the "Other Group Island", 19% of the children in the synchrony condition chose to do so. In both conditions,

children were roughly equally likely to choose the “Middle Island”. No significant associations were found between children’s sex, age, movement set or tempo and the children’s island choices, all $ps > .05$. A detailed summary of the Island Game responses by sex, age, movement set and tempo can be found in Appendix Table S4. These findings align with the questionnaire results above; children’s behavioural responses in the Island Game strongly predicted their scores on the out-group IOS Scale, $F(1, 100) = 12.00, p = 0.0008, R^2 = 0.11$, and out-group bonding questionnaire (OB_{long}): $F(1, 100) = 14.51, p = 0.0002, R^2 = 0.13$, giving confidence in the Island Game as a novel behavioural measure of social bonding and preference in children.

Table 7.6
Frequencies (n) of children’s Island Game responses by condition. Column percentages are provided in parentheses next to the frequencies.

	Synchrony	Non-synchrony	Total
"Own Group Island"	17 (35%)	32 (59%)	49 (48%)
"Middle island"	22 (46%)	22 (41%)	44 (43%)
"Other Group Island"	9 (19%)	0 (0%)	9 (9%)

7.1.5 Discussion

This study investigated whether performing matched and synchronously timed movements reduces intergroup biases and increases bonding among participants. In line with previous research on minimal group effects, children initially displayed in-group favouritism following group allocation and a brief identity-building activity. Subsequent performance of movements in synchrony, as compared to non-synchronous movement, with the opposing group significantly increased out-group bonding. After synchronous movement, there was no difference between bonding to the in-group and the out-group, as measured by the long questionnaire items, though pictorial IOS responses suggest some lingering in-group bias in perceived closeness. Importantly, while synchrony appears to have increased out-group bonding, non-synchrony did not significantly affect bonding towards the out-group, nor did synchrony increase in-group bonding.

This suggests that merely getting together and moving in the same space has little effect on bonding between groups, and that it is synchronous movement specifically that brings about a significant positive change. As pre-test ratings for the in-group were near-ceiling, the role of synchrony in strengthening bonding within already-formed groups remains unclear.

In addition to questionnaire measures, a novel behavioural measure (i.e., the Island Game) was also used as a gauge of social bonding. Analyses from both the questionnaires and the behavioural measure revealed increased out-group bonding in the synchrony condition compared to the non-synchrony condition. Since the post-test questionnaires clearly show that in-group bonding was as high after the Moves Task as it was initially, the Island Game responses more likely reflect increased out-group bonding, rather than reduced in-group bonding. The Island Game took physical closeness as a proxy for social closeness. This idea finds its roots in established measures of affiliation in primate communities (Clay & de Waal, 2013) and in social psychology studies revealing a relation between physical and social closeness (Fay & Maner, 2012; Halberstadt et al., 2016; IJzerman & Semin, 2010). The design of the Island Game was based on playground games that children commonly enjoy and therefore offers high ecological validity (Pica, 2011; Torbert & Schneider, 1993). Children's ratings indicate that the Island Game was fun to play.

Importantly, behavioural responses in the Island Game strongly predicted self-report measures in out-group IOS and out-group bonding questionnaire. This high convergence in findings helps eliminate possible alternative explanations for children's choice of the other group's island, such as indicating aggression (e.g., dominating the other group's space). Unlike the questionnaire measures, game instructions did not entail or draw attention to group identity or group competition. The Island Game

therefore potentially captures implicit aspects of intergroup biases and social closeness. One limitation of the game, however, is the potential for interdependence; after the first trial, children's responses in the subsequent iterations of the game seem to be prone to be influenced by other children's choices. Methodological solutions to reduce such influences could be considered in future developments of the design. Alternatively, larger sample sizes could allow multilevel analysis. These observations notwithstanding, convergent findings with the questionnaire responses confirm that the Island Game successfully measured group bonding with a single-trial assessment.

Several psychological mechanisms may play a role in creating the observed positive effects of movement synchrony on group social bonding. Previous research has shown that people who view their partners more positively tend to spontaneously synchronise their movements with them more than do partners with weaker rapport (Miles et al., 2010). Moving in synchrony can also lead to increased perceptions of similarity (Wiltermuth & Heath, 2009; Valdesolo & Desteno, 2011; Rabinowitch & Knafo-Noam, 2015). Thus, in the current study, performing the same movements in time to the same beats with the out-group might have enhanced rapport and feelings of similarity, thereby alleviating relative negative bias towards the out-group.

Synchronous movement also increases perceived entitativity (i.e., having the properties of a single, united entity; Campbell, 1958). People who move synchronously with each other are perceived as higher on entitativity (Lakens, 2010) and perceptions of entitativity are mediated by psychological attributions, such as assuming that synchronous partners feel the same, or that they like each other more (Lakens & Stel, 2011). Similarly, from a first-person perspective, co-participants report feeling more connected and as part of the same team upon performing synchronous movements (Cohen, Mundry, & Kirschner, 2013; Wiltermuth & Heath, 2009; Wiltermuth, 2012a;

2012b). Although no direct measure of entitativity was taken in the present study, children in the synchrony condition scored higher than children in the non-synchrony condition in the IOS Scale and out-group bonding questionnaire, which included items about perceived similarity and connectedness. Therefore, the results may indicate higher perceptions of unity with the other group following synchronous compared to non-synchronous movement.

From a broader evolutionary perspective, it has been suggested that movement synchrony may have facilitated cooperation in large human societies, where bonding with genetically unrelated individuals presented unique challenges (Dunbar & Shultz, 2010). By moving in time to the shared rhythm, personal identities are thought to merge into a unified group identity (McNeill, 1995), accompanied by feelings of collective joy (Ehrenreich, 2006) and collective effervescence (Durkheim, 1915). There is a growing amount of empirical support for the facilitatory effects of movement synchrony on emotion sharing and empathy (Cross, Laurence, & Rabinowitch, 2012; Valdesolo & Desteno, 2011). Understanding and sharing the emotional states of others promotes pro-social behaviours both in human children (Dunfield, 2014) and in non-human primates (Hare, Melis, Woods, Hastings, & Wrangham, 2007; Melis, Hare, & Tomasello, 2006). Therefore, movement synchrony may be an effective mechanism in social bonding, serving to mitigate emotional tension among individuals and groups and bond them together within a collective group identity.

The current study contributes to our understanding of the developmental origins of both intergroup bias and the social bonding effects of synchronous movement. In revealing an effect of synchrony on out-group bonding, the findings shed light on the flexibility of intergroup biases in middle childhood years, an underexplored question in the social developmental literature (though see: Hetherington, Hendrickson, & Koenig,

2014). Notably, at baseline, boys and younger children held a more negative attitude towards the out-group than girls and older children (for similar results, see: Buttelmann & Böhm, 2014). Measures taken after the Moves Task reveal, however, that synchrony erased these differences. That synchronous movement, but not non-synchronous movement, can have these effects could usefully inform social intervention programs, especially in cases where cohesion across groups is challenged by prior social, cultural or economic divides. In this study, minimal group construction produced differences in reported in- versus out-group bonding; yet, it should be noted that out-group bonding was still in the positive range of the scale (for comparable results on minimal group studies with children, see: Dunham, Baron, & Carey, 2011; Nesdale et al., 2004). Relatedly, the increase in out-group bonding, as assessed by the questionnaires, was modest and statistical analyses revealed small effect sizes. Therefore, it remains to be seen whether the positive social effects of movement synchrony could mitigate negative sentiment or even hostility towards real-world out-groups where social divides are strongly entrenched.

Different types of synchronous movements included in bonding activities could yield variable effects also. The movements in the present study were contextualised within a joint physical play context. Previous research indicates the social benefits of PA and exercise in children's play (e.g., Barkley et al., 2014; Biddle & Asare, 2011). In the future, it will be important to explore how the bonding effects of synchrony manifest in other cross-group contexts, such as in musical interactions (e.g., Kirschner & Tomasello, 2010). Another important point to note is that, in the current study, both the type of the moves and the timing of the beats were manipulated in order to attain maximal difference across conditions. The rationale was that, in a highly interactive group context, observing others perform the same movement in time to a slightly

different beat than one's own beats could interfere with the children's performances, yielding significantly poorer synchronisation with own beats in the non-synchrony condition. Previous research shows that although children at 7-8 years of age can synchronise proficiently with external stimuli, they still have problems when it comes to performing anti-phase synchrony, e.g., bringing an arm up on the down-beat and down on the up-beat (Volman & Geuze, 2000). To avoid confounds of motor competency in performing anti-phase synchrony, the current study manipulated both the rhythms and the movement types in the non-synchrony condition.

Research on automatic imitation shows that seeing another individual perform an action can automatically motivate mirrored movement in the observer as well (e.g., Heyes, 2011). Starting from infancy into adulthood, observing others perform an action also activates the areas in the brain (i.e., mirror neurons) that are engaged when performing those actions (Heyes, 2011; Lepage & Théoret, 2007; Rizzolatti & Craighero, 2004). Activation of the mirror neuron system has also been associated with fostering feelings of empathy and closeness (e.g., Bastiaansen, Thioux, & Keysers, 2009; Rizzolatti & Sinigaglia, 2010). Hence, a similar mechanism might have operated and influenced the positive social outcomes in the synchrony condition of the current study, where the movements between the two opposing groups were identical in terms of both structure and timing. Altering the movement types and contexts, future research can disentangle the particular contributions of similarity of structure and similarity of timing on the observed social bonding effects. In the future, it would also be productive to investigate how movement synchrony influences bonds across group members in intergroup settings in adults. Despite the vast literature on dyadic social bonding effects of synchrony in adults, there have been relatively fewer studies on synchrony-induced bonding within groups (Cohen et al., 2013; Davis, Taylor, & Cohen, 2015; Reddish,

Fischer, et al., 2013; Tarr et al., 2015) and none that has examined how synchrony influences intergroup dynamics or group-related biases.

From infancy into adulthood, group-based differences strongly influence social preferences, attitudes, and behaviours towards others. This study showed that a brief, fun game, which involved performing matched, synchronous movements with an opposing group, reduced biases across group divides. The study shows that negative effects of groupishness, a prominent aspect of children's social lives, can be subject to change under certain circumstances. The new behavioural measure developed, the Island Game, as well as the questionnaires used, offer valid, reliable measures of social bonding that are convenient to administer to children between ages 7 and 12. Results can helpfully inform social and educational intervention programmes that aim to increase social closeness and cooperation in group settings. Future research should continue to investigate the mechanisms by which movement synchrony forges social bonds, the range of contexts and activities in which these effects work, and how it can be used to effectively erase negative out-group biases across real-world divides. In a broader scientific framework, the current findings also advance our understanding of the links between motor, cognitive and social development in middle childhood years.

These and other discussion points will be further elaborated on in the following chapter. The General Discussion will evaluate the findings of the three studies conducted within the scope of this thesis within broad evolutionary and developmental debates outlined earlier in Chapter 1. Moreover, potential mechanisms giving rise to the observed outcomes will be discussed, possible practical applications of the current findings will be laid out and directions for future research will be suggested.

8

GENERAL DISCUSSION

This thesis investigated the social bonding effects of movement synchrony in an ontogenetic perspective. Three studies addressed this question at three different time points in development: infancy, early childhood and middle childhood. The studies were motivated by evolutionary and developmental theories on human cooperation and social bonding. Although ample research has hinted at the importance of coordinated, synchronous movements in the formation and maintenance of social relationships from early on in childhood, the direct effect of movement synchrony on early social preferences and cooperative behaviour has been largely unexplored. By providing evidence for the facilitatory effects of movement synchrony on social bonding, the studies conducted in this thesis have enhanced our understanding in this area. This chapter will provide a thorough discussion of the current findings in a broad evolutionary and developmental framework, elaborate on the potential mechanisms that may have yielded the observed effects, point to the limitations of the current studies, suggest how the findings may inform applied fields and propose directions for future research.

8.1 SYNOPSIS OF THE FINDINGS IN EVOLUTIONARY PERSPECTIVE

Large scale human cooperation with genetically unrelated individuals has received attention from researchers across numerous disciplines seeking to explain its proximate mechanisms and evolution. One proximate mechanism that has attracted increasing interest among anthropologists and social, evolutionary and developmental psychologists is physical coordination and rhythmic synchronisation of movements among individuals. It has been proposed that such movements foster carer-infant bonding in the early stages of life (Dissanayake, 2000), increase cooperative behaviours and attitudes among adults (Dunbar & Shultz, 2010) and serve a coalitional function when performed by groups in inter-group settings (Hagen & Bryant, 2003). Nuances

exist between these approaches in terms of their emphases on various evolutionary functions, and the current thesis does not aim to compare them to one another or test which one of the functions is more plausible. Instead, the aim here is to establish the developmental origins of a phenomenon (i.e., social bonding and cooperation as stemming from coordinated, rhythmically synchronised movements among individuals) that has been widely and consistently observed in ethnographic investigations and experimental studies with adults. Such an investigation can shed light on the evolutionary theories of movement synchrony and cooperative behaviour and contribute to a fuller understanding of how social bonds between humans emerge and are maintained.

The first study of this thesis showed that 12-month-old infants had a preference for synchronously moving others exclusively in a social context. Nine-month-old infants did not display any preferences for synchronous entities either in the social or in the non-social context. Two aspects of these findings are worth highlighting: (a) that younger infants did not show any preference for synchronous movement, and (b) that a synchrony preference was observed in the social but not in the non-social condition. That younger infants did not display a synchrony preference may be indicative of a developing neuro-cognitive machinery that enables the detection of spatially matched movements (Catmur et al., 2009). For more discussion on this point, see Section 8.2.2 below.

Infant-carer interactions that are marked by mutual coordination and synchronisation of movements are correlated with increased responsiveness of the carer to the infant's needs (Bernard, Meade, & Dozier, 2013), as well as better physiological and behavioural regulation (Feldman, 2012) and emotional alignment between the interactants (Feldman, 2007b). Therefore, it was reasoned at the start of this study that

infants may be sensitive to the timing of others' actions and have an active preference for synchronous movement in social settings, where their preference can potentially foster social interactions. The results confirmed this proposal in the case of the 12-month-old infants. These findings potentially support the proposed evolutionary function of movement synchrony for infant-carer bonding by showing that it guides infants' social preferences.

The second study was conducted in order to test more directly the idea that movement synchrony would facilitate costly cooperation between the participating partners. The helping task used to measure cooperative behaviour was costly in that it demanded the children to postpone their own goals and enjoyment (i.e., feeding the fish themselves) and help the other child instead. Therefore, differently from the previous studies with children (Rabinowitch & Knafo-Noam, 2015; Trainor & Cirelli, 2015), the effects of movement synchrony were investigated (a) when the movements were volitionally and actively performed by the children, (b) when the children were required to engage in costly cooperative behaviour afterwards, and (c) when the context was children's peer interactions. A significant and large effect was found such that performing simple movements synchronously such as clapping hands and tapping for a short period of time (i.e., 40 seconds) yielded more helping behaviour compared to performing the same movement activity non-synchronously. Moreover, synchronising pairs engaged in more eye contact and smiled at each other more than children in the non-synchrony condition. Mutual smiling and eye contact are important social markers that may indicate affiliation and bonding (Gironzetti, Pickering, Huang, Zhang, Menjo, & Attardo, 2016; Hamilton, 2015) and can foster emotion sharing and unconscious mimicry (Wang & Hamilton, 2013; Wirth, Sacco, Hugenberg, & Williams, 2010).

From an evolutionary perspective, movement synchrony has been proposed to facilitate social bonding and costly cooperation within groups. Several studies with adults have confirmed this proposal by showing increased costly sharing and helping behaviour among the interactants following movement synchrony compared to non-synchrony (e.g., Valdesolo & Desteno, 2011; Wiltermuth & Heath, 2009). The current study reveals that this effect is in place already in early childhood and potentially influences children's cooperation with peers.

Having established that active movement synchrony can facilitate bonding and cooperation in children, the final study of this thesis sought to test the reach of these effects. Evolutionary theories of synchrony have suggested that the bonding effects of movement synchrony would be especially significant in intergroup settings, where synchronous movements within the group would potentially signal the group's unity and strength to opposing groups (Hagen & Bryant, 2003; Merker, 2000). Could it also be the case, however, that bonding across groups increases when the opposing groups perform synchronous movements? The third study tested this idea by examining the change in negative out-group biases and attitudes following movement performances, where the opposing groups (as determined by a minimal group split) did the moves either synchronously with each other or non-synchronously.

A comparison of social bonding towards the out-group before and after the movement activity showed an increase after synchronous, but not non-synchronous, movement performances. Moreover, after the completion of the movement activity, out-group bonding was significantly higher in the synchrony than in the non-synchrony condition, as was evident by both the children's questionnaire responses and by the implicit behavioural measure of social closeness. This indicates that the groupishness effect that is created by movement synchrony was strong enough to override the biases

incurred by allocation into separate minimal groups. Although several studies with adults have revealed the groupishness effect of movement synchrony (Cohen et al., 2013; Reddish, Fischer, et al., 2013; Wiltermuth & Heath, 2009), none to date had examined how the effects are reflected on the participants' attitudes and behaviours towards out-groups (but see: Miles, Lumsden, Richardson, & Macrae, 2011; Reddish, Bulbulia, & Fischer, 2013). The present study provides the first data supporting the proposed group-level social bonding effects of movement synchrony above and beyond existing group divides.

The three studies conducted in this thesis established the existence of a social bonding effect of movement synchrony in childhood. The effects were demonstrated at different time points in development and on different aspects of pro-sociality based on the children's socio-cognitive abilities, increasing the ecological validity of the findings. Due to the foundational focus of the current thesis, the mechanisms that may have given rise to the observed effects could not be investigated in detail. In the following section, some of the potential mechanisms that might have played a role will be discussed with a view to providing direction for future research on this topic.

8.2 MECHANISMS UNDERLYING THE PRO-SOCIAL EFFECTS OF MOVEMENT SYNCHRONY

Having ascertained the social effects of movement synchrony among adult participants in controlled experiments, researchers have now started to investigate the underlying mechanisms leading to these effects. Various cognitive, neurological and hormonal mechanisms have been proposed. In this section, three of the mechanisms that are most relevant to the findings of the current study will be examined; namely, similarity, shared representations and the mirror neuron system and the neuro-hormonal mechanisms.

8.2.1 Similarity

Humans like and prefer to bond with those who are similar to themselves (Haun & Over, 2015). This is manifest in young infants' preferences for others who are same-race, same-age, same-gender and who speak the same native language as them (Kinzler et al., 2010). This preference for similar others, so-called homophily (Haun & Over, 2015), can be thought of as a cognitive heuristic, which helps individuals to identify others who have higher potential to be genetically similar to self. Numerous studies have shown that people increase the similarity between themselves and another person by spontaneously and unconsciously copying others' behaviours when they want to affiliate with them and, conversely, that being mimicked increases liking between partners (Heyes, 2011; Stel et al., 2010; Stel, van Baaren, & Vonk, 2008; van Baaren, Janssen, Chartrand, & Dijksterhuis, 2009). Similar findings were obtained in the case of synchrony as well, where individuals spontaneously and unconsciously synchronised the rhythm of their movements to others and that synchronisation of movements facilitated affiliation between the partners (Richardson et al., 2007, 2005; Schmidt & Brien, 1997; Zivotofsky & Hausdorff, 2007). All these studies suggest that humans almost automatically tend to increase similarity with others by copying movements and following the same rhythms with them.

Several studies with adults have shown that performing matched movements in time to the same rhythms increases participants' perceptions of being similar to one another (Valdesolo & Desteno, 2011; Valdesolo et al., 2010; Wiltermuth & Heath, 2009). One recent study with 8- to 9-year-olds found that to be the case in children also (Rabinowitch & Knafo-Noam, 2015). Following a brief synchronous tapping activity, children thought they were similar to their partners in terms of appearance, character, hobbies and artistic taste. It seems, then, that similarity in a purely visual/physical trait

(i.e., synchronisation of movements) is generalised to similarity in other domains about which individuals do not have any information. Notably, the emergence of synchrony in these studies was ‘coincidental’; it occurred as a by-product of individuals following their own rhythms rather than agreeing and making a conscious effort to synchronise with each other. Thus, it can be inferred that the generalised similarity effect is not necessarily about shared intentionality or other high-level processes, but about a more basic-level, perhaps automatic process that triggers the creation of positive social images in response to acoustic/visual/physical similarities in the context of a joint activity.

In the studies of the current thesis as well, synchrony emerged as a by-product of individuals following their own rhythms, suggesting that a similarity mechanism might have operated here. However, a mediating effect of similarity on the movement synchrony-social bonding link was not tested directly. Only in the final study, the post-test bonding questionnaire included questions about similarity such as “I think I am similar to my/the other group in general” and “I share the same goals as my/the other group”. Responses to these questions correlated strongly with the other questions that assessed pro-social attitudes, groupishness and liking. As all items were grouped together in analyses, similarity was not analysed separately. Still, based on the questionnaire results, it can be said that synchronous movement elevated children’s perceptions of being similar to others in general when compared with non-synchronous movement. It will be important for future research to investigate whether perceived similarity mediates the social effects of movement synchrony. Moreover, assessing degrees of synchrony and whether they correspond to differing degrees of similarity perception would be of interest. The current studies faced challenges in successfully getting children to precisely follow the rhythms and in accurately assessing their degree

of synchrony; it would be useful in future research to automatise measures of synchronisation using higher-level technology.

8.2.2 Shared representations and the Mirror Neuron System (MNS)

Individual neurons in certain areas of the brain, namely in inferior parietal lobule and ventral premotor cortex, fire both as an individual performs an action and as they observe someone else perform it (initial findings on chimpanzees: Di Pellegrino, Fadiga, Fogassi, Gallese & Rizzolatti, 1992; review on studies with humans: Rizzolatti & Craighero, 2004). This has been taken to suggest that, in perceiving others' actions, our brains simulate the observed action in some sense as though the self were performing it, thereby allowing 'first-person access' to others' actions (Gallese et al., 2004). Neural processing of others' actions as if they were one's own actions has been proposed to facilitate understanding others' goals (Bertenthal & Longo, 2008) and emotions (Bastiaansen et al., 2009).

Specifically, it has been proposed that the MNS can explain mental state and intention sharing (Fogassi et al., 2005; Uddin et al., 2007). Notably, mirror neurons become more active not just in response to visual stimuli but also to the sounds of actions (Kohler, 2002), which has been suggested to imply that MNS may have played a role in language evolution (Iacoboni, 2009). These suggestions as to the crucial role of MNS in high-level social cognitive functions have triggered a debate on whether mirror neurons are innate (Lepage & Théoret, 2007; Meltzoff, 2011) or whether their development depends on learning by experience (Giudice, Manera, & Keysers, 2009; Heyes, 2010).

A growing number of EEG studies have been conducted on MNS in childhood and infancy, using desynchronisation of the *mu* rhythm as indicative of increased

activation of mirror neurons (Marshall & Meltzoff, 2011; Nyström, 2008; Pineda, 2005). It was found that at as young as 8 to 9 months, *mu* rhythm desynchronisation is observed during action execution and observation of goal-directed actions, but not non-goal-directed actions (Liao, Acar, Makeig, & Deak, 2015; Marshall, Young, & Meltzoff, 2011; Nyström, Ljunghammar, Rosander, & von Hofsten, 2011; Southgate et al., 2010). These studies also showed that MNS activation was strongly related to the infants' own motor abilities (i.e., higher neural activation when the infants can perform the actions themselves) and learning (i.e., higher and sooner neural activation with repeated exposure to the same action sequence) (Southgate et al., 2010; van Elk, van Schie, Hunnius, Vesper, & Bekkering, 2008). Altogether, the developmental evidence suggests that although mirror neurons may be in place at birth (and possibly even before), first-person experience with action execution and learning from the environment are crucial for the development of MNS (Giudice et al., 2009; Heyes, 2010; Woodward & Gerson, 2014).

How can MNS be a mechanism for explaining the social effects of movement synchrony? We know that during imitation, where one first observes a series of actions and then executes them himself/herself, MNS activation is higher than during the execution of other controlled movement tasks (Iacoboni & Dapretto, 2006). In the case of synchronous movements, participants, in addition to executing the same actions and observing their partners do the same, also share the timing of their rhythms. Arguably, when similarity in actions is coupled with similarity in timing, MNS activation would be even more enhanced.

Echoing the proposals for the relevance of the MNS in empathy and higher level social cognition, some researchers have suggested that movement coordination and action copying lead to neural coupling between the interactants, which would then

transfer into a conceptual blurring of the self and other (Lawrence et al., 2006; Shaw, Czekóová, Chromec, Mareček, & Brázdil, 2013). This self-other blurring, it is argued, may account for generalised similarity effects and feelings of increased connectedness, closeness and being part of the same entity (Paladino, Mazzurega, Pavani, & Schubert, 2010; Reddish, Fischer, et al., 2013). No study to date has looked at whether rhythmic synchronisation of movements activates mirror neurons differently than non-synchronous movements.

Considering the involvement of MNS in processing others' goal-directed actions around 9 months of age, it would be interesting to investigate whether the synchrony preference difference found in 12-month-olds in Study 1 of this thesis would appear in relevant neurological measures as well, reflecting differential activation of MNS in the two age groups. Further, in older ages, a potential difference between active and passive synchronised movements (i.e., where the participants perform volitional actions versus are moved by others) could be examined to understand the role of MNS more fully. Future research should first investigate more specifically whether movement synchrony affects MNS activity differently than non-synchrony and, if so, whether the observed social outcomes are related to this activation.

8.2.3 Neuro-hormonal mechanisms

Neuro-hormones, released from specialised cells in the nervous system, play a crucial role in regulating bodily functions and have significant impact on people's psychological states. It has been proposed that particularly oxytocin and the endogenous opioid system (EOS), which includes endorphins, are involved in producing the observed positive social effects of movement synchrony (Dunbar & Shultz, 2010; Freeman, 2000; Machin & Dunbar, 2011). Endorphins are known as the body's endogenous morphine; they regulate pain and reward processes and have an effect on

elevating mood (Le Merrer, Becker, Befort, & Kieffer, 2009). Oxytocin has established effects on parturition, mother-infant bonding and mediation of threat perception, fear and anxiety (Grillon et al., 2013).

Importantly, both the EOS and oxytocin are well-known for their effects on promoting social bonding (Brent, Chang, Gariépy, & Platt, 2014; MacDonald & Leary, 2005; Panksepp et al., 1994; Young, Liu, & Wang, 2008). Comparative research shows that endorphins are involved in primate grooming, which is considered to be an important manifestation of close relationships in primate societies (Graves, Wallen, & Maestripieri, 2002; Keverne, Martensz, & Tuite). In humans, there is some evidence that endorphins mediate the beneficial effects of social affiliation on physical pain (for a review, see: MacDonald & Leary, 2005). These studies are insightful from a reverse perspective, as social pain, caused by social exclusion for instance, can in some respects be considered the opposite of social bonding. In one study, real-time fMRI scans were performed on people, who, within the context of a ball-tossing game, were excluded from the play by the other players. It was found that similar neurophysiological pathways that are activated in response to physical pain were activated in the case of social exclusion too (Eisenberger, Lieberman, & Williams, 2003).

In many mammal species including humans, opioids are also released during social contact between mothers and infants (especially under stressful conditions), serving to make maternal investment and bonding rewarding (Panksepp et al., 1994). Importantly, the opioid system modulates the release of oxytocin (Depue & Morrone-Strupinsky, 2005), enabling normal progression of the labour process and promoting mothers' responsiveness to infant-related stimuli during caregiving (Brown, Russell, & Leng, 2000; Saltzman & Maestripieri, 2011). In addition to its well-established role in mother-infant bonding, oxytocin also plays a role in attraction and bonding between

romantic partners (Ulmer-Yaniv et al., 2016). Thus, the activation of the EOS and oxytocin may play a role in the social bonding outcomes that are observed in the current studies as well.

A growing amount of research indicates that the EOS and oxytocin are implicated in activities that involve rhythmic synchronous movement, such as music, dance and physical exercise. Yet, direct measurement of those neuro-hormones often requires invasive, costly or lengthy procedures (e.g., sampling spinal fluid, Positron Emission Tomography scans: Machin & Dunbar, 2011 or increased wait-time to reach effective concentration levels: Striepens et al., 2013). Hence, the existing evidence is based on a mixture of behavioural proxies and a rather limited amount of neural measurements. Neuroscientific studies have revealed that sustained physical exercise results in the release of endogenous opioids, which also accounts for the elevated positive mood that the performers experience following intensive exercise – a phenomenon also dubbed the “runner’s high” (Boecker et al., 2008; Galdino, Duarte, & Perez, 2010; for similar results with endocannabinoid involvement, see: Raichlen, Foster, Gerdeman, Seillier, & Giuffrida, 2012).

Several behavioural studies have also shown that performing physical exercise synchronously within a group, compared to alone, elevated the participants’ pain threshold, which was used as a proxy for increased endorphin activity (Cohen et al., 2010; Sullivan & Rickers, 2012). Listening to and producing music and dancing has also been found to facilitate pain tolerance (Dunbar, Kaskatis, MacDonald, & Barra, 2012), pain relief (Bradt, 2010) and the release of oxytocin in medical settings (Nilsson, 2009). Increasingly, music interventions and therapies are being used with postoperative patients in order to reduce patients’ anxiety, pain and stress (for a review, see: Bernatzky, Presch, Anderson, & Panksepp, 2011). Altogether, these widely varied

studies support the suggestion that synchronised rhythmic movements performed in group settings can trigger the EOS and oxytocin system, and thereby produce positive social bonding outcomes.

Recently, studies have begun to compare more directly the effect of synchronous movement to non-synchronous movement on altering participants' pain threshold and social bonding. The evidence seems to be mixed. Synchronous movement was not found to increase participants' pain threshold when the movement activity involved exertive rowing (Davis et al., 2015) or drumming in a laboratory setting (Cohen et al., 2013). Yet, when participants (mean age: 14 years old) performed exertive, dance-like full-body movements, increases in pain threshold and social bonding were observed (Tarr et al., 2015). Notably, however, the increase in social bonding was not mediated by pain threshold, suggesting synchronous movement facilitated pain tolerance and bonding separately.

A similar mechanism may have played a role in the final study of this thesis, where children performed full-body movements synchronously versus non-synchronously with an out-group. Relevantly, Tarr and colleagues (2015) found that compared to non-synchrony, synchronous movement yielded a significant change in pro-social attitudes towards the synchronising partners, but not towards others in the children's class who had not taken part in the movement activity. Combined with the findings of the final study of this thesis, this suggests that it is important for the out-group to be actively involved in the synchronous movement activity in order for bonding to be facilitated. Although neuro-hormonal mechanisms were not explored in the current thesis, given their importance for social regulation from early years of life, EOS and oxytocin may have been implicated and may have mediated the synchrony-dependent increases in pro-social behaviour and bonding.

8.3 INTEGRATING MOTOR, SOCIAL AND COGNITIVE DOMAINS IN PRO-SOCIAL DEVELOPMENT

This research supported an integrative approach to child development in which the development of pro-sociality was investigated in relation to other, seemingly simple aspects of embodied human interaction. Children obtain meaning from motor behaviours of others as they act on the physical and social world. One important element of meaning that is available to infants from early in development, which the current thesis focussed on, is the timing of other people's actions. This information appears to enable children to form causal links between people's intentions and actions as well as to align their own behaviours accordingly (Fonagy et al., 2007; Rochat et al., 1998), eventually maturing into abilities to share intentions and engage in joint actions with others (Knoblich & Sebanz, 2008).

In the past couple of decades, developmental science has witnessed a surge of experimental studies on children's early pro-sociality and understanding of others' mental states (Paulus & Moore, 2012). The new tools and measurement methods applied have yielded findings showing signs of joint attention towards the end of the first year and pro-social behaviours already in the second year of life. There have been two important consequences of this growing research on pro-sociality. Firstly, this trajectory of changes around the turn of the first and the second year has been argued to reveal 'revolutionary periods' in the development of social cognition and pro-sociality (Adamson & Bakeman, 1991; Brownell, Nichols, & Svetlova, 2011). Secondly, increasing evidence for the precursors of pro-social preferences and behaviours has led to the suggestion that humans have an inborn capacity to attribute mental states to others (Baillargeon, Scott, & Bian, 2016) and a unique motivation to engage with others pro-socially (Herrmann, Call, Hernández-Lloreda, Hare, & Tomasello, 2007; Tomasello & Moll, 2010; Warneken, 2015). However, recently, these views have started to be

challenged on grounds that (a) the developmental trajectory is not as discontinuous as it is claimed to be, and (b) early existence of pro-sociality does not necessarily point to unique, inborn motivations or skills for cooperation. As will be seen in more detail below, both of these positions advocate an integrative investigation of social, cognitive and motor aspects of development.

The argument for discontinuity in development stems from the marked change in children's social-cognitive abilities around the start of the first and second years of life. One such 'revolution', for example, is characterised by the emergence of triadic interactions around 12 months, whereby the infant, together with another person, jointly attends to an object of mutual interest (Striano & Rochat, 1999). Due to the seemingly immediate emergence of the social skills that are required for triadic interactions, this leap was deemed a "curious developmental gap" (Adamson & Bakeman, 1991, p. 21) and has given rise to accounts that try to link the two developmental stages by attributing to infants an innate capacity to engage pro-socially with others. However, it might be that precursors of advanced social skills such as abstract/symbolic thinking and mental-state attributions are already manifest at younger ages, albeit in a less elaborate and implicit way than they are in older children and adults. An embodied account has much to contribute here as it offers the opportunity to learn about the development of social cognition by investigating the "production and mutual perception of body states, body movements, and their outcomes" (Daum, Sommerville, & Prinz, 2009, p. 1197).

Let us consider an integrative approach to the abovementioned "curious developmental gap" for the emergence of triadic interactions in infancy. A good example of the gradual transition comes from research examining parallel developments in motor abilities and mother-infant social interactions between 4 months and 12

months of age (de Barbaro et al., 2013). De Barbaro and colleagues (2013) showed that at 4 months, infants' motor capacities confined their engagement with objects only to those objects that their mothers handed to them; there was less reaching out with hands and arms to novel objects. At the moment of receiving objects, infants' attention shifted immediately to objects and then to the mother, where the infant and the mother maintained eye contact and mutually smiled at each other. At 6 months, infants became physically more capable of grasping objects without the mother's help. Thus, the infants could now divert their attention to the mother and hold/reach for a novel object at the same time.

At 9 months, growing motor abilities further enabled the infants to act on and manipulate objects (e.g., spinning or banging the toy) and shift attention between the object and the mother more swiftly. Consequently, mothers started to follow the infants' gaze more frequently and more turn-taking occurred as the infant and the mother pointed to objects, vocalised and handed in toys to each other. Finally, at 12 months, infants became able to handle and manipulate objects separately with both hands. With this increase in motor proficiency, infants could divide their attention between the object and the mother and could not only follow the mother's gaze or pointing gesture to direct their own attention to objects but they could also direct the mother's attention to the object using gaze or pointing gesture themselves.

This close look at the interactions between motor and social aspects of development reveal a persistent and continuous developmental pattern, eventually leading to triadic interactions. Such an approach clarifies the conditions under which advanced social-cognitive skills emerge and whether, and to what extent, high-level explanations are needed. It also underscores the importance of conceptualising and

investigating motor, social and cognitive aspects of development as inter-related, in order not to miss or misconstrue parts of the developmental story.

In developmental debates on cooperation and pro-social behaviour, a focus on high-level explanations has also engendered assertions about inborn capacities and motivations for pro-sociality. The findings of two seminal studies, one suggesting theory of mind (ToM) development at 15 months (Onishi & Baillargeon, 2005) and the other showing instrumental helping behaviour at 18 months (Warneken & Tomasello, 2006), have proposed -and numerous other studies have followed- the idea that infants have inborn mentalising capacities and motivations to act pro-socially. Specifically, it is argued that 3-month-old infants can attribute goals to others (Luo, 2011) and that around 12 to 14 months, children start helping others with the intention to benefit them (Warneken, 2015). Yet, due to the infants being pre-verbal, this line of research has had to rely on indirect and/or implicit measures for inferring pre-verbal infants' mental states and reasoning, which have alternative, lower-level interpretations as well (Butterfill & Apperly, 2013; Heyes, 2014; Hunnius & Bekkering, 2014; Paulus & Moore, 2012).

For instance, in Warneken and Tomasello's (2006) classic study on helping behaviour, infants' reactions are measured in response to an adult accidentally dropping an object on the floor and insistently but unsuccessfully trying to reach for it (experimental condition) versus an adult intentionally throwing an object on the floor and not making any subsequent attempts to reach for it (control condition). That infants across a number of studies were shown to help more in the experimental than in the control condition has been taken as evidence that their helping behaviour is motivated by an altruistic desire to alleviate the distress of the person in need (Warneken, 2015). However, there is also evidence that infants help non-human agents, who clearly are not

in a negative or needy state at time of the ‘accident’ (Kenward & Gredebäck, 2013). This may suggest that infants’ responses are motivated by a rather automatic process of ‘goal contagion’, where observing a purposeful action automatically triggers in the infant the desire to fulfil the goal, regardless of the neediness of the actor (Chartrand & Bargh, 1999). Such an explanation would be considered lower-level, because it does not require that the infant makes inferences about the helpee’s desire or need to achieve a goal.

Yet another study has shown that when no communicative cues were provided by the adult who accidentally dropped versus intentionally threw an object, 3.5-year-old children helped indiscriminately in both conditions and only 5-year-olds helped more in the experimental condition (Paulus, Hunnius, Struik & Bekkering, 2011). This may imply that not the neediness of the adult, but the emerging opportunity to socially engage with others is what drives children’s early helping behaviour (Paulus & Moore, 2012). This study also shows that infants infer the neediness of the adult largely from their negative emotional expressions and gestures. It may thus be that, in the classic version of the experiment, infants automatically adopt the negative emotions of the other through ‘emotional contagion’ and respond by helping in order to alleviate their own distress rather than that of the helpee (Kärtner, Keller, & Chaudhary, 2010). Further discussion on the limits of this widely-used helping task and suggestions on how to disentangle these possibilities can be found in Tunçgenç (2016).

Altogether, the current state of the research shows the importance of looking beyond mentalistic interpretations to consider other possible lower-level explanations on the development of pro-sociality (Paulus, 2014). Applying this approach to the current research, for example, it could be said that even though 12-month-old infants chose synchronously-moving toys over non-synchronous ones exclusively in a social

context, this need not suggest that the infants attributed mental states to the social toys or that they inferred sharing of intentions or affect with them. It might be that, based on their experience with the importance of timed movements in real-life social interactions and communication, the infants viewed synchrony as especially salient in the case of social toys. Arguably, similar experience of synchronising movements with non-social objects could have created a preference for synchrony in the non-social condition. Alternatively, infants with limited social interaction (and therefore limited experience with coordinating and synchronising movements with others) may not show the observed preference for synchronous others in a social condition.

In order to reveal all these and other possibilities, an integrative approach is essential. By jointly investigating motor, social and cognitive aspects, a more thorough and accurate understanding of the development of social cognition and pro-sociality can be attained. The current thesis followed such an integrative approach and revealed how strongly motor movement can impact the development of social bonding and pro-sociality. Future research with a focus on the links among different aspects of development should continue to elucidate our understanding of the ontogeny of social cognition in children (Prinz, Beisert, & Herwig, 2013).

8.4 IMPLICATIONS OF THE FINDINGS FOR APPLIED FIELDS

Identifying the factors that facilitate social bonding, cooperative tendencies and behaviours in childhood can have implications for a wide range of applied contexts, including psychosocial health, education settings and social interventions.

Acknowledging (a) that the current studies were not conducted with consideration of the constraints of applications in mind and (b) that single studies rarely form a robust basis for far-reaching applied projects, this section aims to propose possible implications that the current studies may have beyond strictly theoretical debates. It is important to note,

however, that future studies investigating the durability and range of the positive social effects of movement synchrony are essential before firm conclusions about applications can be made.

The first study showed that at 12 months, infants display an exclusively social preference for synchronous movement compared to non-synchronous movement. The importance of physical coordination between infants and carers for social and communicative development has been discussed widely by other researchers (Feldman, 2007c). Deficiencies in movement coordination can signal social interaction problems, as evident by an increasing number of studies, which show parallels between infants' coordination deficiency and later diagnosis of autism spectrum disorders (ASDs) (Tordjman et al., 2015). For instance, it was found that long before an ASD diagnosis (i.e., before 18 months of age), infant-parent interaction patterns showed a deviant pattern of progress, whereby the infants responded less contingently to the parents' bids of engagement (Saint-Georges et al., 2011). A comparison of infants at low-risk versus high-risk of ASDs has further shown that at as young as 4 months, high-risk infants, who were later diagnosed with ASDs, failed to respond to their parents' vocalisations and smiling in a contingent manner (Sandercock, Jones, Klin, & Shultz, 2015). One experimental study has shown that, compared to typically developing children, children with ASDs exhibited less spontaneous synchronisation whilst rocking in rocking chairs with their parents (Marsh et al., 2013). Given all these findings, it may also be that a social preference for synchrony, as was found in the first study of this thesis, is lacking in children with ASDs. Investigations on infants' abilities and preferences for synchrony in social settings could be critically important for identifying the precursors of social interaction deficits in infants and could help to inform early diagnosis and treatment opportunities.

The second and third studies of this thesis may contribute to applied fields by offering ways of facilitating pro-sociality among children. The second study established that after performing synchronous movements, helping behaviour among peers increased significantly, as did mutual smiling and eye contact during the interaction. This may have important implications for facilitating peer-play and cohesion in classroom settings. Facilitating pro-social behaviour in the classroom is of great interest to parents and educators due to its strong links with social and academic competence (Bergin, 2014). Studies have repeatedly shown that children who behave pro-socially are liked more by their classmates (Denham, McKinley, Couchoud, & Holt, 1990; McDowell, O'Neil, & Parke, 2000). The reverse is also true; rejection by classmates influences children's likelihood of displaying aggressive, anti-social behaviour (Coie & Cillessen, 1993; Denham & Couchoud, 1990a). Moreover, pro-social behaviour positively predicts children's academic competence at early childhood ages (and beyond), as indicated by intelligence test results, vocabulary capacity, reading, literacy and numeracy skills and executive functioning (Bierman, Torres, Domitrovich, Welsh, & Gest, 2009; Galindo & Fuller, 2010; Miles & Stipek, 2006).

Musical interventions are being used increasingly as a way to develop children's social-emotional skills (Piek, McLaren, Kane, Jensen, & Dender, 2012; Srinivasan & Bhat, 2013). These interventions often involve a mixture of activities, where the children imitate the actions of each other, make music using instruments and move their bodies in synchrony to the musical rhythms. In both typically developing children and children with ASDs, these interventions seem to yield improvements in emotion sharing, joint attention, empathy, eye contact and spontaneous initiation of social interactions (Kim, Wigram, & Gold, 2008; Overy & Molnar-Szakacs, 2009; Wan et al., 2010). The results of the second study of this thesis suggest that, among the many

factors involved in musical interactions, synchronisation of movements with other children may be a key element in producing these positive social outcomes, especially the improvements in eye contact, emotion sharing (through mutual smiling) and pro-social behaviour. Although the synchronous movement activity in the current study was very brief (i.e., 40 seconds) and the observed effects are only known to occur immediately afterwards, longer and repeated applications of such activities may have longer-term effects on facilitating social interactions and pro-social behaviour in young children.

The findings of the third study can also be applied to foster pro-sociality in group settings. In Study 3, it was shown that the initial negative group biases that children had towards out-groups, as compared with in-groups, can be alleviated with a brief synchronous movement activity that is performed together with the out-group. Importantly, children felt similarly close towards their in-group and the out-group following synchronous movement. Given the similarity of mechanisms in the formation of inter-group biases in minimal and real-world social divides (Baron & Dunham, 2015), the current results may have implications for interventions that aim to forge bonds across groups that are divided based, for example, on ethnic, religious or socio-economic differences.

Evidence from cultural intervention programmes support the view that collective movement, such as in dance, exercise and sports, can reduce inter-group biases and increase bonding and cooperation across groups. School-based community development programs involving dancing in time to rhythms, playing instruments or performing physical activities have been shown to increase a range of positive outcomes, including a sense of collective identity, understanding of others' cultural values, inclusion of out-group members and feelings of belongingness (Bailey, 2005; Dillon, 2006; Marsh,

2012). Similarly, training programs conducted with children aged 8–11, which had an emphasis on music production within groups, facilitated emotional empathy (Rabinowitch et al., 2012), sympathy and pro-social attitudes (Schellenberg et al., 2015). Therefore, given its repeatedly demonstrated effects on facilitating social interactions and pro-social behaviour, synchronous and matched movement performances can help forge bonds across existing group divides. Future research should investigate more specifically the conditions under which such effects can be achieved in real-world divides.

8.5 FUTURE RESEARCH DIRECTIONS

The three studies conducted in this thesis have established for the first time that movement synchrony positively influences pro-sociality and social bonding via different kinds of synchronous activity and at different points in childhood. Due to the scarcity of previous research on this topic, the current studies aimed to discover whether the social effects, long proposed in evolutionary-developmental theories, and recently established in adult studies, would be exhibited in children as well. This aim to provide an initial empirical exploration of this question has been achieved in the form of a “proof of concept”, but now leaves many questions about possible mechanisms and their interaction, and about applications to clinical, social and education contexts and questions. These questions are now wide open for future investigation.

Firstly, the cognitive, neural and physiological mechanisms that may underlie the found social effects were not directly examined. In future research, synchrony manipulations should endeavour to tease apart and directly test the separate effects of morphological similarity and timing contingency on social bonding. A possible difference between morphological similarity and timing contingency can inform us about the cognitive and neural mechanisms involved in the effects of movement

synchrony. Whereas phylogenetically ancient associative learning processes may suffice for the detection of contingent timing, detecting morphological similarity may require matched representation of actions of self and other at the neural and possibly also the conceptual level (Brass & Heyes, 2005).

It is also important to investigate the neuro-hormonal basis of the effects. As has been discussed above, both endogenous opioids and oxytocin are implicated in human social bonding. Given the hypothesised significance of coordinated, synchronised movements for the formation of initial carer-infant bonds (Dissanayake, 2000; Feldman, 2007a; Trehub, 2001), it is important to assess whether performing synchronous movements with carers versus with strangers and/or non-social entities would activate neuro-hormonal systems differently, and whether these activations would predict bondedness between the partners. With children at early and middle childhood ages, it would also be informative to investigate whether, similar to adults and young adolescents (Davis et al., 2015; Tarr et al., 2015), movement synchrony triggers mechanisms involved in pain and reward and alleviates perceived physical pain.

Another pressing question for future research from an integrative developmental perspective is how the social bonding effects of movement synchrony interact with the children's developing motor capabilities. Do the observed effects hold only for those movements that are in the children's repertoire or can novel movements (i.e., ones that the children's motor system are unfamiliar with) also create similar social bonding effects? This investigation would elucidate (a) the developmental trajectory of the effects, (b) children's social learning from others' interactions even when they are not involved in the interaction themselves, and (c) the involvement of the MNS in producing the effects. We know from prior studies that infants start to entrain their own movements to auditory rhythms at 5 months (Zentner & Eerola, 2010). This indicates

that by the age of 12 months, which is the earliest age found to date for a social synchrony preference (Chapter 3), infants have had abundant experience in producing rhythmical movements themselves.

Imitation literature suggests that experience with producing movements determines the ease with which one automatically imitates movements that they observe in others (Catmur et al., 2009). If a similar mechanism is in place for the effect of synchrony, then the null results with 9-month-old infants in the first study may be contradicted in follow-up research by using actions that are more familiar to infants than rocking back and forth, or prior training. On the other hand, if prior experience with the movements is not a prerequisite for the social effects of movement synchrony to occur, then this may provide infants with an opportunity to reason about the social world even before they are capable of interacting in ways that they observe others to do. Regarding MNS involvement, the current findings stimulate a series of questions for future research: (1) Does movement synchrony recruit different cognitive, neural and hormonal mechanisms than non-synchrony? (2) If so, do the activation of these mechanisms predict and/or mediate the social outcomes observed of synchrony? (3) If so, what is the range of social outcomes that can be predicted and how early in development is mirror neuron activation observed as a result of synchrony (e.g., around 12 months or also earlier)?

Finally, a wider variety of pro-social outcomes and contexts needs to be examined in order to understand the full scope and applicability of the established effects. Regarding infancy, we know from the present findings and others (Trainor & Cirelli, 2015) that movement synchrony guides infants' social preferences and helping behaviour. If movement synchrony is important for secure attachment formation (Isabella et al., 1989; Jaffe et al., 2001), it would be interesting to see, for instance,

whether infants would also trust and/or selectively learn from a synchronising partner more than one that does not synchronise, in cases where the infants are in a needy position. Moreover, in early childhood (and beyond), it would be important to investigate how long the increase in pro-sociality endures following synchronous movement with peers.

The second and third studies provided strong evidence that performing synchronous movements facilitates social bonding among peers. Yet, in both studies, the children knew each other; would the effects be observed among strangers as well? Would the effects be observed if the group divide was stronger; would moving in time to the same rhythms still bond children together across strongly entrenched real-life group divides? Similarly, in all of the current studies, synchrony was contrasted with a non-synchrony condition. However, real-world effects of synchrony often involve the contribution of other factors, such as touch, music or successfully achieving goals together (i.e., performance outcomes). Therefore, investigating the effects of synchrony in combination with and in contrast to these other factors might enable better comprehension of its effects on social bonding in real life.

Regarding investigating different contexts, one direction for future research is to examine whether similar effects would emerge in different cultures. Since the current studies aimed mainly to establish the existence of a link between movement synchrony and social bonding, it was essential to derive designs from the richest information possible about the developmental trajectories of motor and social development and to use appropriate measures for the variables under concern. Therefore, the current studies were guided heavily by the existing literature, which predominantly represents “WEIRD” populations (Henrich et al., 2010). Accordingly, the current study participants were recruited from European cities and schools and although they came

from mixed ethnicities and socio-economic backgrounds, the effects of these variables were not tested directly. Future research should look more closely into how various socio-cultural factors can affect the link between movement synchrony and social bonding in children.

Additionally, future research should expand its demographic scope to include non-typically developing populations. Previous research shows that children with ASDs are less likely to spontaneously synchronise their movement rhythms with their parents (Marsh et al., 2013) and that social-cognitive impairments (such as Developmental Coordination Disorder, Dyslexia or ASDs) are strongly correlated with deficiencies in motor abilities (for a review, see: Leonard & Hill, 2014). Potential differences in the manifestation of the movement synchrony-social bonding link in these populations can both enhance our understanding on how it works and also inform interventions to improve the social and cognitive abilities of the affected children.

Investigation of these and other questions on (a) the cognitive, neural and neuro-hormonal mechanisms, (b) the contribution of motor development, and (c) a greater variety of motor and pro-social behaviours, contexts and populations would provide a thorough understanding about how the social effects of movement synchrony are produced.

8.6 FINAL REMARKS

This thesis presented experimental data from three studies that investigated the social bonding effects of movement synchrony at three distinct time points in childhood. Altogether, the studies provide firm evidence that synchronous movements facilitate social bonding in children. In particular, the first study demonstrated the emergence of a social preference for synchronously moving others at 12 months of age, but not earlier at 9-month-olds. This study provides the earliest evidence to date on the origins of

infants' synchrony preference. The second study showed that in early childhood years (ages 4 to 6), movement synchrony had a positive effect on helping behaviour, mutual smiling and eye contact between peers. These findings contributed to the literature by showing for the first time that active performance of synchronous movements, compared to non-synchrony, can facilitate active and potentially costly helping behaviour in peer-play, as well as more implicit behaviours that are important for closely bonded social interactions, such as mutual smiling and eye contact. Lastly, the third study revealed that the social bonding effects of movement synchrony were observed across already existing group divides. This was indicated by increased feelings of closeness and togetherness across groups after performing matched and synchronous movements, but not after performing different movements in time to different rhythms. Extending the existing literature on the early emergence of inter-group biases, this study provided preliminary evidence on how negative biases towards out-groups can be alleviated with a synchronous movement activity.

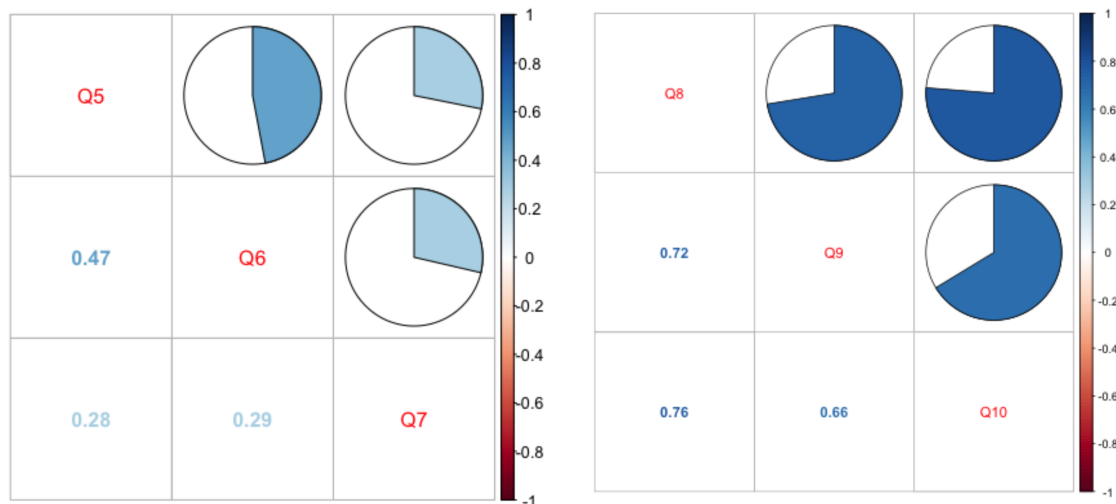
In addition to these empirical contributions, the studies implemented novel, age-appropriate methods for the assessment of synchronous movement and various aspects of social bonding. The first study adopted an original TV set-up, which enabled presentation of the video stimulus as if it were a real-life image, increasing the ecological validity of the findings. For the second and third studies, where the children were required to actively produce movements by following certain rhythms, special movement tasks were designed. These tasks were designed in line with children's motor capabilities at the given ages (e.g., simple clapping-tapping movements for the younger children and full-body movements for the older ones) and their abilities to synchronise with external rhythms (i.e., the rhythmic stimuli were within children's Spontaneous Motor Tempo ranges). Finally, a new, implicit behavioural measure of social closeness

was devised for Study 3. This new measure was successfully implemented and was shown to correlate closely with established questionnaire results.

Future research should continue to investigate in more detail the underlying mechanisms yielding the effects discovered using more varied motor movements, pro-social behaviours, contexts and populations. Only then can a robust ontogenetic picture of social bonding and pro-sociality be drawn, with intricate links formed between the social, cognitive, motor and neural aspects of development.

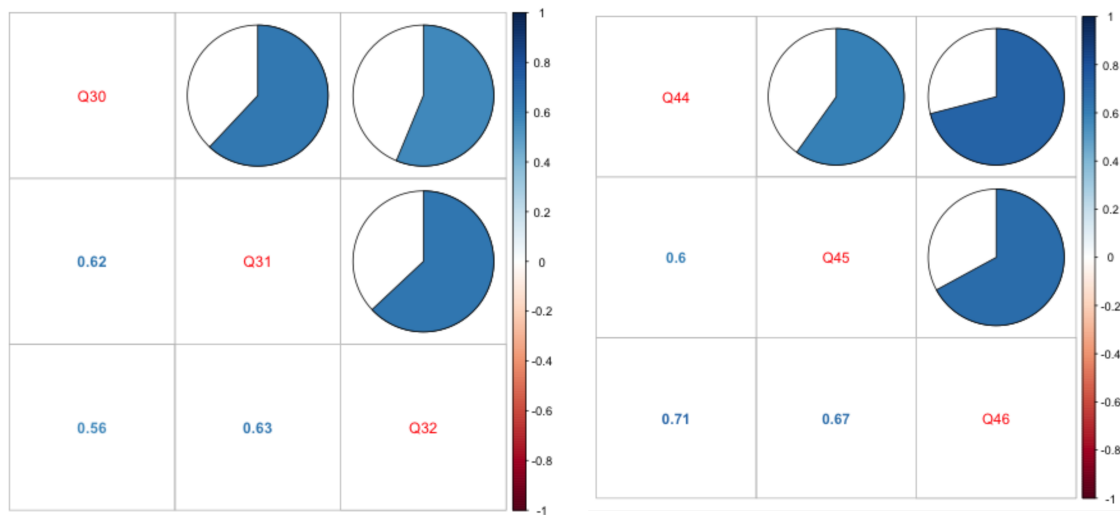


APPENDICES



S1a. Pre-test in-group questionnaire

S1b. Pre-test out-group questionnaire



S1c. Post-test in-group questionnaire

S1d. Post-test out-group questionnaire

Figure S1. Inter-item correlation matrices for the IB and OB questionnaires; all items were retained as their inter-item with correlations were between .3 and .9.

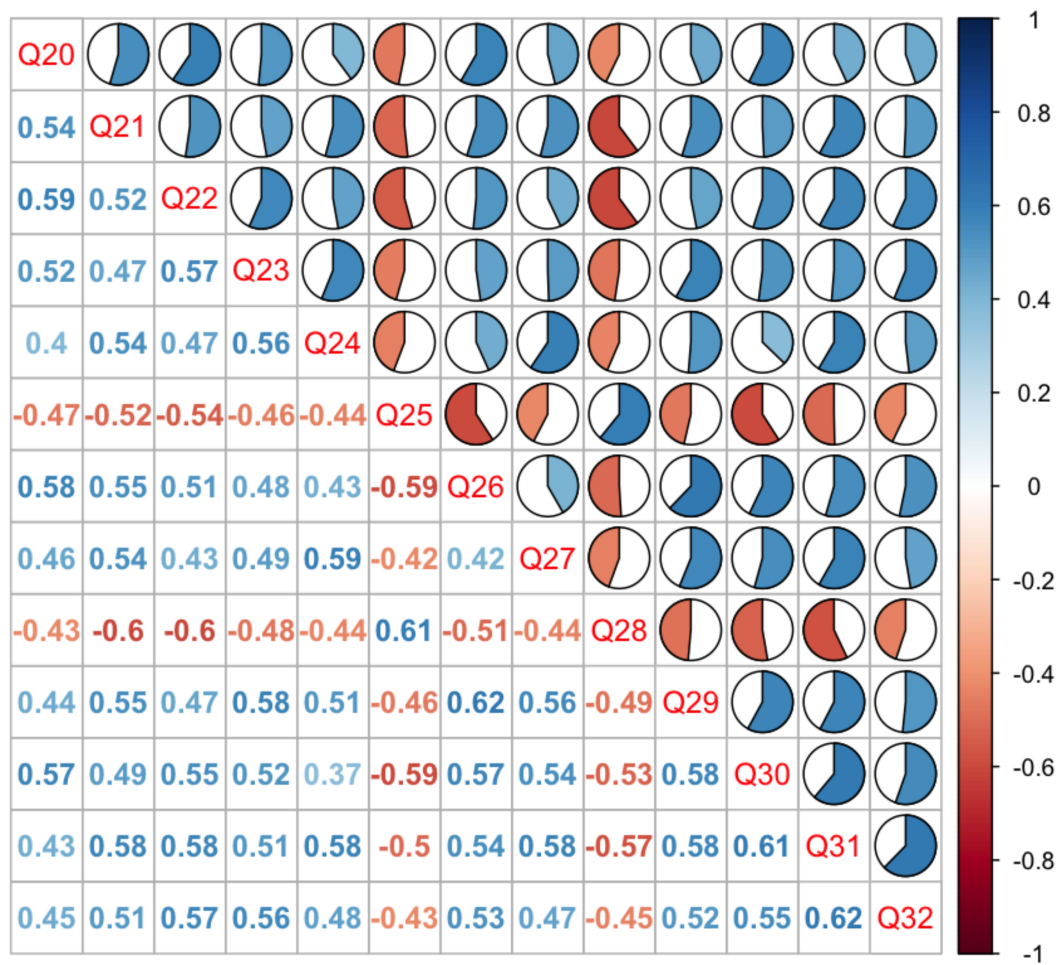


Figure S2. Inter-item correlation matrix for the IB_{long} questionnaire; all items were retained as their inter-item with correlations were between .3 and .9.

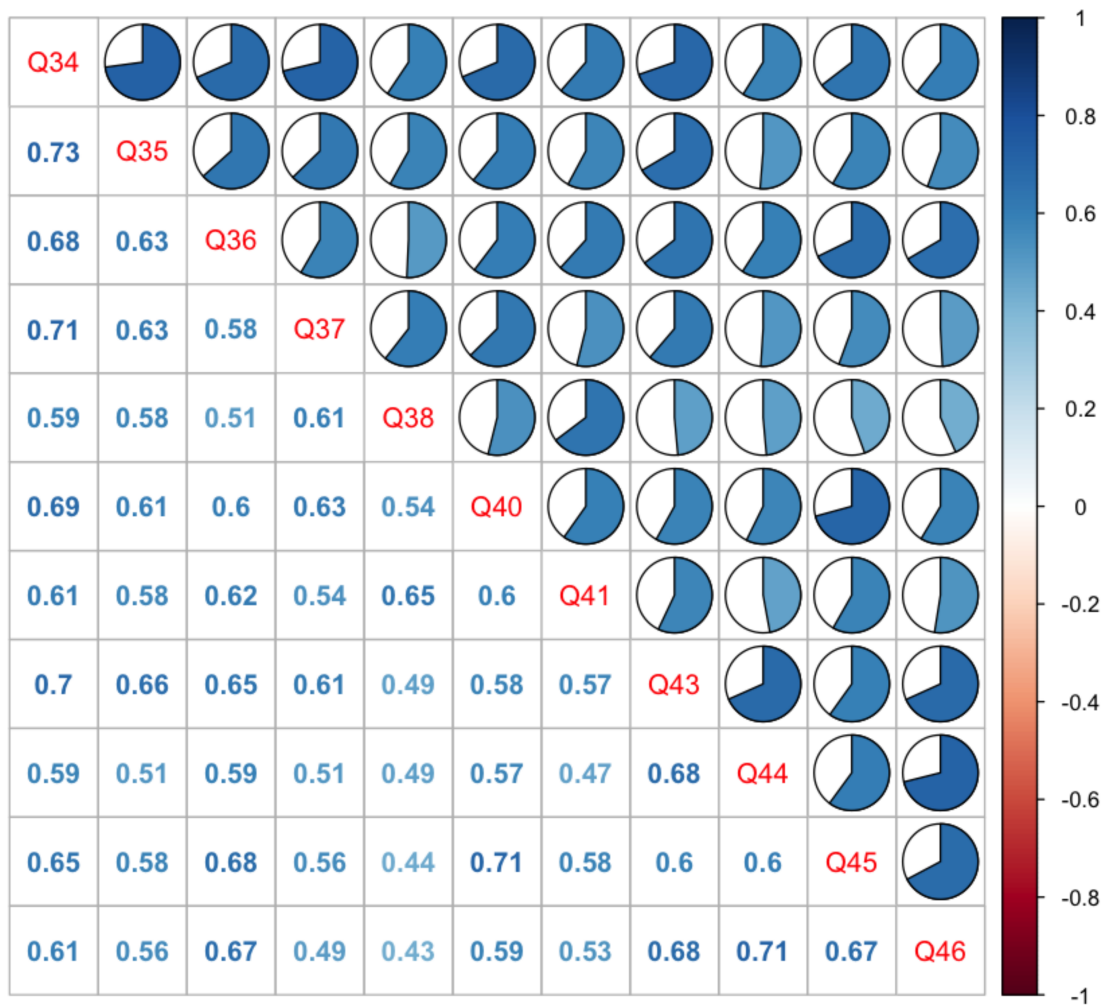


Figure S3. Reproduced inter-item correlation matrix for the OB_{long} questionnaire after items Q39 and Q42 were dropped due to having inter-item correlations < .3 and loadings < .4.

Table S1

Analyses conducted to assess the suitability of the questionnaires for factor analysis

	Kaiser-Meyer-Olkin Test (threshold > .6)	Bartlett Test	Determinant values to check for multicollinearity (threshold > .00001)
IB _{pre-test}	.62	$\chi^2 (3) = 43.61, p < .0001$	0. 69344
OB _{pre-test}	.73	$\chi^2 (3) = 176.25, p < .0001$	0. 18672
IB _{post-test}	.73	$\chi^2 (3) = 141.71, p < .0001$	0. 34148
OB _{post-test}	.74	$\chi^2 (3) = 155.73, p < .0001$	0. 25762
IB _{long}	.91	$\chi^2 (78) = 848.77, p < .0001$	0. 00038
OB _{long}	.94	$\chi^2 (55) = 896.53, p < .0001$	0.00028

Table S2

Component loadings, communalities, eigenvalues of the components retained and the percentage of total variance explained based on principal component analysis with oblimin rotation for the short social bonding questionnaires

Questionnaire Items	Loadings		Communalities	
	Pre-test	Post-test	Pre-test	Post-test
I like my group the other group	.82 .93	.86 .90	.68 .86	.74 .81
I would enjoy helping my group the other group	.80 .91	.90 .89	.64 .82	.81 .79
My group The other group is cool	.67 .88	.89 .90	.44 .77	.80 .80
Questionnaire Items	Questionnaire characteristics			
	Pre-test		Post-test	
Eigenvalues (in-group out-group)	1.76 2.45		2.35 2.41	
Percentage of total variance explained (in-group out-group)	59 82		78 80	
Cronbach's alpha for internal consistency (in-group out-group)	.64 .89		.85 .88	

Table S3

Component loadings, communalities, eigenvalues of the components retained and the percentage of total variance explained based on principal component analysis with oblimin rotation for the long social bonding questionnaires. Items with a “–” sign had loadings < .4 and hence, were dropped from further analyses of the respective questionnaire.

Questionnaire Items	Loadings	Communalities
I feel connected to my group the other group	.73 .86	.53 .74
I feel on the same team with my group the other group	.76 .82	.59 .68
I feel good about my group the other group	.73 .85	.53 .72
I think I am similar to my group the other group in general	.73 .81	.53 .66
I share the same goals as my group the other group	.69 .74	.47 .54
I feel bad about my group the other group	– .72	– .52
I work well together with my group the other group	.79 .84	.62 .70
I am united with my group the other group	.73 .78	.53 .61
I don't like my group the other group	– .69	– .48
I would stick together with my group the other group during challenges	.78 .85	.60 .72
I like my group the other group	.81 .82	.66 .67
I would enjoy helping my group the other group	.94 .84	.70 .71
My group the other group is cool	.80 .81	.64 .65
Eigenvalues (in-group out-group)	7.39 7.40	
Percentage of total variance explained (in-group out-group)	57 67	
Cronbach's alpha for internal consistency (in-group out-group)	.82 .80	

Table S5

Frequencies (n) of children's Island Game responses by factors sex, age, movement set and tempo and chi-square test results.

		Own Group Island	Middle island	Other Group Island	χ^2 results
Age	7-year-olds	5	3	1	$\chi^2(8) = 5.25$, $p = .73$
	8-year-olds	17	19	3	
	9-year-olds	15	12	3	
	10-year-olds	9	7	0	
	11-year-olds	3	3	2	
Sex	Male	25	17	7	$\chi^2(2) = 4.92$, $p = .09$
	Female	24	27	2	
Group Color	Orange	27	21	3	$\chi^2(2) = 1.60$, $p = .45$
	Green	22	23	6	
Movement Set	Set 1	23	25	3	$\chi^2(2) = 2.00$, $p = .37$
	Set 2	26	19	6	
Tempo	585ms	23	24	4	$\chi^2(2) = 0.66$, $p = .72$
	555ms	26	20	5	

BIBLIOGRAPHY

- About, F.E. (1988). *Children and Prejudice*. New York: Blackwell.
- Abramovitch, R., & Grusec, J. E. (1978). Peer imitation in a natural setting. *Child Development*, 49(1), 60–65.
- Abrams, D. (2011). Wherein lies children's intergroup bias? Egocentrism, social understanding, and social projection. *Child Development*, 82(5), 1579–1593. <http://doi.org/10.1111/j.1467-8624.2011.01617.x>
- Abrams, D., & Rutland, A. (2008). The development of subjective group dynamics. In *Intergroup Attitudes and Relations in Childhood Through Adulthood* (pp. 47–65). GB: Oxford University Press.
- Abrams, D., Rutland, A., & Cameron, L. (2003). The development of subjective group dynamics: Children's judgments of normative and deviant in-group and out-group individuals. *Child Development*, 74(6), 1840–1856. <http://doi.org/10.1046/j.1467-8624.2003.00641.x>
- Abrams, D., Rutland, A., Cameron, L., & Marques, J. M. (2003). The development of subjective group dynamics: When ingroup bias gets specific. *British Journal of Developmental Psychology*, 21, 155–176. <http://doi.org/10.1046/j.1467-8624.2003.00641.x>
- Abrams, D., Rutland, A., Pelletier, J., & Ferrell, J. M. (2009). Children's group nous: Understanding and applying peer exclusion within and between groups. *Child Development*, 80(1), 224–243. <http://doi.org/10.1111/j.1467-8624.2008.01256.x>
- Abrams, D., Weick, M., Thomas, D., Colbe, H., & Franklin, K. M. (2011). On-line ostracism affects children differently from adolescents and adults. *The British Journal of Developmental Psychology*, 29, 110–123. <http://doi.org/10.1348/026151010X494089>
- Adamson, L. B., & Frick, J. E. (2003). The still face: A History of a shared experimental paradigm. *Infancy*, 4(4), 451–473. http://doi.org/10.1207/S15327078IN0404_01
- Alcock, K. J., Passingham, R. E., Watkins, K., & Vargha-Khadem, F. (2000). Pitch and timing abilities in inherited speech and language impairment. *Brain and Language*, 75(1), 34–46. <http://doi.org/10.1006/brln.2000.2323>
- Alloway, T. P. (2007). Working memory, reading, and mathematical skills in children with developmental coordination disorder. *Journal of Experimental Child Psychology*, 96(1), 20–36. <http://doi.org/10.1016/j.jecp.2006.07.002>
- Alpert, B., Field, T., Goldstein, S., & Perry, S. (1990). Aerobics enhances cardiovascular fitness and agility in preschoolers. *Health Psychology*, 9(1), 48–56. <http://doi.org/10.1037//0278-6133.9.1.48>
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.
- Anderssen, N., & Wold, B. (1992). Parental and peer influences on leisure-time physical activity in young adolescents. *Research Quarterly for Exercise and Sport*, 63, 341–348.
- Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, 63, 596–612.
- Asendorpf, J. B., & Baudonniere, P. (1993). Self-awareness and other-awareness:

- Mirror self-recognition and synchronic imitation among unfamiliar peers. *Developmental Psychology*, 29(1), 88–95.
- Asendorpf, J. B., Warkentin, V., & Baudonni, P. (1996). Self-awareness and other-awareness II: Mirror self-recognition, social contingency awareness, and synchronic imitation. *Developmental Psychology*, 32(2), 313–321.
- Assaïante, C. (2012). Action et représentation de l'action au cours de l'enfance et de l'adolescence: Une approche fonctionnelle. *Neurophysiologie Clinique*, 42(1–2), 43–51. *Emotion*, 9(2/3), 151–165. <http://doi.org/10.1080/02699939508409006>
- Astington, J., & Jenkins, J. (1995). Theory of mind development and social understanding. *Cognition and Emotion*, 9(2/3), 151–165. <http://doi.org/10.1080/02699939508409006>
- Badenes, L. V., Estevan, R. A. C., & Bacete, F. J. G. (2000). Theory of mind and peer rejection at school. *Social Development*, 9(3), 271–283. <http://doi.org/10.1111/1467-9507.00125>
- Bagwell, C. L., Molina, B. S. G., Pelham, W. E., & Hoza, B. (2001). Attention-deficit hyperactivity disorder and problems in peer relations: Predictions from childhood to adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, 40(11), 1285–1292. <http://doi.org/10.1097/00004583-200111000-00008>
- Bahrack, L. E., & Watson, J. S. (1985). Detection of intermodal proprioceptive visual contingency as a potential basis of self-perception in infancy. *Developmental Psychology*, 21(6), 963–973. <http://doi.org/10.1037/0012-1649.21.6.963>
- Bailey, R. (2005). Evaluating the relationship between physical education, sport and social inclusion. *Educational Review*, 57(1), 71–90. <http://doi.org/10.1080/0013191042000274196>
- Baillargeon, R., Scott, R. M., & Bian, L. (2016). Psychological reasoning in infancy. *Annual Review of Psychology*, 67, 337–344. <http://doi.org/10.15541/jim20150424>
- Baillargeon, R., Scott, R. M., & He, Z. (2010). False-belief understanding in infants. *Trends in Cognitive Sciences*, 14, 110–118. <http://doi.org/10.1016/j.tics.2009.12.006>
- Ball, E. J., O'Connor, J., Abbott, R., Steinbeck, K. S., Davies, P. S. W., Wishart, C., ... Baur, L. A. (2001). Total energy expenditure, body fatness, and physical activity in children aged 6–9 y. *American Journal of Clinical Nutrition*, 74, 524–528.
- Banaji, M. R., Baron, A. S., Dunham, Y., & Olson, K. (2008). The development of intergroup social cognition: Early emergence, implicit nature, and sensitivity to group status. In *Intergroup Attitudes and Relations in Childhood Through Adulthood* (pp. 87–102). GB: Oxford University Press.
- Bar-Haim, Y., & Bart, O. (2006). Motor function and social participation in kindergarten children. *Social Development*, 15, 296–310.
- Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science*, 17(2), 159–163.
- Bar-Tal, D., Raviv, A., & Goldberg, M. (1982). Helping behavior among preschool children: An observational study. *Child Development*, 53, 396–402.
- Bardid, F., Huyben, F., Lenoir, M., Seghers, J., De Martelaer, K., Goodway, J. D., & Deconinck, F. J. A. (2016). Assessing fundamental motor skills in Belgian children aged 3–8 years highlights differences to US reference sample. *Acta Paediatrica*, 1–10. <http://doi.org/10.1111/apa.13380>
- Barkley, J. E., Salvy, E. J., Sanders, G. J., Dey, S., Von Carlowitz, K. P., & Williamson, M. L. (2014). Peer influence and physical activity behavior in young children: An

- experimental study. *Journal of Physical Activity and Health*, 11(2), 404-409. doi: 10.1123/jpah.2011-0376
- Baron-Cohen, S., Ring, H. A., Bullmore, E. T., Wheelwright, S., Ashwin, C., & Williams, S. C. R. (2000). The amygdala theory of autism. *Neuroscience and Biobehavioral Reviews*, 24(3), 355–364. [http://doi.org/10.1016/S0149-7634\(00\)00011-7](http://doi.org/10.1016/S0149-7634(00)00011-7)
- Baron, A. S., & Banaji, M. R. (2006). The development of implicit attitudes. *Psychological Science*, 17(1), 53–58. <http://doi.org/10.1111/j.1467-9280.2005.01664.x>
- Baron, A. S., & Dunham, Y. (2015). Representing “us” and “them”: Building blocks of intergroup cognition. *Journal of Cognition and Development*, 8372(May), 1–22. <http://doi.org/10.1080/15248372.2014.1000459>
- Baron, A. S., Dunham, Y., Banaji, M., & Carey, S. (2014). Constraints on the acquisition of social category concepts. *Journal of Cognition and Development*, 15(2), 238–268. <http://doi.org/10.1080/15248372.2012.742902>
- Barr, R. (2010). *Transfer of learning between 2D and 3D sources during infancy: Informing theory and practice*. *Developmental Review* (Vol. 30). <http://doi.org/10.1080/10508610802471096>. Looking
- Barton, E. J., Olszewski, M. J., & Madsen, J. J. (1979). The effects of adult presence on the prosocial behavior of preschoolchildren. *Child Behavior Therapy*, 1(3), 271–286. <http://doi.org/10.1300/J473v01n03>
- Baruch, C., & Drake, C. (1997). Tempo Discrimination in Infants. *Infant Behavior & Development*, 20(4), 573–577.
- Bastiaansen, J. A. C. J., Thioux, M., & Keysers, C. (2009). Evidence for mirror systems in emotions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364, 2391–2404. <http://doi.org/10.1098/rstb.2009.0058>
- Bateson, P., & Laland, K. N. (2013). Tinbergen’s four questions: An appreciation and an update. *Trends in Ecology and Evolution*, 28(12), 712–718. <http://doi.org/10.1016/j.tree.2013.09.013>
- Batson, D. C., & Powell, A. A. (2003). Altruism and prosocial behavior. In T. Millon & M. J. Lerner (Eds.), *Handbook of Psychology: Personality and Social Psychology* (Vol. 5, pp. 463–485). New Jersey: John Wiley & Sons, Inc. <http://doi.org/10.1177/008124630803800410>
- Bayley, N. (1936). The development of motor abilities during the first three years. *Monographs of the Society for Research in Child Development*, 1(1), 1-26.
- Behne, T., Carpenter, M., Call, J., & Tomasello, M. (2005). Unwilling versus unable: Infants’ understanding of intentional action. *Developmental Psychology*, 41(2), 328–37. <http://doi.org/10.1037/0012-1649.41.2.328>
- Behne, T., Liszkowski, U., Carpenter, M., & Tomasello, M. (2012). Twelve-month-olds’ comprehension and production of pointing. *The British Journal of Developmental Psychology*, 30(Pt 3), 359–75. <http://doi.org/10.1111/j.2044-835X.2011.02043.x>
- Beighle, A., & Moore, M. (2012). Physical activity before and after school. *Journal of Physical Education, Recreation & Dance*, 83(December), 25–28. <http://doi.org/10.1080/07303084.2012.10598792>
- Beighle, A., & Morrow, J. R. (2014). Promoting physical activity: Addressing barriers and moving forward. *Journal of Physical Education, Recreation & Dance*, 85(March), 23–26. <http://doi.org/10.1080/07303084.2014.937190>
- Bennett, M., & Sani, F. (2008a). Children’s subjective identification with social groups. In *Intergroup Attitudes and Relations in Childhood Through Adulthood* (pp. 19–

- 31). GB: Oxford University Press.
- Bennett, M., & Sani, F. (2008b). Children's subjective identification with social groups: A group-reference effect approach. *British Journal of Developmental Psychology*, 26, 381–387. <http://doi.org/10.1111/j.1467-7687.2007.00642.x>
- Bennett, M., & Sani, F. (2008c). Children's subjective identification with social groups: A self-stereotyping approach. *Developmental Science*, 11(1), 69–75. <http://doi.org/10.1111/j.1467-7687.2007.00642.x>
- Bennett, M., & Sani, F. (2011). The internalisation of group identities in childhood. *Psychological Studies*, 56(1), 117–124. <http://doi.org/10.1007/s12646-011-0063-4>
- Bergeson, T. R., & Trehub, S. E. (2006). Infants' perception of rhythmic patterns. *Music Perception: An Interdisciplinary Journal*, 23(4), 345–360.
- Bergin, C. (2014). Educating students to be prosocial at school. In *Prosocial Development: A Multidimensional Approach*. <http://doi.org/10.1093/acprof>
- Bernard, K., Meade, E. B., & Dozier, M. (2013). Parental synchrony and nurturance as targets in an attachment based intervention: building upon Mary Ainsworth's insights about mother-infant interaction. *Attachment & Human Development*, 15(5–6), 507–23. <http://doi.org/10.1080/14616734.2013.820920>
- Bernatzky, G., Presch, M., Anderson, M., & Panksepp, J. (2011). Emotional foundations of music as a non-pharmacological pain management tool in modern medicine. *Neuroscience and Biobehavioral Reviews*, 35(9), 1989–1999. <http://doi.org/10.1016/j.neubiorev.2011.06.005>
- Bernieri, F. J., Reznick, J. S., & Rosenthal, R. (1988). Synchrony, pseudosynchrony, and dissynchrony: Measuring the entrainment process in mother-infant interactions. *Journal of Personality and Social Psychology*, 54(2), 243–253. <http://doi.org/10.1037/0022-3514.54.2.243>
- Bertenthal, B. I., & Longo, M. R. (2008). Motor knowledge and action understanding: A developmental perspective. *Embodiment, Ego-Space, and Action*, 34, 323–368.
- Bhat, A. N., Landa, R. J., & Galloway, J. C. (2011). Current perspectives on motor functioning in infants, children, and adults with autism spectrum disorders. *Physical Therapy*, 91(7), 1116–1129. <http://doi.org/10.2522/ptj.20100294>
- Bhide, A., Power, A., & Goswami, U. (2013). A rhythmic musical intervention for poor readers: A comparison of efficacy with a letter-based intervention. *Mind, Brain, and Education*, 7(2), 113–123. <http://doi.org/10.1111/mbe.12016> <http://doi.org/10.1016/j.cortex.2012.05.005>
- Biddle, S. J. H., & Asare, M. (2011). Physical activity and mental health in children and adolescents: A review of reviews. *British Journal of Sports Medicine*, 45(11), 886–895. <http://doi.org/10.1136/bjsports-2011-090185>
- Bierman, K. L., Torres, M. M., Domitrovich, C. E., Welsh, J. A., & Gest, S. D. (2009). Behavioral and cognitive readiness for school: Cross-domain associations for children attending head start. *Social Development*, 18(2), 305–323. <http://doi.org/10.1111/j.1467-9507.2008.00490.x>
- Birch, L. L., & Billman, J. (1986). Preschool children's food sharing with friends and acquaintances. *Child Development*, 57, 387–395.
- Blaffer Hrdy, S. (2007). Evolutionary context of Human Development: The cooperative breeding model, 39–68.
- Blake, P. R., & McAuliffe, K. (2011). "I had so much it didn't seem fair" Eight-year-olds reject two forms of inequity. *Cognition*, 120(2), 215–224. <http://doi.org/10.1016/j.cognition.2011.04.006>
- Bobin-Bègue, A., Droit-Volet, S., & Provasi, J. (2014). Young children's difficulties in switching from rhythm production to temporal interval production. *Frontiers in*

- Psychology*, 5(December), 1346. <http://doi.org/10.3389/fpsyg.2014.01346>
- Bobin-Bègue, A., & Provasi, J. (2008). Régulation rythmique avant 4 ans: Effet d'un tempo auditif sur le tempo moteur. *L'année Psychologique*, 108(4), 631–658. <http://doi.org/10.4074/S000350330800403X>
- Boecker, H., Sprenger, T., Spilker, M. E., Henriksen, G., Koppenhoefer, M., Wagner, K. J., ... Tolle, T. R. (2008). The runner's high: Opioidergic mechanisms in the human brain. *Cerebral Cortex*, 18(November), 2523–2531. <http://doi.org/10.1093/cercor/bhn013>
- Bradley, K., Bonbright, J., & Dooling, S. (2013). *Evidence: A report on the impact of dance in the K-12 setting*.
- Bradley, R. H., McRitchie, S., Houts, R. M., Nader, P., & O'Brien, M. (2011). Parenting and the decline of physical activity from age 9 to 15. *The International Journal of Behavioral Nutrition and Physical Activity*, 8(1), 33. <http://doi.org/10.1186/1479-5868-8-33>
- Bradt, J. (2010). The effects of music entrainment on postoperative pain perception in pediatric patients. *Music and Medicine*, 2(3), 150–157. <http://doi.org/10.1177/1943862110369913>
- Brand, R. J., Baldwin, D. A., & Ashburn, L. A. (2002). Evidence for “motionese”: Modifications in mothers' infant-directed action. *Developmental Science*, 5(1), 72–83. <http://doi.org/10.1111/1467-7687.00211>
- Branta, C. J., Haubenstricker, V., & Seefeldt, V. (1984). Age changes in motor skills during childhood and adolescence. *Exercise, Sport and Science Review*, 12, 467–52
- Brass, M., & Heyes, C. (2005). Imitation: Is cognitive neuroscience solving the correspondence problem? *Trends in Cognitive Sciences*, 9(10), 489–95. <http://doi.org/10.1016/j.tics.2005.08.007>
- Brent, L. J. N., Chang, S. W. C., Gariépy, J. F., & Platt, M. L. (2014). The neuroethology of friendship. *Annals of the New York Academy of Sciences*, 1316(1), 1–17. <http://doi.org/10.1111/nyas.12315>
- Bretherton, I., Fritz, J., Zahn-Waxler, C., & Ridgeway, D. (1986). Learning to talk about emotions: A functionalist perspective. *Child Development*, 57(3), 529–548.
- Broad, K. D., Curley, J. P., & Keverne, E. B. (2006). Mother-infant bonding and the evolution of mammalian social relationships. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 361(1476), 2199–214. <http://doi.org/10.1098/rstb.2006.1940>
- Broesch, T. L., & Bryant, G. a. (2013). Prosody in infant-directed speech Is similar across western and traditional cultures. *Journal of Cognition and Development*, (October), 1–13. <http://doi.org/10.1080/15248372.2013.833923>
- Brown, C. H., Russell, J. A., & Leng, G. (2000). Opioid modulation of magnocellular neurosecretory cell activity. *Neuroscience Research*, 36(2), 97–120. [http://doi.org/10.1016/S0168-0102\(99\)00121-2](http://doi.org/10.1016/S0168-0102(99)00121-2)
- Brown, S. (2000). Evolutionary models of music: From sexual selection to group selection. In Tonneau F., Thompson N. S., (Eds.), *Perspectives in ethology*, (Vol 13, pp. 231–282). NY: Plenum Publishers.
- Brownell, C. A., Nichols, S. R., & Svetlova, M. (2011). Converging developments in prosocial behavior and self-other understanding in the second year of life: The second social-cognitive revolution. In *Social Cognitive Development* (pp. 1–11).
- Brownell, C. A., Ramani, G. B., & Zerwas, S. (2006). Becoming a social partner with peers: Cooperation and social understanding in one- and two-year-olds. *Child Development*, 77(4), 803–821. <http://doi.org/10.1111/j.1467-8624.2006.00904.x>.Becoming

- Bruner, J. S. (1957). On perceptual readiness. *Psychological Review*, 64(2), 123–152. <http://doi.org/10.1037/h0043805>
- Bryant, G. A., Liénard, P., & Clark Barrett, H. (2012). Recognizing infant-directed speech across distant cultures: Evidence from Africa. *Journal of Evolutionary Psychology*, 10(2), 47–59. <http://doi.org/10.1556/JEP.10.2012.2.1>
- Bryson, S. E., Zwaigenbaum, L., Brian, J., Roberts, W., Szatmari, P., Rombough, V., & McDermott, C. (2007). A prospective case series of high-risk infants who developed autism. *Journal of Autism and Developmental Disorders*, 37(1), 12–24. <http://doi.org/10.1007/s10803-006-0328-2>
- Bücher, K. (1897). *Arbeit und Rhythmus*. Leipzig: Hirzel.
- Buhrmester, D., Goldfarb, J., & Cantrell, D. (1992). Self-presentation when sharing with friends and nonfriends. *Journal of Early Adolescence*, 12(1), 61–79.
- Bukowski, W. M., Rubin, K. H., & Parker, J. (2001). Social competence. In N. J. Smelser & P. B. Baltes (Eds.) & N. Eisenberg (Sec. Ed.), *International encyclopedia of social and behavioral sciences* (pp. 14258–14264). Oxford, England: Elsevier Science.
- Bukowski, W. M., & Sippola, L. K. (2001). Groups, individuals, and victimization: A view of the peer system. In J. Juvonen & S. Graham (Eds.), *Peer harassment in school: The plight of the vulnerable and victimized* (pp. 355–377). New York: Guilford Press.
- Buon, M., Jacob, P., Margules, S., Brunet, I., Dutat, M., Cabrol, D., & Dupoux, E. (2014). Friend or foe? Early social evaluation of human interactions. *PloS One*, 9(2), e88612. <http://doi.org/10.1371/journal.pone.0088612>
- Bürgi, F., Meyer, U., Granacher, U., Schindler, C., Marques-Vidal, P., Kriemler, S., et al. (2011). Relationship of physical activity with motor skills, aerobic fitness and body fat in preschool children: A cross-sectional and longitudinal study (Bal-labeina). *International Journal of Obesity*, 35(7), 937e944. <http://dx.doi.org/10.1038/ijo.2011.54>
- Burkart, J. M., Hrdy, S. B., & Van Schaik, C. P. (2009). Cooperative breeding and human cognitive evolution. *Evolutionary Anthropology*, 18(5), 175–186. <http://doi.org/10.1002/evan.20222>
- Burkart, J. M., & van Schaik, C. P. (2009). Cognitive consequences of cooperative breeding in primates? *Animal Cognition*, 13(1), 1–19. <http://doi.org/10.1007/s10071-009-0263-7>
- Burns, M. P., & Sommerville, J. A. (2014). “I pick you”: The impact of fairness and race on infants’ selection of social partners. *Frontiers in Psychology*, 5(February), 93. <http://doi.org/10.3389/fpsyg.2014.00093>
- Butler, S. C., O’Sullivan, L. P., Shah, B. L., & Berthier, N. E. (2014). Preference for infant-directed speech in preterm infants. *Infant Behavior & Development*, 37(4), 505–511. <http://doi.org/10.1016/j.infbeh.2014.06.007>
- Buttelmann, D., & Böhm, R. (2014). The ontogeny of the motivation that underlies in-group bias. *Psychological Science*, 25(4), 921–7. <http://doi.org/10.1177/0956797613516802>
- Butterfill, S. A., & Apperly, I. A. (2013). How to construct a minimal theory of mind. *Mind and Language*, 28(5), 606–637. <http://doi.org/10.1111/mila.12036>
- Butterworth, G., & Cochran, E. (1980). Towards a mechanism of joint visual attention in human infancy. *International Journal of Behavioral Development*, 3(3), 253–272. <http://doi.org/10.1177/016502548000300303>
- Butterworth, G., & Jarrett, N. (1991). What minds have in common is space: Spatial mechanisms serving joint visual attention in infancy. *British Journal of*

- Developmental Psychology*, 9(1), 55–72. <http://doi.org/10.1111/j.2044-835X.1991.tb00862.x>
- Cairney, J., Veldhuizen, S., & Szatmari, P. (2010). Motor coordination and emotional-behavioral problems in children. *Current Opinion in Psychiatry*, 23, 324–329. <http://doi.org/10.1097/YCO.0b013e32833aa0aa>
- Cameron, D. J., & Grahn, J. A. (2014). Neuroscientific investigations of musical rhythm. *Acoustics Australia*, 42(2), 111–116.
- Cameron, L., Rutland, A., Douch, R., & Brown, R. (2006). Changing children's intergroup attitudes toward refugees: Testing different models of extended contact. *Child Development*, 77(5), 1208–1219. <http://doi.org/10.1111/j.1467-8624.2006.00929.x>
- Cameron, L., Rutland, A., Turner, R., Holman-Nicolas, R., & Powell, C. (2011). Changing attitudes with a little imagination': Imagined contact effects on young children's intergroup bias. *Annals of Psychology*, 27, 708–717. Retrieved from http://kar.kent.ac.uk/27770/1/anale_de_psychologia.doc
- Campbell, D. T. (1958). Common fate, similarity, and other indices of the status of aggregates of persons as social entities.
- Campbell, P. S., & Scott-Kassner, C. (2006). *Music in Childhood: From Preschool through the Elementary Grades* (3rd ed.). Belmont, CA: Thomson Schirmer.
- Caplan, M. Z., & Hay, D. F. (1989). Preschoolers' responses to peers' distress and beliefs about bystander intervention. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 30(2), 231–42. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/2708463>
- Carpendale, J. I., & Chandler, M. J. (1996). On the distinction between false belief understanding and subscribing to an interpretive theory of mind. *Child Development*, 67(4), 1686–1706.
- Carpenter, M., Akhtar, N., & Tomasello, M. (1998). Fourteen- through 18-month-old infants differentially imitate intentional and accidental actions. *Infant Behavior & Development*, 21(2), 315–330.
- Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition joint attention and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, 63(4), 1–174.
- Casey, B. J., Tottenham, N., Liston, C., & Durston, S. (2005). Imaging the developing brain: What have we learned about cognitive development? *Trends in Cognitive Sciences*, 9(3), 104–110.
- Castelli, D. M., & Ward, K. (2012). Physical Activity During the School Day. *Journal of Physical Education, Recreation & Dance*, 83(6), 20–29. <http://doi.org/10.1080/07303084.2012.10598791>
- Catmur, C., & Heyes, C. (2013). Is It What You Do, or When You Do It? The Roles of Contingency and Similarity in Pro-Social Effects of Imitation. *Cognitive Science*, 37(8), 1541–1552. <http://doi.org/10.1111/cogs.12071>
- Catmur, C., Walsh, V., & Heyes, C. (2009). Associative sequence learning: The role of experience in the development of imitation and the mirror system. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364, 2369–2380. <http://doi.org/10.1098/rstb.2009.0048>
- Chandler, M., Sokol, B. & Hallett, D. (2001). Moral responsibility and the interpretive turn: Children's changing conceptions of truth and rightness. In B. Malle, L. Moses & D. Baldwin (Eds.), *Intentions and intentionality: Foundations of social cognition* (pp. 345–366). Boston, MA: MIT Press.
- Chang, H., & Trehub, S. E. (1977). Infants' Perception of Temporal Grouping in

- Auditory Patterns. *Child Development*, 48(4), 1666–1670.
- Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology*, 76(6), 893–910.
- Chase, M. A., & Machida, M. (2011). The role of sport as a social status determinant for children: Thirty years later. *Research Quarterly for Exercise and Sport*, 82(4), 731–9. <http://doi.org/10.1080/02701367.2011.10599810>
- Chen, D. W., Fein, G., & Tam, H. P. (2001). Peer conflicts of preschool children: Issues, resolution, incidence, and age-related patterns. *Early Education and Development*, 12, 523–544.
- Cheng, Y., Lee, S.-Y., Chen, H.-Y., Wang, P.-Y., & Decety, J. (2012). Voice and emotion processing in the human neonatal brain. *Journal of Cognitive Neuroscience*, 24(6), 1411–1419. http://doi.org/10.1162/jocn_a_00214
- Choi, Y.-J., & Luo, Y. (2015). 13-month-olds' understanding of social interactions. *Psychological Science*, 26(3), 274–83. <http://doi.org/10.1177/0956797614562452>
- Chow, S. M. K., Henderson, S. E., & Barnett, A. L. (2001). The movement assessment battery for children: A comparison of 4-year-old to 6-year-old children from Hong Kong and the United States. *The American Journal of Occupational Therapy*, 55(1), 55–61.
- Christianson, H. (1938). *Bodily Rhythmic Movements of Young Children in Relation to Rhythm in Music*. New York: Teachers College.
- Cirelli, L. K., Einarson, K. M., & Trainor, L. J. (2014). Interpersonal synchrony increases prosocial behavior in infants. *Developmental Science*, 17(6), 1003–1011. <http://doi.org/10.1111/desc.12193>
- Cirelli, L. K., Wan, S. J., & Trainor, L. J. (2014). Fourteen-month-old infants use interpersonal synchrony as a cue to direct helpfulness. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369.
- Cirelli, L. K., Wan, S. J., & Trainor, L. J. (2016). Social effects of movement synchrony: Increased infant helpfulness only transfers to affiliates of synchronously moving partners. *Infancy*, n/a-n/a. <http://doi.org/10.1111/infa.12140>
- Clark, J. E., & Metcalfe, J. S. (2002). The mountain of motor development: A metaphor. In J. E. Clark & J. Humphrey (Eds.), *Motor Development: Research and Review* (Vol. 2, pp. 163–190). Reston, VA: NASPE Publications.
- Claussen, A. H., Mundy, P. C., Mallik, S. A., & Willoughby, J. C. (2002). Joint attention and disorganized attachment status in infants at risk. *Development and Psychopathology*, 14, 279–291.
- Clay, Z., & de Waal, F. B. M. (2013). Bonobos respond to distress in others: Consolation across the age spectrum. *PLoS ONE*, 8(1). <http://doi.org/10.1371/journal.pone.0055206>
- Clayton, M., Sager, R., & Will, U. (2004). In time with the music: The concept of entrainment and its significance for ethnomusicology. *ESEM CounterPoint*, 1, 1–45.
- Cohen, E., Ejsmond-Frey, R., Knight, N., & Dunbar, R. I. M. (2010). Rovers' high: Behavioural synchrony is correlated with elevated pain thresholds. *Biology Letters*, 6, 106–108. <http://doi.org/10.1098/rsbl.2009.0670>
- Cohen, E., & Haun, D. (2013). The development of tag-based cooperation via a socially acquired trait. *Evolution and Human Behavior*, 34(3), 230–235. <http://doi.org/10.1016/j.evolhumbehav.2013.02.001>
- Cohen, E., Mundry, R., & Kirschner, S. (2013). Religion, synchrony and cooperation. *Religion, Brain & Behavior*, 4(1), 20–30.

- <http://doi.org/10.1080/2153599X.2012.741075>
- Coie, J. D., & Cillessen, A. H. N. (1993). Peer rejection: Origins and effects on children's development. *Current Directions in Psychological Science*, 2(3), 89–92.
- Coie, J. D., & Dodge, K. A. (1983). Continuities and changes in children's social status: A five year longitudinal study. *Merrill-Palmer Quarterly*, 29, 261–282.
- Coie, J. D., Dodge, K. A., & Kupersmidt, J. B. (1990). Peer group behavior and social status. In S. R. Asher & J. D. Coie (Eds.), *Peer rejection in childhood* (pp. 17–59). New York: Cambridge University Press.
- Coie, J. D., & Kupersmidt, J. (1983). A behavioral analysis of emerging social status in boys' groups. *Child Development*, 54, 1400–1416.
- Condon, W. S., & Ogston, W. D. (1966). Sound film analysis of normal and pathological behavior patterns. *The Journal of Nervous and Mental Disease*, 143(4), 338–347.
- Cools, W., De Martelaer, K., Samaey, C., & Andries, C. (2011). Fundamental movement skill performance of preschool children in relation to family context. *Journal of Sports Sciences*, 29(7), 649–660.
<http://doi.org/10.1080/02640414.2010.551540>
- Cooper, R. P., & Aslin, R. N. (1990). Preference for infant-directed speech in the first month after birth. *Child Development*, 61(5), 1584–1595.
- Corbeil, M., Trehub, S. E., & Peretz, I. (2015). Singing Delays the Onset of Infant Distress. *Infancy*, n/a-n/a. <http://doi.org/10.1111/infa.12114>
- Corriveau, K. H., & Goswami, U. (2009a). Rhythmic motor entrainment in children with speech and language impairments: Tapping to the beat. *Cortex*, 45(1), 119–130. <http://doi.org/10.1016/j.cortex.2007.09.008>
- Corriveau, K. H., & Goswami, U. (2009b). Rhythmic motor entrainment in children with speech and language impairments: Tapping to the beat. *Cortex*, 45(1), 119–130. <http://doi.org/10.1016/j.cortex.2007.09.008>
- Corsaro, W. a., & Eder, D. (1990). Children's peer cultures. *Annual Review of Sociology*, 16(1990), 197–220.
<http://doi.org/10.1146/annurev.so.16.080190.001213>
- Cowan, E.A., & Pratt, B.M. (1934). The hurdle jump as a developmental and diagnostic test of motor coordination for children from three to 12 years of age. *Child Development*, 5, 107–121.
- Cowell, J. M., & Decety, J. (2015a). *Precursors to Morality in Development: A Complex Interplay between Neural, Socio-environmental, and Behavioral Facets*.
- Cowell, J. M., & Decety, J. (2015b). The neuroscience of implicit moral evaluation and its relation to generosity in early childhood. *Current Biology*, 25(1), 93–7.
<http://doi.org/10.1016/j.cub.2014.11.002>
- Cross, I., Laurence, F., & Rabinowitch, T. (2012). Empathy and creativity in group musical practices: Towards a concept of empathic creativity. In G. E. McPherson & G. Welch (Eds.), *The Oxford Handbook of Music Education*. Oxford, UK: Oxford University Press. 337–353.
- Crown, C. L., Feldstein, S., Jasnow, M. D., Beebe, B., & Jaffe, J. (2002). The cross-modal coordination of interpersonal timing: Six-week-olds infants' gaze with adults' vocal behavior. *Journal of Psycholinguistic Research*, 31(1), 1–23.
Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/11924837>
- Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences*, 13(4), 148–153. <http://doi.org/10.1016/j.tics.2009.01.005>
- Csibra, G., Gergely, G., Bíró, S., Koós, O., & Brockbank, M. (1999). Goal attribution without agency cues: The perception of “pure reason” in infancy. *Cognition*, 72(3),

- 237–67. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/10519924>
- Curtis, D.M. (1975). *Norms of an eleven year study of selected motor performance tests for Hawaiian children, five to 12 years of age* (Unpublished doctoral dissertation), Curriculum and Instruction Department, University of Hawaii at Manoa.
- Cutler, A. (1994). The perception of rhythm in language. *Cognition*, 50, 79–81. [http://doi.org/10.1016/0010-0277\(94\)90021-3](http://doi.org/10.1016/0010-0277(94)90021-3)
- D'Entremont, B. (2000). A perceptual-attentional explanation of gaze following in 3- and 6-month-olds. *Developmental Science*, 3(3), 302–311.
- Dannemiller, J. L., & Stephens, B. R. (1988). A critical test of infant pattern preference models. *Child Development*, 59(1), 210–6. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/3342713>
- Daum, M. M., Attig, M., Gunawan, R., Prinz, W., & Gredebäck, G. (2012). Actions Seen through Babies' Eyes: A Dissociation between Looking Time and Predictive Gaze. *Frontiers in Psychology*, 3(September), 1–13. <http://doi.org/10.3389/fpsyg.2012.00370>
- Daum, M. M., Sommerville, J. A., & Prinz, W. (2009). Becoming a social agent: Developmental foundations of an embodied social psychology. *European Journal of Social Psychology*, 39, 1196–1206. <http://doi.org/10.1002/ejsp>
- David, D., Wade-Woolley, L., Kirby, J. R., & Smithrim, K. (2007). Rhythm and reading development in school-age children: A longitudinal study. *Journal of Research in Reading*, 30(2), 169–183. <http://doi.org/10.1111/j.1467-9817.2006.00323.x>
- Davis, A., Taylor, J., & Cohen, E. (2015). Social bonds and exercise: Evidence for a reciprocal relationship. *PLoS ONE*, 10(8), 1–14. <http://doi.org/10.1371/journal.pone.0136705>
- Dawkins, R. (1976). *The Selfish Gene*. Oxford: Oxford University Press.
- Dawson, G., Hill, D., Spencer, A., Galpert, L., & Watson, L. (1990). Affective exchanges between young autistic children and their mothers. *Journal of Abnormal Child Psychology*, 18(3), 335–45. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/2376657>
- de Barbaro, K., Johnson, C. M., & Deák, G. O. (2013). Twelve-month □□social revolution emerges from mother-infant sensorimotor coordination: A longitudinal investigation. *Human Development*, 56(4), 223–248. <http://doi.org/10.1159/000351313>
- De Bruyn, L., Leman, M., Demey, M., Desmet, F., & Moelants, D. (2009). Measuring and quantifying the impact of social interaction on listeners' movements to music. In S. Ystad, R. Kronland- Martinet, & K. Jensen (Eds.), *Computer Music Modeling and Retrieval: Genesis of Meaning in Sound and Music. Proceedings of the 5th International Symposium on Computer Music Modeling and Retrieval* (pp. 298–305). Heidelberg, Germany: Springer.
- De Bruyn, L., Leman, M., & Moelants, D. (2008). Quantifying children's embodiment of musical rhythm in individual and group settings. In K. Miyazaki, Y. Hiraga, M. Adachi, Y. Nakajima, & M. Tsuzaki (Eds.), *Proceedings of the 10th International Conference on Music Perception and Cognition* (pp. 662–667). Adelaide, Australia: Causal Productions.
- de Castelnau, P., Albaret, J.-M., Chaix, Y., & Zanone, P.-G. (2008). A study of EEG coherence in DCD children during motor synchronization task. *Human Movement Science*, 27(2), 230–41. <http://doi.org/10.1016/j.humov.2008.02.006>
- de Castelnau, P., Albaret, J. M., Chaix, Y., & Zanone, P. G. (2007). Developmental coordination disorder pertains to a deficit in perceptuo-motor synchronization independent of attentional capacities. *Human Movement Science*, 26(3), 477–490.

- <http://doi.org/10.1016/j.humov.2007.03.001>
- de Guzman, M. R. T., Edwards, C. P., & Carlo, G. (2005). Prosocial behaviors in context: A study of the Gikuyu children of Ngecha, Kenya. *Journal of Applied Developmental Psychology*, 26(5), 542–558.
<http://doi.org/10.1016/j.appdev.2005.06.006>
- DeBoer, M. M., & Boxer, A. M. (1979). Signal functions of infant facial expression and gaze direction during mother-infant face-to-face play. *Child Development*, 50(4), 1215–1218. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/535437>
- Decety, J., & Jackson, P. L. (2004). The functional architecture of human empathy. *Behavioral and Cognitive Neuroscience Reviews*, 3(2), 71–100.
<http://doi.org/10.1177/1534582304267187>
- Dellatolas, G., Watier, L., Le Normand, M. T., Lubart, T., & Chevrie-Muller, C. (2009). Rhythm reproduction in kindergarten, reading performance at second grade, and developmental dyslexia theories. *Archives of Clinical Neuropsychology*, 24(6), 555–563. <http://doi.org/10.1093/arclin/acp044>
- Demany, L., McKenzie, B., & Vurpillot, E. (1977). Rhythm Perception in Early Infancy. *Nature*, 266.
- Denham, S. A. (2007). Dealing with feelings: How children negotiate the worlds of emotions and social relationships. *Cogniție Creier Comportament*, XI(1), 1–48.
- Denham, S. A., Bassett, H. H., Brown, C., Way, E., & Steed, J. (2013). “I know how you feel”: Preschoolers’ emotion knowledge contributes to early school success. *Journal of Early Childhood Research*, 13(3), 252–262.
<http://doi.org/10.1177/1476718X13497354>
- Denham, S. A., Bassett, H. H., Thayer, S. K., Mincic, M. S., Sirotkin, Y. S., & Zinsser, K. (2012). Observing preschoolers’ social-emotional behavior: Structure, foundations, and prediction of early school success. *The Journal of Genetic Psychology*, 173(3), 246–278. <http://doi.org/10.1080/00221325.2011.597457>
- Denham, S. A., Blair, K. A., Demulder, E., Levitas, J., Sawyer, K., Auerbach-Major, S., & Queenan, P. (2003). Preschool emotional competence: Pathway to social competence? *Child Development*, 74(1), 238–256.
- Denham, S. A., & Couchoud, E. A. (1990a). Young preschoolers’ ability to identify emotions in equivocal situations. *Child Study Journal*, 20, 193–202.
- Denham, S. A., & Couchoud, E. A. (1990b). Young preschoolers’ understanding of emotions. *Child Study Journal*, 20(3), 171–192.
- Denham, S. A., McKinley, M., Couchoud, E. A., & Holt, R. (1990). Emotional and behavioral predictors of preschool peer ratings. *Child Development*, 61(4), 1145–1152.
- Denham, S., Salisch, V. M., Olthof, T., Kochanoff, A., & Caverly, S. (2004). Emotional and Social Development in Childhood. In P. K. Smith & C. H. Hart (Eds.), *Blackwell handbook of childhood social development: Blackwell handbooks of developmental psychology*.
- DeOreo, K.L. & Keogh, J. (1980). Performance of fundamental motor tasks. In C. B. Corbin (Ed.), *A textbook of motor development* (2nd ed.), (pp. 76-91). Dubuque, IA: W. C. Brown.
- Department of Education (2013). *Fundamental movement skills: Learning, teaching and assessment*. Western Australia.
- Depue, R. A., & Morrone-Strupinsky, J. V. (2005). A neurobehavioral model of affiliative bonding: Implications for conceptualizing a human trait of affiliation. *Behavioral and Brain Sciences*, 28(3), 313– 95. doi:10.1017/S0140525X05000063

- DeRosier, M., Cillessen, A. H. N., Coie, J. D., & Dodge, K. A. (1994). Group social context and children's aggressive behavior. *Child Development*, 65(4), 1068-1079. doi: 10.1111/j.1467-8624.1994.tb00803.x
- Dewey, D., Kaplan, B. J., Crawford, S. G., & Wilson, B. N. (2002). Developmental coordination disorder: Associated problems in attention, learning, and psychosocial adjustment. *Human Movement Science*, 21(5-6), 905-918. [http://doi.org/10.1016/S0167-9457\(02\)00163-X](http://doi.org/10.1016/S0167-9457(02)00163-X)
- Dillon, S. (2006). Assessing the positive influence of music activities in community development programs. *Music Education Research*, 8(November 2012), 267-280. <http://doi.org/10.1080/14613800600779543>
- Dimech, A. S., & Seiler, R. (2010). The association between extra-curricular sport participation and social anxiety symptoms in children. *Journal of Clinical Sport Psychology*, 4(3), 191-203. Retrieved from <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=psyc7&NEWS=N&AN=2010-24198-002>
- Dissanayake, E. (2000). Antecedents of the temporal arts in early mother-infant interaction. In N. L. Wallin, B. Merker & S. Brown (Eds.), *The origins of music* (pp. 389-410). USA: MIT Press.
- Drake, C., Jones, M. R., & Baruch, C. (2000). *The development of rhythmic attending in auditory sequences: attunement, referent period, focal attending*. *Cognition* (Vol. 77).
- Drewing, K. (2006). Sensorimotor synchronization across the life span. *International Journal of Behavioral Development*, 30(3), 280-287. <http://doi.org/10.1177/0165025406066764>
- Drolet, A. L., & Morris, M. W. (2000). Rapport in conflict resolution: Accounting for how face-to-face contact fosters mutual cooperation in mixed-motive conflicts. *Journal of Experimental Social Psychology*, 36, 26-50. <http://doi.org/10.1006/jesp.1999.1395>
- Drummond, J., Paul, E. F., Waugh, W. E., Hammond, S. I., & Brownell, C. a. (2014). Here, there and everywhere: Emotion and mental state talk in different social contexts predicts empathic helping in toddlers. *Frontiers in Psychology*, 5(April), 361. <http://doi.org/10.3389/fpsyg.2014.00361>
- Dunbar, R. I. M. (1993). Co-evolution of neocortex size, group size and language in humans. *Behavioral and Brain Sciences*, 16(4), 681-735.
- Dunbar, R. I. M. (2010b). Brain and behaviour in primate evolution. In P.H. Appeler & J. Silk (Eds.), *Mind the gap: Tracing the origins of human universals* (pp. 315-330). Springer, Berlin.
- Dunbar, R. I. M., Kaskatis, K., MacDonald, I., & Barra, V. (2012). Performance of music elevates pain threshold and positive affect: Implications for the evolutionary function of music. *Evolutionary Psychology*, 10(4), 688-702. <http://doi.org/epjournal-2536> [pii]
- Dunbar, R. I. M., & Shultz, S. (2010). Bondedness and sociality. *Behaviour*, 14(7), 775-803. <http://doi.org/10.1163/000579510X501151>
- Dunfield, K. A. (2010). *Redefining prosocial behaviour: The production of helping, sharing, and comforting acts in human infants and toddlers* (Unpublished doctoral dissertation). Queen's University, Canada.
- Dunfield, K. A. (2014). A construct divided: Prosocial behavior as helping, sharing, and comforting subtypes. *Frontiers in Psychology*, 5(AUG), 1-13. <http://doi.org/10.3389/fpsyg.2014.00958>
- Dunham, Y., Baron, A. S., & Banaji, M. R. (2006). From American city to Japanese

- village: A cross-cultural Investigation of implicit race attitudes. *Child Development*, 77(5), 1268–1281.
- Dunham, Y., Baron, A. S., & Carey, S. (2011). Consequences of “minimal” group affiliations in children. *Child Development*, 82(3), 793–811.
<http://doi.org/10.1111/j.1467-8624.2011.01577.x>
- Dunham, Y., Chen, E. E., & Banaji, M. R. (2013). Two signatures of implicit intergroup attitudes: developmental invariance and early enculturation. *Psychological Science*, 24(April), 860–8. <http://doi.org/10.1177/0956797612463081>
- Dunlap, L. (1997). *An Introduction to Early Childhood Special Education*. Boston, MA: Allyn and Bacon.
- Dunn, J., Cutting, A.L., & Fisher, N. (2002). Old friends, new friends: Predictors of children’s perspective on their friends at school. *Child Development*, 73, 621– 635.
- Dunn, J., & Hughes, C. (1998). Young children’s understanding of emotions within close relationships. *Cognition & Emotion*, 12(2), 171–190.
<http://doi.org/10.1080/026999398379709>
- Durkheim, E. (1915/1965). *The Elementary Forms of the Religious Life*, (J.W. Swain, Trans.). New York: Free Press.
- Dwyer, C. M. (2008). Individual variation in the expression of maternal behaviour: A review of the neuroendocrine mechanisms in the sheep. *Journal of Neuroendocrinology*, 20, 526-534
- Dyck, M. J., Piek, J. P., Hay, D. A., & Hallmayer, J. F. (2007). The relationship between symptoms and abilities in autism. *Journal of Developmental and Physical Disabilities*, 19(3), 251–261. <http://doi.org/10.1007/s10882-007-9055-7>
- Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed. In W. Damon [Series Ed.] & N. Eisenberg [Volume Ed.], *Handbook of Child Psychology: Social, Emotional, and Personality Development* (pp. 105-107). New York: Wiley.
- Eckerman, C. O., Davis, C. C., & Didow, S. M. (1989). Toddlers’ emerging ways of achieving social coordinations with a peer. *Child Development*, 60(2), 440–453.
- Eckerman, C. O., & Peterman, K. (2015). Peers and infant social/ communicative development. In *Blackwell handbook of infant development* (pp. 1–18).
<http://doi.org/10.1111/b.9780631212355.2004.00016.x>
- Eckert, H.M. (1973). Age changes in motor skills. In G. L. Rarick (Ed.), *Physical activity: Human growth and development* (pp. 154-175). New York: Academic PI Press.
- Edelman, L. L., & Harring, K. E. (2014). Music and social bonding: The role of non-diegetic music and synchrony on perceptions of videotaped walkers. *Current Psychology*, (2012), 613–620. <http://doi.org/10.1007/s12144-014-9273-y>
- Eerola, T., & Luck, G. (2006). An investigation of pre-schoolers’ corporeal synchronization with music. In *9th International Conference on Music Perception and Cognition* (pp. 472–476).
- Ehrenreich, B. (2006). *Dancing in the Streets: A History of Collective Joy*. New York, NY: Metropolitan.
- Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: Informing development of a conceptual model of health through sport. *International Journal of Behavioral Nutrition and Physical Activity*, 10, 98–119. <http://doi.org/10.1186/1479-5868-10-98>
- Eisenberg, N., Cameron, E., Tryon, K., & Dodez, R. (1981). Socialization of prosocial behavior in the preschool classroom. *Developmental Psychology*, 17(6), 773–782.
<http://doi.org/10.1037/0012-1649.17.6.773>

- Eisenberg, N., Fabes, R. A., Bernzweig, J., Karbon, M., Poulin, R., & Hanish, L. (1993). The relations of emotionality and regulation to preschoolers' social skills and sociometric status. *Child Development*, 64, 1418-1438.
- Eisenberg, N., Fabes, R. A., Shepard, S. A., Murphy, B. C., Guthrie, I. K., Jones, S., ... Maszk, P. (1997). Contemporaneous and longitudinal prediction of childrens sympathy from dispositional regulation and emotionality. *Child Development*, 68(4), 642-664.
- Eisenberg, N., Lennon, R., & Roth, K. (1983). Prosocial development: A longitudinal study. *Developmental Psychology*, 19(6), 846-855. <http://doi.org/10.1037/0012-1649.19.6.846>
- Eisenberg, N., McCreath, H., & Ahn, R. (1988). Vicarious Emotional Responsiveness and Prosocial Behavior: Their Interrelations in Young Children. *Personality and Social Psychology Bulletin*, 14(2), 298-311. <http://doi.org/10.1177/0146167288142008>
- Eisenberger, N. I., Lieberman, M. D., & Williams, K. D. (2003). Does rejection hurt? An fMRI study of social exclusion. *Science*, 302(5643), 290-292. <http://doi.org/10.1126/science.1089134>
- Ekman, P. (1993). Facial expression and emotion. *American Psychologist*. <http://doi.org/10.1037/0003-066x.48.4.384>
- Elashi, F. B., & Mills, C. M. (2014). Do children trust based on group membership or prior accuracy? The role of novel group membership in children's trust decisions. *Journal of Experimental Child Psychology*, 128, 88-104. <http://doi.org/10.1016/j.jecp.2014.07.003>
- Elsner, B. (2007). Infants' imitation of goal-directed actions: The role of movements and action effects. *Acta Psychologica*, 124(1), 44-59. <http://doi.org/10.1016/j.actpsy.2006.09.006>
- Endedijk, H. M., Ramenzoni, V. C. O., Cox, R. F. A., Cillessen, A. H. N., Bekkering, H., & Hunnius, S. (2015). Development of interpersonal coordination between peers during a Drumming Task. *Developmental Psychology*, 51(5), 714-721.
- Enesco, I., Navarro, A., Paradela, I., & Callejas, C. (2002). Spanish children's and adolescents' judgments about ethnic exclusion: The case of Gypsies and Africans. Paper presented at the 32nd Annual Meeting of the Jean Piaget Society. Society for the Study of Knowledge and Development, Philadelphia, PA.
- Engelmann, J. M., Herrmann, E., & Tomasello, M. (2012). Five-year olds, but not chimpanzees, attempt to manage their reputations. *PLoS ONE*, 7(10). <http://doi.org/10.1371/journal.pone.0048433>
- Eric, R. (1999). Representations of Janissary music (Mehter) as musical exoticism in western compositions, 1670-1824, *Journal of Musicological Research*, 19(1), 41-88, doi: 10.1080/01411899908574768
- Evaldsson, A.-C., & Corsaro, W. A. (1998). Play and games in the peer cultures of preschool and preadolescent children: An interpretative approach. *Childhood*, 5(4), 377-402.
- Eveland- Sayers, B. M., Farley, R. S., Fuller, D. K., Morgan, D. W., & Caputo, J. L. (2009). Physical Fitness and Academic Achievement in Elementary School Children. *Journal of Physical Activity and Health*, 6, 99-104. <http://doi.org/10.1249/01.mss.0000274573.54238.aa>
- Falck-Ytter, T., Gredebäck, G., & von Hofsten, C. (2006). Infants predict other people's action goals. *Nature Neuroscience*, 9(7), 878-879. <http://doi.org/10.1038/nn1729>
- Falk, D. (2004). Prelinguistic evolution in early hominins: Whence motherese? *The Behavioral and Brain Sciences*, 27(4), 491-503-83. Retrieved from

- <http://www.ncbi.nlm.nih.gov/pubmed/15773427>
- Fantz, R. L. (1961). The origin of form perception. *Scientific American*, 66–73.
- Fantz, R. L. (1963). Pattern vision in newborn infants. *Science*, 140(3564), 296–297.
- Farver, J. A. M., Kim, Y. K., & Lee, Y. (1995). Cultural differences in Korean-American and Anglo-American preschoolers' social interaction and play behaviors. *Child Development*, 66, 1088–1099.
- Fawcett, C., & Liszkowski, U. (2012). Infants anticipate others' social preferences. *Infant and Child Development*, 21, 239–249. <http://doi.org/10.1002/icd>
- Fawcett, A. J., & Nicholson, R. I. (1995). Persistent deficits in motor skill of children with dyslexia. *Journal of Motor Behavior*, 27, 235–240.
- Fay, A. J., & Maner, J. K. (2012). Warmth, spatial proximity, and social attachment: The embodied perception of a social metaphor. *Journal of Experimental Social Psychology*, 48(6), 1369–1372. <http://doi.org/10.1016/j.jesp.2012.05.017>
- Fehr, E., Bernhard, H., & Rockenbach, B. (2008). Egalitarianism in young children. *Nature*, 454(7208), 1079–1083. <http://doi.org/10.1038/nature07155>
- Feldman, R. (2007a). On the origins of background emotions: From affect synchrony to symbolic expression. *Emotion*, 7(3), 601–611. <http://doi.org/10.1037/1528-3542.7.3.601>
- Feldman, R. (2007b). Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *Journal of Child Psychology and Psychiatry*, 48(3–4), 329–54. <http://doi.org/10.1111/j.1469-7610.2006.01701.x>
- Feldman, R. (2007c). Parent–infant synchrony: Biological foundations and developmental outcomes. *Current Directions in Psychological Science*, 16(6), 340–345. <http://doi.org/10.1111/j.1467-8721.2007.00532.x>
- Feldman, R. (2012). Bio-behavioral Synchrony: A Model for Integrating Biological and Microsocial Behavioral Processes in the Study of Parenting. *Parenting*, 12(August 2014), 154–164. <http://doi.org/10.1080/15295192.2012.683342>
- Feldman, R., & Eidelman, A. I. (2007). Maternal Postpartum Behavior and the Emergence of Infant – Mother and Infant – Father Synchrony in Preterm and Full-Term Infants : The Role of Neonatal Vagal Tone. *Developmental Psychobiology*. <http://doi.org/10.1002/dev>
- Feldman, R., Greenbaum, C. W., & Yirmiya, N. (1999). Mother-infant affect synchrony as an antecedent of the emergence of self-control. *Developmental Psychology*, 35(5), 223–231.
- Feldstein, S., Jaffe, J., Beebe, B., Crown, C. L., Jasnow, M., Fox, H., & Gordon, S. (1993). Coordinated interpersonal timing in adult-infant vocal interactions: A cross-site replication. *Infant Behavior & Development*, 16, 455–470.
- Ferguson, C. A. (1964). Baby talk in six languages. *American Anthropologist*, 66(6), 103–114.
- Fernald, A. (1989). Intonation and communicative intent in mother speech: Is the melody the message? *Child Development*, 60(6), 1497–1510.
- Field, A. Miles, J. & Field, Z. (2012). *Discovering Statistics Using R*. London: SAGE Publications Ltd.
- Findlay, L. C., Garner, R. E., & Kohen, D. E. (2009). Children' s organized physical activity patterns from childhood into adolescence. *Journal of Physical Activity and Health*, 6, 708–715.
- Fisher, A., Reilly, J. J., Kelly, L. A., Montgomery, C., Williamson, A., Paton, J. Y., ... (2005). Fundamental movement skills and habitual physical activity in young

- children. *Medicine and Science in Sports and Exercise*, 37(4), 684e688. <http://dx.doi.org/10.1249/01.mss.0000159138.48107.7d>
- Fitzpatrick, P. A., Schmidt, R. C., & Lockman, J. J. (1996). Dynamical patterns in the development of clapping. *Child Development*, 67(6), 2691–2708.
- Fletcher, A. C., Nickerson, P., & Wright, K. L. (2003). Structured leisure activities in middle childhood: Links to well-being. *Journal of Community Psychology*, 31, 641–659. <http://doi.org/10.1017/CBO9781107415324.004>
- Flom, R., & Pick, A. D. (2005). Experimenter affective expression and gaze following in 7-month-olds. *Infancy*, 7(2), 207–218. http://doi.org/10.1207/s15327078in0702_5
- Flynn, V., Masur, E. F., & Eichorst, D. L. (2004). Opportunity versus disposition as predictors of infants' and mothers' verbal and action imitation. *Infant Behavior and Development*, 27(3), 303–314. <http://doi.org/10.1016/j.infbeh.2003.12.003>
- Fogassi, L., Ferrari, P. F., Gesierich, B., Rozzi, S., Chersi, F., & Rizzolatti, G. (2005). Parietal lobe: From action organization to intention understanding. *Science*, 308, 662–667. <http://doi.org/10.1126/science.1106138>
- Fonagy, P., Gergely, G., & Target, M. (2007). The parent-infant dyad and the construction of the subjective self. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 48(3–4), 288–328. <http://doi.org/10.1111/j.1469-7610.2007.01727.x>
- Fraisse, P., Pichot, P., & Clairouin, G. (1969). Les aptitudes rythmiques. Etude comparee des oligophrenes et des enfants normaux. *Journal de Psychologie Normale et Pathologique*, 42, 309–330.
- Franceschini, R., Venturini, P. L., Cataldi, A., Barreca, T., Ragni, N., & Rolandi, E. (1989). Plasma beta-endorphin concentrations during suckling in lactating women. *BJOG: An International Journal of Obstetrics and Gynaecology*, 96(6), 711–713. <http://doi.org/10.1111/j.1471-0528.1989.tb03287.x>
- Frankenburg, W. K., & Dodds, J. B. (1967). The Denver developmental screening test. *Journal of Pediatrics*, 71, 181–191.
- Freeman, W. J. (2000). A neurobiological role of music in social bonding. In *The Origins of Music* (pp. 411–424).
- Frega, A. L. (1979). Rhythmic tasks with 3-, 4-, and 5-year-old children: A study made in Argentine Republic. *Bulletin of the Council for Research in Music Education*, 59, 32–34.
- Gable, S., & Isabella, R. A. (1992). Maternal contributions to infant regulation of arousal. *Infant Behavior & Development*, 15, 95–107. [http://doi.org/10.1016/0163-6383\(92\)90009-U](http://doi.org/10.1016/0163-6383(92)90009-U)
- Gaertner, S. L., Dovidio, J. F., Guerra, R., Rebelo, M., Monteiro, M. B., Riek, B. M., & Houlette, M. A. (2008). The common in-group identity model: Application to children and adults. In *Intergroup Attitudes and Relations in Childhood Through Adulthood* (pp. 204–219). GB: Oxford University Press.
- Galdino, G. S., Duarte, I. D. G., & Perez, A. C. (2010). Participation of endogenous opioids in the antinociception induced by resistance exercise in rats. *Brazilian Journal of Medical and Biological Research*, 43(9), 906–909.
- Galindo, C., & Fuller, B. (2010). The social competence of Latino kindergartners and growth in mathematical understanding. *Developmental Psychology*, 46(3), 579–592. <http://doi.org/10.1037/a0017821>
- Gallahue, D. L., & Ozmun, J. C. (2005). *Understanding Motor Development: Infants, Children, Adolescents, Adults* (6th ed.). Boston, MA: McGraw-Hill. Goodman.
- Gallese, V., Keysers, C., & Rizzolatti, G. (2004). A unifying view of the basis of social

- cognition. *Trends in Cognitive Sciences*, 8(9), 396–403.
<http://doi.org/10.1016/j.tics.2004.07.002>
- Galliger, Depue, R. A., & Morrone-Strupinsky, J. V. (2005). A neurobehavioral model of affiliative bonding: implications for conceptualizing a human trait of affiliation. *Behavioral and Brain Sciences*, 28(3), 313–350. doi:
<http://dx.doi.org/10.1017/S0140525X05000063>
- Garfinkel, Y. (2003). *Dancing at the Dawn of Agriculture*. Austin: University of Texas Press.
- Garfinkle, A. N., & Schwartz, I. S. (2002). Peer imitation: Increasing social interactions in children with autism and other developmental disabilities in inclusive preschool classrooms. *Topics in Early Childhood Special Education*, 22(1), 26–38.
- Gergely, G., & Csibra, G. (2003). Teleological reasoning in infancy: The naïve theory of rational action. *Trends in Cognitive Sciences*, 7(7), 287–292.
[http://doi.org/10.1016/S1364-6613\(03\)00128-1](http://doi.org/10.1016/S1364-6613(03)00128-1)
- Gerry, D., Unrau, A., & Trainor, L. J. (2012). Active music classes in infancy enhance musical, communicative and social development. *Developmental Science*, 15(3), 398–407. <http://doi.org/10.1111/j.1467-7687.2012.01142.x>
- Gerry, D. W., Faux, A. L., & Trainor, L. J. (2010). Effects of kindermusik training on infants' rhythmic enculturation. *Developmental Science*, 13(3), 545–51.
<http://doi.org/10.1111/j.1467-7687.2009.00912.x>
- Gerson, S. A., Schiavio, A., Timmers, R., & Hunnius, S. (2015). Active drumming experience increases infants' sensitivity to audiovisual Synchrony during observed Drumming Actions. *PloS One*, 10, e0130960.
<http://doi.org/10.1371/journal.pone.0130960>
- Getchell, N. (2006). Age and Task-Related Differences in Timing Stability, Consistency, and Natural Frequency of Children's Rhythmic, Motor Coordination. *Developmental Psychobiology*, 675–685. <http://doi.org/10.1002/dev>
- Geuze, R. H., & Kalverboer, A. F. (1994). Tapping a rhythm: A problem of timing for children who are clumsy and dyslexic? *Adapted Physical Activity Quarterly*, 11, 203–213.
- Gilbert, J. P. (1983). A comparison of the motor music skills of nonhandicapped and learning-disabled children, *Journal of Research in Music Education*, 37(2), 147–155.
- Gilbert, A. G. (2005). Dance education in the 21st century: A global perspective. *Journal of Physical Education, Recreation & Dance*, 76(5), 26–35.
<http://doi.org/10.1080/07303084.2005.10608250>
- Gironzetti, E., Pickering, L., Huang, M., Zhang, Y., Menjo, S., & Attardo, S. (2016). Smiling synchronicity and gaze patterns in dyadic humorous conversations. *International Journal of Humor Research*, 29(2), 301–324. doi: 10.1515/humor-2016-0005
- Giudice, M. Del, Manera, V., & Keysers, C. (2009). Programmed to learn ? The ontogeny of mirror neurons. *Developmental Science*, 12(2), 350–363.
<http://doi.org/10.1111/j.1467-7687.2008.00783.x>
- Glass, J. S., & Benshoff, J. M. (2002). Facilitating group cohesion among adolescents through challenge course experiences. *Journal of Experiential Education*, 25(2), 268–277. <http://doi.org/10.1177/105382590202500204>
- Glenn, S. M., Cunningham, C. C., & Joyce, P. F. (1981). A study of auditory preferences in nonhandicapped infants and infants with Down's Syndrome. *Child Development*, 52(4), 1303–1307.
- Goldman, L. R. (1998). *Child's Play: Myth, Mimesis and Make-Believe*. Oxford: Berg.

- Goldman & Buysse, (2007). Friendships in very young children. In Saracho, O. N. & Spodek, B. (Eds.), *Contemporary perspectives on socialization and social development in early childhood education*. USA: Information Age Publishing.
- Goodway, J. D., Gallahue, J. C., & Ozmun, D. L. (2013). Motor development in young children. In O. N. Saracho & B. Spodek (Eds.), *Handbook of research on the education of young children* (pp. 89-102). London: Routledge.
- Gopnik, A., & Astington, J. W. (1988). Children's understanding of representational change and Its relation to the understanding of false belief and the appearance-reality distinction. *Child Development*, 59(1), 26–37.
- Goswami, U. (2011). Language, music, and children's brains: A rhythmic timing perspective on language and music as cognitive systems. In *Language and Music as Cognitive Systems*. <http://doi.org/10.1093/acprof>
- Gove, F. L., & Keating, D. P. (1979). Empathic role-taking precursors. *Developmental Psychology*, 15(6), 594–600. <http://doi.org/10.1037/0012-1649.15.6.594>
- Graham, K. L., & Burghardt, G. M. (2010). Current perspectives on the biological study of play. *The Quarterly Review of Biology*, 85(4), 393–418.
- Graham, S., Doubleday, C., & Guarino, P. A. (1984). The development of relations between perceived controllability and the emotions of pity, anger, and guilt. *Child Development*, 55(2), 561–565.
- Gredebäck, G., Johnson, S., & von Hofsten, C. (2009). Eye Tracking in Infancy Research. *Developmental Neuropsychology*, 35(1), 1–19. <http://doi.org/10.1080/87565640903325758>
- Gredebäck, G., Kaduk, K., Bakker, M., Gottwald, J., Ekberg, T., Elsner, C., ... Kenward, B. (2015). The neuropsychology of infants' pro-social preferences. *Developmental Cognitive Neuroscience*, 12, 106–113. <http://doi.org/10.1016/j.dcn.2015.01.006>
- Green, S. K. (1977). Causal attribution of emotion in kindergarten children. *Developmental Psychology*, 13(5), 533–534. <http://doi.org/10.1037/0012-1649.13.5.533>
- Greener, S., & Crick, N. R. (1999). Normative beliefs about prosocial behavior in middle childhood: What does it mean to be nice? *Social Development*, 8, 349–363. <http://doi.org/10.1111/1467-9507.00100>
- Greimel, E., Schulte-Rüther, M., Fink, G. R., Piefke, M., Herpertz-Dahlmann, B., & Konrad, K. (2010). Development of neural correlates of empathy from childhood to early adulthood: An fMRI study in boys and adult men. *Journal of Neural Transmission*, 117(6), 781–791. <http://doi.org/10.1007/s00702-010-0404-9>
- Grieshaber, K. (1987). Children's rhythmic tapping: A critical review of research. *Bulletin of the Council for Research in Music Education*, 90, 73–81.
- Grillon, C., Krimsky, M., Charney, D. R., Vytal, K., Ernst, M., & Cornwell, B. (2013). Oxytocin increases anxiety to unpredictable threat. *Molecular Psychiatry*, 18(9), 958–960. <http://doi.org/10.1126/scisignal.2001449>.Engineering
- Gross, J. J., & John, O. P. (1997). Revealing feelings: Facets of emotional expressivity in self-reports, peer ratings, and behavior. *Journal of Personality and Social Psychology*, 72(2), 435–448. <http://doi.org/10.1037/0022-3514.72.2.435>
- Graves, F. C., Wallen, K., & Maestripieri, D. (2002). Opioids and attachment in rhesus macaque (*Macaca mulatta*) abusive mothers. *Behavioral Neuroscience*, 116(3), 489–93. doi:10.1037//0735-7044.116.3.489
- Grusec, J. E., Davidov, M., & Lundell, L. (2002). Prosocial and helping behavior. In P. K. Smith & C. H. Hart (Eds.), *Blackwell handbook of childhood social development: Blackwell handbooks of developmental Psychology* (pp. 457–474).

- Malden: Blackwell Publishing.
<http://doi.org/10.1111/b.9780631217534.2004.00031.x> Sections
- Gummerum, M., Leman, P. J., & Hollins, T. S. (2014). How do children share information in groups? *Developmental Psychology*, 50(8), 2105–2114.
<http://doi.org/10.1037/a0037144>
- Gurthrie, I. K., Eisenberg, N., Fabes, R. A., Murphy, Bridget, C., Holmgren, R. A., Mazsk, P., & Suh, K. (1997). The Relations of Regulation and Emotionality to Children's Situational Empathy-Related Repsonding. *Motivation and Emotion*, 21(1), 87–108.
- Gutteridge, M. (1939). A study of motor achievements of young children. *Archives of Psychology*, 244, 1–178.
- Hagen, E. H., & Bryant, G. A. (2003). Music and dance as a coalition signaling system. *Human Nature*, 14(1), 21–51.
- Haight, W., & Miller, P. J. (1992). The development of everyday pretend play: A longitudinal study of mothers' participation. *Merrill-Palmer Quarterly*, 38, 331–349.
- Hains, S. M. J., & Muir, D. W. (1996). Infant Sensitivity to Adult Eye Direction. *Child Development*, 67, 1940–1951.
- Haken, H., Kelso, J. A. S., & Bunz, H. (1985). A theoretical model of phase transitions in human hand movements. *Biological Cybernetics*, 51, 347–356.
- Halberstadt, J., Jackson, J. C., Bilkey, D., Jong, J., Whitehouse, H., McNaughton, C., & Zollmann, S. (2016). Incipient Social groups: An analysis via in vivo behavioral tracking. *PLoS ONE*, 11(3), 1–14. <http://doi.org/10.1371/journal.pone.0149880>
- Hamilton, A. F. D. C. (2015). Gazing at me: the importance of social meaning in understanding direct gaze cues. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 20150080, 18–23. <http://doi.org/10.1098/rstb.2015.0080>
- Hamlin, J. K. (2013). Failed attempts to help and harm: Intention versus outcome in preverbal infants' social evaluations. *Cognition*, 128(3), 451–74.
<http://doi.org/10.1016/j.cognition.2013.04.004>
- Hamlin, J. K. (2015). The case for social evaluation in preverbal infants: Gazing toward one's goal drives infants' preferences for Helpers over Hinderers in the hill paradigm. *Frontiers in Psychology*, 5(January), 1–9.
<http://doi.org/10.3389/fpsyg.2014.01563>
- Hamlin, J. K., Mahajan, N., Liberman, Z., & Wynn, K. (2013). Not like me = bad: Infants prefer those who harm dissimilar others. *Psychological Science*, 24(4), 589–594. <http://doi.org/10.1177/0956797612457785>
- Hamlin, J. K., & Wynn, K. (2011). Young infants prefer prosocial to antisocial others. *Cognitive Development*, 26(1), 30–39.
<http://doi.org/10.1016/j.cogdev.2010.09.001> Young
- Hamlin, J. K., Wynn, K., & Bloom, P. (2007). Social evaluation by preverbal infants. *Nature*, 450(7169), 557–559. <http://doi.org/10.1038/nature06288>
- Hamlin, J. K., Wynn, K., & Bloom, P. (2010). 3-month-olds show a negativity bias in their social evaluations. *Developmental Science*, 13(6), 923–929.
<http://doi.org/10.1111/j.1467-7687.2010.00951.x> 3-month-olds
- Hamlin, J. K., Wynn, K., & Bloom, P. (2012). Reply to Scarf et al.: Nuanced social evaluation: Association doesn't compute. *Proceedings of the National Academy of Sciences*, 109(22), E1427–E1427. <http://doi.org/10.1073/pnas.1204712109>
- Hamlin, J. K., Wynn, K., Bloom, P., & Mahajan, N. (2011). How infants and toddlers react to antisocial others. *Proceedings of the National Academy of Sciences*, 108(50), 19931–19936. <http://doi.org/10.1073/pnas.1110306108>

- Handlon, B. J., & Gross, P. (1959). The development of sharing behavior. *Journal of Abnormal and Social Psychology*, 59, 425–428.
- Hannon, E. E., & Trehub, S. E. (2005). Metrical categories in infancy and adulthood. *Psychological Science*, 16(1), 48–55. <http://doi.org/10.1111/j.0956-7976.2005.00779.x>
- Hardin D., & Garcia, M. (1982). Diagnostic performance tests for elementary children: Grades 1 to 4. *Journal of Physical Education, Recreation and Dance*, 53, 48-49.
- Hardy, L. L., King, L., Farrell, L., Macniven, R., & Howlett, S. (2010). Fundamental movement skills among Australian preschool children. *Journal of Science and Medicine in Sport*, 13(5), 503–508. <http://doi.org/10.1016/j.jsams.2009.05.010>
- Hardy, L. L., King, L., Kelly, B., Farrell, L., & Howlett, S. (2010). Munch and move: Evaluation of a preschool healthy eating and movement skill program. *The International Journal of Behavioral Nutrition and Physical Activity*, 7(1), 80. <http://doi.org/10.1186/1479-5868-7-80>
- Hare, B., Melis, A. P., Woods, V., Hastings, S., & Wrangham, R. (2007). Tolerance Allows Bonobos to Outperform Chimpanzees on a Cooperative Task. *Current Biology*, 17(7), 619–623. <http://doi.org/10.1016/j.cub.2007.02.040>
- Hartup, W. W., Laursen, B., Stewart, M. I., & Eastenson, A. (1988). Conflict and the friendship relations of young children. *Child Development*, 59(6), 1590–1600. <http://doi.org/10.2307/1130673>
- Haskell, W. L. (1996). Physical activity, sport, and health: Toward the next century. *Research Quarterly for Exercise and Sport*, 67, 37–48.
- Haubenstricker, J., Branta, C. F., & Seefeldt, V. D. (1999). History of the motor performance study and related programs. In J. Haubenstricker & D. L. Feltz (Eds.), *100 years of kinesiology: History, research, and reflections* (pp. 103–125). East Lansing, MI: Department of Kinesiology.
- Haubenstricker, J., Branta, C., Ulrich, B., Brakora, L., & E-Lotfalian, A. (1984). Quantitative and qualitative analysis of jumping behavior in young children. Paper presented at the *Midwest District Convention of the American Alliance of Health, Physical Education, Recreation and Dance*, Indianapolis, USA.
- Haubenstricker, J., & Seefeldt, V. (1986). Acquisition of motor skills during childhood. In V. Seefeldt (Ed.), *Physical activity and well-being* (pp. 41-101). Reston, VA: American Alliance Health, Physical Education, Recreation, and Dance.
- Haun, D., & Over, H. (2015). Like me : A homophily-based account of human culture. In *Epistemological dimensions of evolutionary psychology* (pp. 117–130).
- Hay, D. F. (1979). Cooperative interactions and sharing between very young children and their parents. *Developmental Psychology*, 15(6), 647–653. <http://doi.org/10.1037//0012-1649.15.6.647>
- Hay, D. F., & Cook, K. V. (2007). The transformation of prosocial behavior from infancy to childhood. In *Socioemotional development in the toddler years: Transitions and transformations* (pp. 100–124).
- Hay, J., & Missiuna, C. (1998). Motor proficiency in children reporting low levels of participation in physical activity. *Canadian Journal of Occupational Therapy*, 65(2), 64-71.
- Hay, D. F., & Murray, P. (1982). Giving and Requesting: Social Facilitation of Infants' Offers to Adults. *Infant Behavior & Development*, 5, 301–310.
- Hay, D. F., Nash, A., & Pedersen, J. (1981). Responses of six-month-olds to the distress of their peers. *Child Development*, 52(3), 1071–1075.
- Hay, D. F., Payne, A., & Chadwick, A. (2004). Peer relations in childhood. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 45(1), 84–108.

- <http://doi.org/10.1046/j.0021-9630.2003.00308.x>
- Helwig, C. C., & Turiel, E. (2004). Children's social and moral reasoning. In P. K. Smith & C. H. Hart (Eds.), *Blackwell handbook of childhood social development: Blackwell handbooks of developmental psychology*.
- Henrich, J. (2009). The evolution of costly displays, cooperation and religion: Credibility enhancing displays and their implications for cultural evolution. *Evolution and Human Behavior*, 30, 244–260.
<http://doi.org/10.1016/j.evolhumbehav.2009.03.005>
- Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, 33, 61–135.
- Herrmann, E., Call, J., Hernández-Lloreda, M. V., Hare, B., & Tomasello, M. (2007). Humans have evolved specialized skills of social cognition: The cultural intelligence hypothesis. *Science*, 317(5843), 1360–6.
<http://doi.org/10.1126/science.1146282>
- Hetherington, C., Hendrickson, C., & Koenig, M. (2014). Reducing an in-group bias in preschool children: the impact of moral behavior. *Developmental Science*, 17(6), 1042–1049. <http://doi.org/10.1111/desc.12192>
- Heyes, C. (2010). Where do mirror neurons come from? *Neuroscience and Biobehavioral Reviews*, 34, 575–583.
<http://doi.org/10.1016/j.neubiorev.2009.11.007>
- Heyes, C. (2011). Automatic imitation. *Psychological Bulletin*, 137(3), 463–83.
<http://doi.org/10.1037/a0022288>
- Heyes, C. (2014). False belief in infancy: A fresh look. *Developmental Science*, 5, 647–659. <http://doi.org/10.1111/desc.12148>
- Hilderman, C. E. (2015). *Music and movement: The influence of tempo on the mirror neuron system in children*.
- Hilton, C., Wente, L., LaVesser, P., Ito, M., Reed, C., & Herzberg, G. (2007). Relationship between motor skill impairment and severity in children with Asperger syndrome. *Research in Autism Spectrum Disorders*, 1(4), 339–349.
<http://doi.org/10.1016/j.rasd.2006.12.003>
- Hitti, A., Mulvey, K. L., Rutland, A., Abrams, D., & Killen, M. (2014). When is it okay to exclude a member of the ingroup? Children's and adolescents' social reasoning. *Social Development*, 23(3), 451–469. <http://doi.org/10.1111/sode.12047>
- Hoffman, M. L. (1975). Developmental synthesis of affect and cognition and its implications for altruistic motivation. *Developmental Psychology*, 11(5), 607–622.
<http://doi.org/10.1037//0012-1649.11.5.607>
- Hogrefe, J. G., Wimmer, H., & Perner, J. (1986). Ignorance versus false belief: A developmental lag in attribution of epistemic states. *Child Development*, 57(3), 567–582.
- Hold-Cavell, B. C., Attili, G., & Schleidt, M. (1986). A cross-cultural comparison of children's behaviour during their first year in a preschool. *International Journal of Behavioural Development*, 9, 471–483.
- Holfelder, B., & Schott, N. (2014). Relationship of fundamental movement skills and physical activity in children and adolescents: A systematic review. *Psychol Sport Exerc*, 15(4), 382–391. <http://doi.org/10.1016/j.psychsport.2014.03.005>
- Holmgren, R. A., Nancy, E., & Fabes, R. A. (1998). The relations of children's situational empathy-related emotions to dispositional prosocial behaviour. *International Journal of Behavioral Development*, 22(1), 169–193.
<http://doi.org/10.1080/016502598384568>
- Hood, B. M., Willen, J. D., & Driver, J. (1998). Adult's Eyes Trigger Shifts of Visual

- Attention in Human Infants. *Psychological Science*, 9(2), 131–134.
<http://doi.org/10.1111/1467-9280.00024>
- Houlette, M., Gaertner, S. L., Johnson, K. M., Banker, B. S., Riek, B. M., & Dovidio, J. F. (2004). Developing a more inclusive social identity: An elementary school intervention. *Journal of Social Issues*, 60, 35–55.
- House, B., Henrich, J., Sarnecka, B., & Silk, J. B. (2013). The development of contingent reciprocity in children. *Evolution and Human Behavior*, 34(2), 86–93.
<http://doi.org/10.1016/j.evolhumbehav.2012.10.001>
- Howe, N., & Ross, H. S. (1990). Socialization, perspective-taking, and the sibling relationship. *Developmental Psychology*, 26(1), 160–165.
<http://doi.org/10.1037/0012-1649.26.1.160>
- Howes, C., & Phillipsen, L. (1992). Gender and friendship: Relationships within peer groups of young children. *Social Development*, 1, 230–242.
- Huang, S. Y., Hogg, J., Zandieh, S., & Bostwick, S. B. (2012). A ballroom dance classroom program promotes moderate to vigorous physical activity in elementary school children. *American Journal of Health Promotion*, 26, 160–165.
<http://doi.org/10.1016/j.surg.2006.10.010>
- Hughes, C., & Leekam, S. (2004). What are the links between theory of mind and social relations? Review, reflections and new directions for studies of typical and atypical development. *Social Development*, 13, 590–619.
- Humphreys, A. P., & Smith, P. K. (1987). Rough and tumble, friendship, and dominance in school children: Evidence for continuity and change with age. *Child Development*, 58(1), 201–212.
- Hunnius, S., & Bekkering, H. (2010). The early development of object knowledge: A study of infants' visual anticipations during action observation. *Developmental Psychology*, 46(2), 446–454. <http://doi.org/10.1037/a0016543>
- Hunnius, S., & Bekkering, H. (2014). What are you doing? How active and observational experience shape infants' action understanding. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369(1644), 20130490.
<http://doi.org/10.1098/rstb.2013.0490>
- Iacoboni, M. (2009). Imitation, empathy, and mirror neurons. *Annual Review of Psychology*, 60, 653–670. <http://doi.org/10.1146/annurev.psych.60.110707.163604>
- Iacoboni, M., & Dapretto, M. (2006). The mirror neuron system and the consequences of its dysfunction. *Nat Rev Neurosci*, 7(December), 942–951.
<http://doi.org/10.1038/nrn2024>
- Iivonen, S., & Sääkslahti, A. K. (2014). Preschool children's fundamental motor skills: a review of significant determinants. *Early Child Development and Care*, 184(7), 1107–1126. <http://doi.org/10.1080/03004430.2013.837897>
- IJzerman, H., & Semin, G. R. (2010). Temperature perceptions as a ground for social proximity. *Journal of Experimental Social Psychology*, 46(6), 867–873.
<http://doi.org/10.1016/j.jesp.2010.07.015>
- Isabella, R. A., Belsky, J., & von Eye, A. (1989). Origins of infant-mother attachment: An examination of interactional synchrony during the infant's first year. *Developmental Psychology*, 25(1), 12–21. <http://doi.org/10.1037/0012-1649.25.1.12>
- Isenhower, R. W., Marsh, K. L., Richardson, M. J., Helt, M., Schmidt, R. C., & Fein, D. (2012). Rhythmic bimanual coordination is impaired in young children with autism spectrum disorder. *Research in Autism Spectrum Disorders*, 6(1), 25–31.
<http://doi.org/10.1016/j.rasd.2011.08.005>

- Iverson, J. M., & Braddock, B. A. (2006). Gesture and motor skill in relation to language in children with language impairment. *Journal of Speech, Language, and Hearing Research, 54*, 72-86.
- Izard, C. E. (1992). Basic emotions, relations among emotions, and emotion-cognition relations. *Psychological Review, 99*(3), 561-565. <http://doi.org/10.1037//0033-295X.99.3.561>
- Jackson, M., & Tisak, M. S. (2001). Is prosocial behaviour a good thing? Developmental changes in children's evaluations of helping, sharing, cooperating, and comforting. *British Journal of Developmental Psychology, 19*(3), 349-367. <http://doi.org/10.1348/026151001166146>
- Jacobs, J. E., & Vernon, M. K. (2009). Activity Choices in Middle Childhood: The Roles of Gender Self-Beliefs and Parents Influence. In J. L. Mahoney, R. W. Larson, & J. S. Eccles (Eds.), *Organized activities as contexts of development* (pp. 235-254). Lawrence Erlbaum Associates.
- Jaeggi, A. V., Burkart, J. M., & Van Schaik, C. P. (2010). On the psychology of cooperation in humans and other primates: Combining the natural history and experimental evidence of prosociality. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1553), 2723-2735. <http://doi.org/10.1098/rstb.2010.0118>
- Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., Jasnow, Michael, D., Rochat, P., & Stern, D. N. (2001). Rhythms of dialogue in infancy: Coordinated timing in development. *Monographs of the Society for Research in Child Development, 66*(2), i-viii + 1-149.
- Jago, R., MacDonald-Wallis, K., Thompson, J. L., Page, A. S., Brockman, R., & Fox, K. R. (2011). Better with a buddy: Influence of best friends on children's physical activity. *Medicine and Science in Sports and Exercise, 43*(34), 259-265. <http://doi.org/10.1249/MSS.0b013e3181edefaa>
- Jarus, T., Lourie-Gelberg, Y., Engel-Yeger, B., & Bart, O. (2011). Participation patterns of school-aged children with and without DCD. *Research in Developmental Disabilities, 32*, 1323-1331.
- Jarvis, P. (2006). "Rough and tumble" play: Lessons in life. *Evolutionary Psychology, 4*, 330-346.
- Jasnow, M., & Feldstein, S. (1986). Adult-like temporal characteristics of mother-infant vocal interactions. *Child Development, 57*(3), 754-761.
- Johnson, S. C., Booth, A., & O'Hearn, K. (2001). Inferring the goals of a nonhuman agent. *Cognitive Development, 16*(1), 637-656. [http://doi.org/10.1016/S0885-2014\(01\)00043-0](http://doi.org/10.1016/S0885-2014(01)00043-0)
- Johnson, S., Slaughter, V., & Carey, S. (1998). Whose gaze will infants follow? The elicitation of gaze following in 12-month-olds. *Developmental Science, 1*(2), 233-238.
- Jones, R. A., Hinkley, T., Okely, A. D., & Salmon, J. (2013). Tracking physical activity and sedentary behavior in childhood: A systematic review. *American Journal of Preventive Medicine, 44*(6), 651-658. Retrieved from <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed11&NEWS=N&AN=2013316552>
- Jordan, F. L. (1994). *A validation of the Welkart sequence of levels of beat coordination for children aged 3-7*.
- Jordan, J. J., McAuliffe, K., & Warneken, F. (2014). Development of in-group favoritism in children's third-party punishment of selfishness. *Proceedings of the National Academy of Sciences, 111*(35), 1-6.

- <http://doi.org/10.1073/pnas.1402280111>
- Kambas, A., Michalopoulou, M., Fatouros, I. G., Christoforidis, C., Manthou, E., Giannakidou, et al. (2012). The relationship between motor proficiency and pedometer-determined physical activity in young children. *Pediatric Exercise Science*, 24, 34e44.
- Kanioglou, A., Tsorbatzoudis, H., & Barkoukis, V. (2005). Socialization and behavioral problems of elementary school pupils with developmental coordination disorder. *Perceptual and Motor Skills*, 101, 163–173.
- Karger, R. H. (1979). Synchrony in Mother-Infant Interactions. *Child Development*, 50(3), 882–885.
- Kärtner, J., Keller, H., & Chaudhary, N. (2010). Cognitive and social influences on early prosocial behavior in two sociocultural contexts. *Developmental Psychology*, 46(4), 905–914. <http://doi.org/10.1037/a0019718>
- Kato, T., Takahashi, E., Sawada, K., Kobayashi, N., Watanabe, T., & Ishii, T. (1983). A computer analysis of infant movements synchronized with adult speech. *Pediatric Research*, 17, 625–628.
- Katzmarzyk, P. T., Malina, R. M. & Bouchard, C. (1999). Physical activity, physical fitness, and coronary heart disease risk factors in youth: The Quebec study. *Preventive Medicine*, 29, 555–562.
- Karmiloff, K. & Karmiloff-Smith, A. (2001). *Pathways to Language: From Fetus to Adolescent*. USA: Harvard University Press.
- Kelly, D. J., Liu, S., Ge, L., Quinn, P. C., Slater, A. M., Lee, K., ... Pascalis, O. (2007). Cross-race preferences for same-race faces extend beyond the African Versus Caucasian contrast in 3-month-old infants. *Infancy*, 11(1), 87–95. <http://doi.org/10.1080/15250000709336871>
- Kelly, D. J., Quinn, P. C., Slater, A. M., Lee, K., Gibson, A., Smith, M., ... Pascalis, O. (2005). Three-month-olds, but not newborns, prefer own-race faces. *Developmental Science*, 8(6). <http://doi.org/10.1111/j.1467-7687.2005.0434a.x>. Three-month-olds
- Kendon, A. (1970). Movement coordination in social interaction: Some examples described. *Acta Psychologica*, 32, 100–125.
- Kennedy-Behr, A., Rodger, S., & Mickan, S. (2013). A comparison of the play skills of preschool children with and without developmental coordination disorder. *OTJR: Occupation, Participation and Health*, 33(4), 198–208. <http://doi.org/10.3928/15394492-20130912-03>
- Kenward, B., & Dahl, M. (2011). Preschoolers distribute scarce resources according to the moral valence of recipients' previous actions. *Developmental Psychology*, 47(4), 1054–1064. <http://doi.org/10.1037/a0023869>
- Kenward, B., & Gredebäck, G. (2013). Infants help a non-human agent. *PloS One*, 8(9), e75130. <http://doi.org/10.1371/journal.pone.0075130>
- Keogh, J. (1969). *Changes in motor performance during early school years*. Technical Report 2-69 (USPHS Grant HD 01059). Department of Physical Education, University of California, Los Angeles.
- Keverne, E. B., Martensz, N. D., & Tuite, B. (1989). Beta-endorphin concentrations in cerebrospinal fluid of monkeys are influenced by grooming relationships. *Psychoneuroendocrinology*, 14(1&2), 155–61.
- Killen, M., Lee-Kim, J., McGlothlin, H., Stangor, C., & Helwig, C. C. (2002). How children and adolescents evaluate gender and racial exclusion. *Monographs of the Society for Research in Child Development*, 67(4), i-viii+1-129.
- Killen, M., McGlothlin, H., & Henning, A. (2008). Explicit judgments and implicit bias.

- In *Intergroup Attitudes and Relations in Childhood Through Adulthood* (pp. 126–145). GB: Oxford University Press.
- Killen, M., Rutland, A., Abrams, D., Mulvey, K. L., & Hitti, A. (2013). Development of intra- and intergroup judgments in the context of moral and social-conventional norms. *Child Development*, 84(3), 1063–1080. <http://doi.org/10.1111/cdev.12011>
- Kim, J., Wigram, T., & Gold, C. (2008). The effects of improvisational music therapy on joint attention behaviors in autistic children: A randomized controlled study. *Journal of Autism and Developmental Disorders*, 38(9), 1758–1766. <http://doi.org/10.1007/s10803-008-0566-6>
- King-Dowling, S., Missiuna, C., Rodriguez, M. C., Greenway, M., & Cairney, J. (2015). Co-occurring motor, language and emotional -behavioral problems in children 3–6 years of age. *Human Movement Science*, 39, 101–108. <http://doi.org/10.1016/j.humov.2014.10.010>
- Kinsbourne, M. (2002). The role of imitation in body ownership and mental growth, In A. N. Meltzoff & W. Prinz (Eds.), *The imitative mind: Development, evolution and brain bases* (pp. 311–330). Cambridge: Cambridge University Press.
- Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2007). The native language of social cognition. *Proceedings of the National Academy of Sciences*, 104(30), 12577–80. <http://doi.org/10.1073/pnas.0705345104>
- Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2012). “Native” objects and collaborators: Infants’ object choices and acts of giving reflect favor for native over foreign speakers. *Journal of Cognition and Development*, 13(1), 67–81. <http://doi.org/10.1080/15248372.2011.567200>
- Kinzler, K. D., Shutts, K., & Correll, J. (2010). Priorities in social categories. *European Journal of Social Psychology*, 40, 581–592. <http://doi.org/10.1002/ejsp>
- Kirschner, S., & Ilari, B. (2013). Joint drumming in Brazilian and German preschool children: Cultural differences in rhythmic entrainment, but no prosocial effects. *Journal of Cross-Cultural Psychology*, 45(1), 137–166. <http://doi.org/10.1177/0022022113493139>
- Kirschner, S., & Tomasello, M. (2009). Joint drumming: Social context facilitates synchronization in preschool children. *Journal of Experimental Child Psychology*, 102, 299–314. <http://doi.org/10.1016/j.jecp.2008.07.005>
- Kirschner, S., & Tomasello, M. (2010). Joint music making promotes prosocial behavior in 4-year-old children. *Evolution and Human Behavior*, 31, 354–364. <http://doi.org/10.1016/j.evolhumbehav.2010.04.004>
- Kleinke, C. L. (1986). Gaze and eye contact: A research review, *Psychological Bulletin*, 100(1), 78–100. doi: 10.1037/0033-2909.100.1.78
- Kleinspehn-Ammerlahn, A., Riediger, M., Schmiedek, F., von Oertzen, T., Li, S.-C., & Lindenberger, U. (2011). Dyadic drumming across the lifespan reveals a zone of proximal development in children. *Developmental Psychology*, 47(3), 632–44. <http://doi.org/10.1037/a0021818>
- Kleinspehn, A. (2008). *Goal-directed interpersonal action synchronization across the lifespan: A dyadic drumming* (Unpublished doctoral dissertation). Free University of Berlin, Germany.
- Knoblich, G., & Sebanz, N. (2008). Evolving intentions for social interaction: From entrainment to joint action. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 363, 2021–31. <http://doi.org/10.1098/rstb.2008.0006>
- Koehne, S., Hatri, A., Cacioppo, J. T., & Dziobek, I. (2016). Perceived interpersonal synchrony increases empathy: Insights from autism spectrum disorder. *Cognition*,

- 146, 8–15. <http://doi.org/10.1016/j.cognition.2015.09.007>
- Koehne, S., Hatri, A., Cacioppo, J. T., & Dziobek, I. (2016). Perceived interpersonal synchrony increases empathy: Insights from autism spectrum disorder. *Cognition*, 146, 8–15. <http://doi.org/10.1016/j.cognition.2015.09.007>
- Kohler, E. (2002). Hearing sounds, understanding actions: Action representation in mirror neurons. *Science*, 297(5582), 846–848. <http://doi.org/10.1126/science.1070311>
- Konvalinka, I., Xygalatas, D., Bulbulia, J., Schjødt, U., Jegindø, E.-M., Wallot, S., ... Roepstorff, A. (2011). Synchronized arousal between performers and related spectators in a fire-walking ritual. *Proceedings of the National Academy of Sciences of the United States of America*, 108(20), 8514–8519. <http://doi.org/10.1073/pnas.1016955108>
- Krombholz, H. (2006). Physical performance in relation to age, sex, birth order, social class, and sports activities of preschool children. *Perceptual & Motor Skills*, 102(2), 477–484. <http://doi.org/10.2466/pms.102.2.477-484>
- Kuentay, A. C. (2001). Occasions for providing resolutions (or not) in Turkish preschool conversational narratives. *Narrative Inquiry*, 11, 411–450.
- Kuhl, P. K., Andruski, J. E., Chistovich, I. A., Chistovich, L. A., Kozhevnikova, E. V., Ryskina, V. L., ... Lacerda, F. (1997). Cross-language analysis of phonetic units in language addressed to infants. *Science*, 277(5326), 684–686. <http://doi.org/10.1126/science.277.5326.684>
- Kuhlman, K. & L. J. Schweingart, (1999). *Movement, music and timing: Timing in child development*. Retrieved from <http://www.highscope.org/Content.asp?ContentId=234> on September 21, 2016.
- Kuhlmeier, V., Wynn, K., & Bloom, P. (2003). Attribution of dispositional states by 12-month-olds. *Psychological Science*, 14(5), 402–408. <http://doi.org/10.1111/1467-9280.01454>
- Ladd, G. W. (1990). Having friends, keeping friends, making friends, and being liked by peers in the classroom: Predictors of children's early school adjustment? *Child Development*, 61(4), 1081–1100.
- Lafrance, M. (1979). Nonverbal synchrony and rapport: Analysis by the cross-lag panel technique. *Social Psychology Quarterly*, 42(1), 66–70.
- Lafrance, M., & Broadbent, M. (1976). Group rapport: Posture sharing as a nonverbal indicator. *Group & Organization Management*, 1, 328–333. <http://doi.org/10.1177/105960117600100307>
- Laible, D., & Karahuta, E. (2014). Prosocial behaviors in early childhood. In *Prosocial Development: A Multidimensional Approach*. <http://doi.org/10.1093/acprof>
- Lakens, D. (2010). Movement synchrony and perceived entitativity. *Journal of Experimental Social Psychology*, 46, 701–708. <http://doi.org/10.1016/j.jesp.2010.03.015>
- Lakens, D., & Stel, M. (2011). If they move in sync, they must feel in sync: Movement synchrony leads to attributions of rapport and entitativity. *Social Cognition*, 29(1), 1–14. <http://doi.org/10.1521/soco.2011.29.1.1>
- Lalonde, C. E., & Chandler, M. J. (1995). False belief understanding goes to school: On the social-emotional consequences of coming early or late to a first theory of mind. *Cognition & Emotion*, 9(February), 167–185. <http://doi.org/10.1080/02699939508409007>
- Landa, R., & Garrett-Mayer, E. (2006). Development in infants with autism spectrum disorders: A prospective study. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, 47(6), 629–638. <http://doi.org/10.1111/j.1469->

7610.2006.01531.x

- Lange, R. (1976). *The Nature of Dance. An Anthropological Perspective*. International Publications Service. New York.
- Larson, R. W., & Verma, S. (1999). How children and adolescents spend time across the world: Work, play, and developmental opportunities. *Psychological Bulletin*, 125(6), 701–736.
- Launay, J., Dean, R. T., & Bailes, F. (2012). Synchronization can influence trust following virtual interaction. *Experimental Psychology*, 60(1), 53–63.
- Lawrence, E. J., Shaw, P., Giampietro, V. P., Surguladze, S., Brammer, M. J., & David, A. S. (2006). The role of “shared representations” in social perception and empathy: an fMRI study. *NeuroImage*, 29, 1173–1184. <http://doi.org/10.1016/j.neuroimage.2005.09.001>
- Le Merrer, J., Becker, J. A. J., Befort, K., & Kieffer, B. L. (2009). Reward processing by the opioid system in the brain. *Physiological Reviews*, 89(4), 1379–1412. <http://doi.org/10.1007/s12671-013-0269-8>
- Lee, Y., Yun, J. E., Kim, E. Y., & Song, H. (2015). The development of infants’ sensitivity to behavioral intentions when inferring others’ social preferences. *Plos One*, 10(9), e0135588. <http://doi.org/10.1371/journal.pone.0135588>
- Legerstee, M. (1991). The role of person and object in eliciting early imitation. *Journal of Experimental Child Psychology*, 51(3), 423–33. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/2072085>
- Legerstee, M., Anderson, D., & Schaffer, A. (1998). Five- and eight-month-old infants recognize their faces and voices as familiar and social stimuli. *Child Development*, 69(1), 37–50. <http://doi.org/10.1111/j.1467-8624.1998.tb06131.x>
- Legerstee, M., Corter, C., & Kienapple, K. (1990). Hand, arm, and facial actions of young infants to a social and nonsocial stimulus. *Child Development*, 61(3), 774–784.
- Legerstee, M., & Markova, G. (2008). Variations in 10-month-old infant imitation of people and things. *Infant Behavior & Development*, 31(1), 81–91. <http://doi.org/10.1016/j.infbeh.2007.07.006>
- Legerstee, M., Pomerleau, A., Malcuit, G., & Feider, H. (1987). The development of infants’ responses to people and a doll: Implications for research in communication. *Infant Behavior & Development*, 10(1), 81–95. [http://doi.org/10.1016/0163-6383\(87\)90008-7](http://doi.org/10.1016/0163-6383(87)90008-7)
- Lafreniere, P. J. (1996). Cooperation as a conditional strategy among peers: Influence of social ecology and kin relations. *International Journal of Behavioural Development*, 19, 39–52.
- Leimgruber, K. L., Shaw, A., Santos, L. R., & Olson, K. R. (2012). Young children are more generous when others are aware of their actions. *PLoS ONE*, 7(10), 1–11. <http://doi.org/10.1371/journal.pone.0048292>
- LeMare, L. J., & Rubin, K. H. (1987). Perspective taking and peer Interaction: structural and developmental analyses. *Child Development*, 58(2), 306–315.
- Leonard, H. C., & Hill, E. L. (2014). The impact of motor development on typical and atypical social cognition and language: A systematic review. *Child and Adolescent Mental Health*, 19(3), 163–170. <http://doi.org/10.1111/camh.12055>
- Lepage, J., & Théoret, H. (2007). The mirror neuron system: Grasping others’ actions from birth? *Developmental Science*, 10(5), 513–529. <http://doi.org/10.1111/j.1467-7687.2007.00631.x>
- Leung, E. H. L., & Rheingold, H. L. (1981). Development of pointing as a social gesture. *Developmental Psychology*, 17(2), 215–220.

- Levine, L. J. (1995). Young children's understanding of the causes of anger and sadness. *Child Development*, 66(3), 697–709.
- Lewis, C., & Carpendale, J. (2004). Social cognition. In P. K. Smith & C. H. Hart (Eds.), *Blackwell handbook of childhood social development: Blackwell handbooks of developmental psychology* (pp. 375–393). Oxford: Blackwell.
- Lewkowicz, D. J. (2003). Learning and discrimination of audiovisual events in human infants: The hierarchical relation between intersensory temporal synchrony and rhythmic pattern cues. *Developmental Psychology*, 39(5), 795–804.
<http://doi.org/10.1037/0012-1649.39.5.795>
- Li, V., Spitzer, B., & Olson, K. R. (2014). Preschoolers reduce inequality while favoring individuals with more. *Child Development*, 85(3), 1123–1133.
<http://doi.org/10.1111/cdev.12198>
- Liao, Y., Acar, Z. A., Makeig, S., & Deak, G. (2015). EEG imaging of toddlers during dyadic turn-taking: Mu-rhythm modulation while producing or observing social actions. *NeuroImage*, 112, 52–60. <http://doi.org/10.1016/j.neuroimage.2015.02.055>
- Linkenauer, S. A., Lerner, M. D., Ramenzoni, V. C., & Proffitt, D. R. (2012). A perceptual-motor deficit predicts social and communicative impairments in individuals with autism spectrum disorders. *Autism Research*, 5(5), 352–362.
<http://doi.org/10.1002/aur.1248>
- Liszkowski, U., Carpenter, M., Henning, A., Striano, T., & Tomasello, M. (2004). Twelve-month-olds point to share attention and interest. *Developmental Science*, 7(3), 297–307. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/15595371>
- Liszkowski, U., Carpenter, M., Striano, T., & Tomasello, M. (2006). 12- and 18-month-olds point to provide information for others. *Journal of Cognition and Development*, 7(2), 173–187. http://doi.org/10.1207/s15327647jcd0702_2
- Liszkowski, U., Carpenter, M., & Tomasello, M. (2008). Twelve-month-olds communicate helpfully and appropriately for knowledgeable and ignorant partners. *Cognition*, 108(3), 732–9. <http://doi.org/10.1016/j.cognition.2008.06.013>
- Løkken, G. (2000). Tracing the social style of toddler peers. *Scandinavian Journal of Educational Research*, 44(2), 163–176. <http://doi.org/10.1080/713696668>
- Loong, C.-Y. (1999). *The effects of tempo in rhythm of young children under five years old* (Unpublished doctoral dissertation). Kent State University, USA.
- Luo, Y. (2011). Three-month-old infants attribute goals to a non-human agent. *Developmental Science*, 14(2), 453–460. <http://doi.org/10.1111/j.1467-7687.2010.00995.x>
- MacDonald, G., & Leary, M. (2005). Why does social exclusion hurt? The relationship between social and physical pain. *Psychological Bulletin*, 131(2), 202–23.
<http://doi.org/10.1037/0033-2909.131.2.202>
- MacDonald, K., Schug, M., Chase, E., & Barth, H. (2013). My people, right or wrong? Minimal group membership disrupts preschoolers' selective trust. *Cognitive Development*, 28(3), 247–259. <http://doi.org/10.1016/j.cogdev.2012.11.001>
- Machin, A. J., & Dunbar, R. I. M. (2011). The brain opioid theory of social attachment: A review of the evidence. *Behaviour*, 148(9–10), 985–1025.
<http://doi.org/10.1163/000579511X596624>
- Macrae, C. N., Duffy, O. K., Miles, L. K., & Lawrence, J. (2008). A case of hand waving: Action synchrony and person perception. *Cognition*, 109, 152–156.
<http://doi.org/10.1016/j.cognition.2008.07.007>
- Malatesta, C. Z., Culver, C., Tesman, J. R., Shepard, B., Fogel, A., Reimers, M., & Zivin, G. (1989). The development of emotion expression during the first two years of life. *Monographs of the Society for Research in Child Development*, 54(1),

- 1–136.
- Malatesta, C. Z., & Haviland, J. M. (1982). Learning display rules: The socialization of emotion expression in infancy. *Child Development*, 53, 991–1003.
- Malbrán, S. (2000). The development of pulse synchrony: An exploratory study of three-year-old. *Bulletin of the Council for Research in Music Education*, 147, 109–115.
- Malbrán, S. (2002). Tapping in time: A longitudinal study at the ages of three to five years. *Bulletin of the Council for Research in Music Education*, 153/154, 71–77.
- Malina, R. M. (2001). *Tracking of physical activity across the lifespan*. Washington, DC.
- Malina, R. M. (2004). Motor development during infancy and early childhood: Overview and suggested directions for research. *Motor Development*, 2, 50–66.
- Malti, T., Gasser, L., & Gutzwiller-Helfenfinger, E. (2010). Children's interpretive understanding, moral judgments, and emotion attributions: Relations to social behaviour. *The British Journal of Developmental Psychology*, 28, 275–292. <http://doi.org/10.1348/026151009X403838>
- Malti, T., Gummerum, M., Keller, M., & Buchmann, M. (2009). Children's moral motivation, sympathy, and prosocial behavior. *Child Development*, 80(2), 442–460. <http://doi.org/10.1111/j.1467-8624.2009.01271.x>
- Malti, T., Gummerum, M., Ongley, S. F., Chaparro, M., Nola, M., & Bae, N. Y. (2015). "Who is worthy of my generosity?" Recipient characteristics and the development of children's sharing. *International Journal of Behavioral Development*, 1–10. <http://doi.org/10.1177/0165025414567007>
- Marsh, K. (2012). "The beat will make you be courage": The role of a secondary school music program in supporting young refugees and newly arrived immigrants in Australia. *Research Studies in Music Education*, 34(2), 93–111. <http://doi.org/10.1177/1321103X12466138>
- Marsh, K. L., Isenhower, R. W., Richardson, M. J., Helt, M., Verbalis, A. D., Schmidt, R. C., & Fein, D. (2013). Autism and social disconnection in interpersonal rocking. *Frontiers in Integrative Neuroscience*, 7(February), 1–8. <http://doi.org/10.3389/fnint.2013.00004>
- Marshall, P. J., & Meltzoff, A. N. (2011). Neural mirroring systems: Exploring the EEG mu rhythm in human infancy. *Developmental Cognitive Neuroscience*, 1(2), 110–123. <http://doi.org/10.1016/j.dcn.2010.09.001>
- Marshall, P. J., Young, T., & Meltzoff, A. N. (2011). Neural correlates of action observation and execution in 14-month-old infants: an event-related EEG desynchronization study. *Developmental Science*, 14(3), 474–480. <http://doi.org/10.1111/j.1467-7687.2010.00991.x>
- Martel, F. L., Nevison, C. M., Rayment, D., Simpson, M. J., & Keverne, E. B. (1993). Opioid receptor blockade reduces maternal affect and social grooming in rhesus monkeys. *Psychoneuroendocrinology*, 18(4), 307–321.
- Martel, F. L., Nevison, C. M., Simpson, M. J., & Keverne, E. B. (1995). Effects of opioid receptor blockade on the social behavior of rhesus monkeys living in large family groups. *Developmental Psychobiology*, 28(2), 71–84. <http://doi.org/10.1002/dev.420280202>
- Martin, Alia; Olson, K. (2015). Beyond good and evil: What motivations underlie children's prosocial behaviour. *Perspectives on Psychological Science*, 10(2), 159–175. <http://doi.org/10.1177/1745691615568998>
- Martin, L. J., Carron, A. V., Eys, M. a., & Loughhead, T. M. (2012). Development of a cohesion inventory for children's sport teams. *Group Dynamics: Theory, Research*,

- and Practice, 16(1), 68–79. <http://doi.org/10.1037/a0024691>
- Martin, R. D. (1983). *Human Brain Evolution in an Ecological Context*.
- Masangkay, Z. S., McCluskey, K. A., McIntyre, C. W., Sims-Knight, J., Vaughn, B. E., & Flavell, J. H. (1974). The early development of inferences about the visual percepts of others. *Child Development*, 45(2), 357–366.
- Masataka, N. (2007). Music, evolution and language. *Developmental Science*, 10(1), 35–39. <http://doi.org/10.1111/j.1467-7687.2007.00561.x>
- May, L., Byers-Heinlein, K., Gervain, J., & Werker, J. F. (2011). Language and the newborn brain: Does prenatal language experience shape the neonate neural response to speech? *Frontiers in Psychology*, 2(SEP), 1–9. <http://doi.org/10.3389/fpsyg.2011.00222>
- Mayer, A., & Trauble, B. E. (2012). Synchrony in the onset of mental state understanding across cultures? A study among children in Samoa. *International Journal of Behavioral Development*, 37(1), 21–28. <http://doi.org/10.1177/0165025412454030>
- McAuley, D. J. (2010). Tempo and rhythm. In M. Riess Jones, R. R. Fay, & A. N. Popper (Eds.), *Music perception* (Vol. 36, pp. 165–199). New York, NY: Springer New York. <http://doi.org/10.1007/978-1-4419-6114-3>
- McAuley, D. J., Jones, M. R., Holub, S., Johnston, H. M., & Miller, N. S. (2006). The time of our lives: Life span development of timing and event tracking. *Journal of Experimental Psychology: General*, 135(3), 348–367. <http://doi.org/10.1037/0096-3445.135.3.348>
- McDowell, D. J., O’Neil, R., & Parke, R. D. (2000). Display rule application in a disappointing situation and children’s emotional reactivity: Relations with social competence. *Merrill-Palmer Quarterly*, 46, 306–324.
- McElwain, N. L., & Volling, B. (2002). Relating individual control, social understanding, and gender to child–friend interaction: A relationships perspective. *Social Development*, 11, 362–385.
- McGee, R., Williams, S., Howden-Chapman, P., Martin, J., & Kawachi, I. (2006). Participation in clubs and groups from childhood to adolescence and its effects on attachment and self-esteem. *Journal of Adolescence*, 29(1), 1–17. <http://doi.org/10.1016/j.adolescence.2005.01.003>
- McGlothlin, H., & Killen, M. (2006). Intergroup attitudes of European American children attending ethnically homogeneous schools. *Child Development*, 77(5), 1375–1386. <http://doi.org/10.1111/j.1467-8624.2006.00941.x>
- McGuigan, N., Fisher, R., & Glasgow, R. (2016). The influence of receiver status on donor prosociality in 6- to 11-year-old children. *Child Development*, 87(3), 855–869. <http://doi.org/10.1111/cdev.12517>
- McHale, S. M., Crouter, A. C., & Tucker, C. J. (1999). Family context and gender role socialization in middle childhood: Comparing girls to boys and sisters to brothers. *Child Development*, 70(4), 990–1004. <http://doi.org/10.1111/1467-8624.00072>
- McHale, S. M., Crouter, A. C., & Tucker, C. J. (2001). Free-time activities in middle childhood: Links with adjustment in early adolescence. *Child Development*, 72(6), 1764–1778. <http://doi.org/10.1111/1467-8624.00377>
- McKenzie, T. L., Sallis, J. F., Broyles, S. L., Zive, M. M., Nader, P. R., Berry, C. C., & Brennan, J. J. (2002). Childhood movement skills: Predictors of physical activity in Anglo American and Mexican American adolescents? *Research Quarterly for Exercise and Sport*, 73(3), 238–244. <http://doi.org/10.1080/02701367.2002.10609017>
- McMurray, R.G., Harrell, J.S., & Bangdiwala, S.I., (1994) Aerobic power and physical

- activity of North Carolina elementary school children. *The North Carolina Journal*, 30(2), 5-11.
- McNeill, W. H. (1995). *Keeping Together in Time: Dance and Drill in Human History*. Cambridge, MA: Harvard University Press.
- Meerlo, J. A. M. (1961). Rhythm in babies and adults: Its implications for mental contagion. *Archives of General Psychiatry*, 5, 169–175.
- Mehler, J., & Christophe, A. (1995). Maturation and learning of language in the first year of life. In M. S. Gazzaniga (Ed.), *The cognitive neurosciences* (pp. 943–954). Cambridge, MA: Bradford Books.
- Melis, A. P., Hare, B., & Tomasello, M. (2006). Engineering cooperation in chimpanzees: Tolerance constraints on cooperation. *Animal Behaviour*, 72(2), 275–286. <http://doi.org/10.1016/j.anbehav.2005.09.018>
- Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology*, 31(5), 838–850. <http://doi.org/10.1037//0012-1649.31.5.838>
- Meltzoff, A. (2011). Social cognition and the origins of imitation, empathy, and theory of mind, In U. Goshwami (Ed.) *The wiley-blackwell handbook of childhood cognitive development* (pp. 49-75). Singapore: Blackwell Publishing.
- Meltzoff, A. N., & Decety, J. (2003). What imitation tells us about social cognition: A rapprochement between developmental psychology and cognitive neuroscience. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 358, 491–500. <http://doi.org/10.1098/rstb.2002.1261>
- Mendelson, M. J. (1986). Perception of the temporal pattern of motion in infancy *. *Infant Behavior & Development*, 9, 231–243.
- Mendelson, M. J., & Ferland, M. B. (1982). Auditory-visual transfer in four-month-old infants. *Child Development*, 53(4), 1022–1027.
- Meristo, M., & Surian, L. (2014). Infants distinguish antisocial actions directed towards fair and unfair agents. *PloS One*, 9(10), e110553. <http://doi.org/10.1371/journal.pone.0110553>
- Merker, B. (2000). Synchronous chorusing and human origins. In, N. L. Walin, B. Merker, and S. Brown, (Eds.), *The origins of music* (pp. 315-327). Cambridge: MIT Press.
- Merriam, A. P. (1964). *The Anthropology of Music*. Anuario (Vol. 1). Evanston, Illinois: Northwestern University Press. doi:10.2307/779807
- Metsäpelto, R.-L., & Pulkkinen, L. (2012). Socioemotional behavior and school achievement in relation to extracurricular activity participation in middle childhood. *Scandinavian Journal of Educational Research*, 56(2), 167–182. <http://doi.org/10.1080/00313831.2011.581681>
- Midlarsky, E., & Hannah, M. E. (1985). Competence, reticence, and helping by children and adolescents. *Developmental Psychology*, 21(3), 534–541. <http://doi.org/10.1037/0012-1649.21.3.534>
- Miles, L. K., Griffiths, J. L., Richardson, M. J., & Macrae, C. N. (2010). Too late to coordinate: Contextual influences on behavioral synchrony. *European Journal of Social Psychology*, 40, 52–60. <http://doi.org/10.1002/ejsp>
- Miles, L. K., Lumsden, J., Richardson, M. J., & Macrae, N. C. (2011). Do birds of a feather move together? Group membership and behavioral synchrony. *Experimental Brain Research*, 211, 495–503. <http://doi.org/10.1007/s00221-011-2641-z>
- Miles, L. K., Nind, L. K., Henderson, Z., & Macrae, C. N. (2010). Moving memories: Behavioral synchrony and memory for self and others. *Journal of Experimental*

- Social Psychology*, 46, 457–460. <http://doi.org/10.1016/j.jesp.2009.12.006>
- Miles, L. K., Nind, L. K., & Macrae, C. N. (2009). The rhythm of rapport: Interpersonal synchrony and social perception. *Journal of Experimental Social Psychology*, 45, 585–589. <http://doi.org/10.1016/j.jesp.2009.02.002>
- Miles, S. B., & Stipek, D. (2006). Contemporaneous and longitudinal associations between social behavior and literacy achievement in a sample of low-income elementary school children. *Child Development*, 77(1), 103–117. <http://doi.org/10.1111/j.1467-8624.2006.00859.x>
- Monot, M., Foley, R., & Ross, E. (2004). Affective prosody: Whence motherese. *Behavioral and Brain Sciences*, 27(4), 518–519.
- Moog, H. (1976). *The Musical Experience of the Pre-school Child*. C. Clarke (Trans.). London: Schott.
- Moon, C. M., Lagercrantz, H., & Kuhl, P. K. (2013). Language experienced in utero affects vowel perception after birth: A two-country study. *Acta Paediatrica, International Journal of Paediatrics*, 102(2), 156–160. <http://doi.org/10.1111/apa.12098>
- Moore, C. (2009). Fairness in children's resource allocation depends on the recipient. *Psychological Science*, 20(8), 944–948. <http://doi.org/10.1111/j.1467-9280.2009.02378.x>
- Morrongiello, B. A., & Trehub, S. E. (1987). Age-related changes in auditory temporal perception. *Journal of Experimental Child Psychology*, 44(3), 413–426. [http://doi.org/10.1016/0022-0965\(87\)90043-9](http://doi.org/10.1016/0022-0965(87)90043-9)
- Mrug, S., Brooke, B. S., Hoza, B., Gerdes, A. C., Hinshaw, S. P., Hechtman, L., & Arnold, L. E. (2012). Peer rejection and friendships in children with attention-deficit/hyperactivity disorder: Contributions to long-term outcomes. *Journal of Abnormal Child Psychology*, 40(6), 1013–1026. <http://doi.org/10.1007/s10802-012-9610-2>
- Mulvey, K. L., Hitti, A., Rutland, A., Abrams, D., & Killen, M. (2014a). Context differences in children's ingroup preferences. *Developmental Psychology*, 50(5), 1507–1519. <http://doi.org/10.1037/a0035593>
- Mulvey, K. L., Hitti, A., Rutland, A., Abrams, D., & Killen, M. (2014b). When do children dislike ingroup members? Resource allocation from individual and group perspectives. *Journal of Social Issues*, 70(1), 29–46. <http://doi.org/10.1111/josi.12045>
- Murphy, C., & Messer, D. (1977). Mothers, infants, and pointing: A study of gesture. In H. R. Schafer (Ed.), *Studies in mother-infant interaction* (pp. 325–354). London: Academic Press.
- Murphy, B. C., Shepard, S., Eisenberg, N., Fabes, R. A., & Guthrie, I. K. (1999). Contemporaneous and longitudinal relations of dispositional sympathy to emotionality, regulation, and social functioning. *Journal of Early Adolescence*, 19, 66–97.
- Nagy, E. (2006). From imitation to conversation: The first dialogues with human neonates. *Infant and Child Development*, 15, 223–232. <http://doi.org/10.1002/icd>
- National Health Service. (2016). *Autism spectrum disorder (ASD)*. Retrieved from: <http://www.nhs.uk/conditions/Autistic-spectrum-disorder/Pages/Introduction.aspx>
- Naugle, K. M., Fillingim, R. B., & Riley, J. L. I. (2012). A meta-analytic review of the hypoalgesic effects of exercise. *The Journal of Pain*, 13(12), 1139–1150. <http://doi.org/10.1039/c0ja00272k>
- Naveda, L., & Leman, M. (2010). The spatiotemporal representation of dance and music gestures using topological gesture analysis. *Music Perception*, 28(1), 93–112.

- Nazzi, T., Jusczyk, P. W., & Johnson, E. K. (2000). Language discrimination by English-learning 5-month-olds: Effects of rhythm and familiarity. *Journal of Memory and Language*, 43, 1–19. <http://doi.org/10.1006/jmla.2000.2698>
- Neely, K. C., & Holt, N. L. (2014). Parents' perspectives on the benefits of sport participation for young children. *Sport Psychologist*, 28(3), 255–268. <http://doi.org/10.1123/tsp.2013-0094>
- Nesdale, D., Durkin, K., Maass, A., & Griffiths, J. A. (2004). Group status, outgroup ethnicity and children's ethnic attitudes. *Applied Developmental Psychology*, 25, 237–251. <http://doi.org/10.1016/j.appdev.2004.02.005>
- Nesdale, D., & Flessner, D. (2001). Social identity and the development of children's group attitudes. *Child Development*, 72(2), 506–517.
- Nesdale, D., Griffiths, J. A., Durkin, K., & Maass, A. (2007). Effects of group membership, intergroup competition and out-group ethnicity on children's ratings of in-group and out-group similarity and positivity. *British Journal of Developmental Psychology*, 25, 359–373. <http://doi.org/10.1348/026151006X150382>
- Nesdale, D., Maass, A., Griffiths, J., & Durkin, K. (2003). Effects of in-group and out-group ethnicity on children's attitudes towards members of the in-group and out-group. *British Journal of Developmental Psychology*, 21, 177–192. <http://doi.org/10.1348/026151003765264039>
- Newcomb, A. F., Bukowski, W. M., & Pattee, L. (1993). Children's peer relations: A meta-analytic review of popular, rejected, neglected, controversial, and average sociometric status. *Psychological Bulletin*, 113(1), 99–128.
- Newcombe, N., & Huttenlocher, J. (1992). Children's early ability to solve perspective-taking problems. *Developmental Psychology*, 28(4), 635–643. <http://doi.org/10.1037/0012-1649.28.4.635>
- Nielsen, M., & Dissanayake, C. (2004). Pretend play, mirror self-recognition and imitation: a longitudinal investigation through the second year. *Infant Behavior and Development*, 27(3), 342–365. <http://doi.org/10.1016/j.infbeh.2003.12.006>
- Nilsson, U. (2009). Soothing music can increase oxytocin levels during bed rest after open-heart surgery: A randomised control trial. *Journal of Clinical Nursing*, 18(15), 2153–2161. <http://doi.org/10.1111/j.1365-2702.2008.02718.x>
- Nolan, F., & Jeon, H. (2014). Speech rhythm: A metaphor? *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369.
- Noorden, L. Van. (2014). Auto-correlation and entrainment in the synchronous reproduction of musical pulse: Developments in childhood. *Procedia-Social and Behavioral Sciences*, 126(0), 117–118. <http://doi.org/10.1016/j.sbspro.2014.02.336>
- Nowak, A., Vallacher, R. R., & Zochowski, M. (2005). The emergence of personality: Dynamic foundations of individual variation. *Developmental Review*, 25(3–4), 351–385. <http://doi.org/10.1016/j.dr.2005.10.004>
- Nyström, P. (2008). The infant mirror neuron system studied with high density EEG. *Social Neuroscience*, 3(3–4), 334–347. <http://doi.org/10.1080/17470910701563665>
- Nyström, P., Ljunghammar, T., Rosander, K., & von Hofsten, C. (2011). Using mu rhythm desynchronization to measure mirror neuron activity in infants. *Developmental Science*, 14(2), 327–335. <http://doi.org/10.1111/j.1467-7687.2010.00979.x>
- Okabe, S., Nagasawa, M., Mogi, K., & Kikusui, T. (2012). The importance of mother-infant communication for social bond formation in mammals. *Animal Science Journal*, 83(6), 446–452. <http://doi.org/10.1111/j.1740-0929.2012.01014.x>
- Oke, M., Khattar, A., Pant, P., & Saraswathi, T. S. (1999). A profile of children's play

- in urban India. *Childhood*, 6(2), 207–219.
- Okely, A. D., & Booth, M. L. (2004). Mastery of fundamental movement skills among children in New South Wales: Prevalence and sociodemographic distribution. *Journal of Science and Medicine in Sport*, 7, 358–372. [http://doi.org/10.1016/S1440-2440\(04\)80031-8](http://doi.org/10.1016/S1440-2440(04)80031-8)
- Onishi, K. H., & Baillargeon, R. (2005). Do 15-month-old infants understand false beliefs. *Science*, 308(5719), 255–258. <http://doi.org/10.1126/science.1107621>
- Oostenbroek, J., Suddendorf, T., Nielsen, M., Redshaw, J., Kennedy-Costantini, S., Davis, J., ... Slaughter, V. (2016). Comprehensive longitudinal study challenges the existence of neonatal imitation in humans. *Current Biology*, 1–5. <http://doi.org/10.1016/j.cub.2016.03.047>
- Over, H., & Carpenter, M. (2009). Eighteen-month-old infants show increased helping following priming with affiliation. *Psychological Science*, 20(10), 1189–93. <http://doi.org/10.1111/j.1467-9280.2009.02419.x>
- Overby, L. Y., & Bradley, K. (2003). *Better practice in dance education*. (J. L. J. Tucker, Ed.). Maryland: Maryland State Department of Education.
- Overy, K., & Molnar-Szakacs, I. (2009). Being together in time: Musical experience and the mirror neuron system. *Music Perception*, 26(5), 489–504.
- Ozonoff, S., Young, G. S., Goldring, S., Greiss-Hess, L., Herrera, A. M., Steele, J., ... Rogers, S. J. (2008). Gross motor development, movement abnormalities, and early identification of autism. *Journal of Autism and Developmental Disorders*, 38(4), 644–656. <http://doi.org/10.1007/s10803-007-0430-0>
- Paladino, M.-P., Mazzurega, M., Pavani, F., & Schubert, T. W. (2010). Synchronous multisensory stimulation blurs self-other boundaries. *Psychological Science*, 21(9), 1202–1207. <http://doi.org/10.1177/0956797610379234>
- Pang, A. W.-Y., & Fong, D. T.-P. (2009). Fundamental motor skill proficiency of Hong Kong children aged 6-9 years. *Research in Sports Medicine*, 17(3), 125–44. <http://doi.org/10.1080/15438620902897516>
- Panksepp, J., Nelson, E., & Siviy, S. (1994). Brain opioids and mother-infant motivation. *Acta Paediatrica*, 397, 40–46.
- Paquette-Smith, M., & Johnson, E. K. (2015). I don't like the tone of your voice: Infants use vocal affect to socially evaluate others. *Infancy*, 1–18. <http://doi.org/10.1111/infa.12098>
- Paul, R., & Fountain, R. (1999). Predicting outcomes of early expressive language delay. *Infant-Toddler Intervention*, 92, 123–135.
- Paulus, M. (2014). The emergence of prosocial behavior: Why do infants and toddlers help, comfort, and share? *Child Development Perspectives*, 8(2), 77–81. <http://doi.org/10.1111/cdep.12066>
- Paulus, M., Kühn-Popp, N., Licata, M., Sodian, B., & Meinhardt, J. (2013). Neural correlates of prosocial behavior in infancy: Different neurophysiological mechanisms support the emergence of helping and comforting. *NeuroImage*, 66, 522–530. <http://doi.org/10.1016/j.neuroimage.2012.10.041>
- Paulus, M., Licata, M., Kristen, S., Thoermer, C., Woodward, A. L., & Sodian, B. (2014). Social understanding and self-regulation predict preschoolers' sharing with friends and disliked peers: A longitudinal study. *International Journal of Behavioral Development*, 39(1), 53–64. <http://doi.org/10.1177/0165025414537923>
- Paulus, M., & Moore, C. (2012). Producing and understanding prosocial actions in early childhood. In J. B. Benson (Ed.), *Advances in Child Development and Behavior* (Vol. 42, pp. 271–305). Burlington: Academic Press. <http://doi.org/10.1016/B978-0-12-394388-0.00008-3>

- Pate, R. R., Baranowski, T., Dowda, M., & Trost, S. G. (1996). Tracking of physical activity in young children. *Medicine and Science in Sports and Exercise*, 28, 92–96.
- Pawlby, S.J. (1977). Imitative interaction. In H. Schaffer (Ed.), *Studies in mother–infant interaction* (pp. 203–224). New York: Academic Press.
- Pellegrini, A. D. (1988). Elementary school children's rough-and-tumble play and social competence. *Developmental Psychology*, 24, 802–806.
- Pellegrini, A. D., Blatchford, P., Kato, K., & Baines, E. (2004). A short-term longitudinal study of children's playground games across the first year of school: Implications for social competence and adjustment to school. *Social Development*, 13(1), 107–123.
- Pellegrini, A. D., Dupuis, D., & Smith, P. K. (2007). Play in evolution and development. *Developmental Review*, 27, 261–276.
- Pellis, S. M., & Pellis, V. C. (2007). Rough and tumble play and the development of the social brain. *Current Directions in Psychological Science*, 16(2), 95–98.
<http://doi.org/10.1111/j.1467-8721.2007.00483.x>
- Pellis, S. M., Pellis, V. C., & Bell, H. C. (2010). The function of play in the development of the social brain. *American Journal of Play*, 2(3), 278–296.
- Perner, J., & Roessler, J. (2012). From infants' to children's appreciation of belief. *Trends in Cognitive Sciences*, 16(10), 1–7.
<http://doi.org/10.1016/j.tics.2012.08.004>
- Peterson, C., Slaughter, V., Moore, C., & Wellman, H. M. (2016). Peer social skills and theory of mind in children with autism, deafness, or typical development. *Developmental Psychology*, 52(1), 46–57. <http://doi.org/10.1037/a0039833>
- Peterson, L. (1983). Influence of age, task competence, and responsibility focus on children's altruism. *Developmental Psychology*, 19(1), 141–148.
<http://doi.org/10.1037/0012-1649.19.1.141>
- Petzold, R. G. (1966). *Auditory perception of musical sounds by children in the first six grades*. University of Wisconsin, Madison.
- Phillips-Silver, J., Aktipis, A. C., & Bryant, G. A. (2010). The ecology of entrainment: Foundations of coordinated rhythmic movement. *Music Perception: An Interdisciplinary Journal*, 28(1), 3–14.
- Phillips-Silver, J., & Trainor, L. J. (2005). Feeling the beat: Movement influences infant rhythm perception. *Science*, 308, 1430.
- Phillips-Silver, J., & Trainor, L. J. (2007). Hearing what the body feels: Auditory encoding of rhythmic movement. *Cognition*, 105, 533–546.
<http://doi.org/10.1016/j.cognition.2006.11.006>
- Pica, R. (2011). Helping children cooperate. *Young Child*, 66, 60–61.
- Piek, J. P., Baynam, G. B., & Barrett, N. C. (2006). The relationship between fine and gross motor ability, self-perceptions and self-worth in children and adolescents. *Human Movement Science*, 25(1), 65–75.
<http://doi.org/10.1016/j.humov.2005.10.011>
- Piek, J. P., Bradbury, G. S., Elsley, S. C., & Tate, L. (2008). Motor coordination and social–emotional behaviour in preschool-aged children. *International Journal of Disability, Development and Education*, 55(2), 143–151.
<http://doi.org/10.1080/10349120802033592>
- Piek, J. P., Dawson, L., Smith, L. M., & Gasson, N. (2008). The role of early fine and gross motor development on later motor and cognitive ability. *Human Movement Science*, 27, 668–681.
- Piek, J. P., Hands, B., & Licari, M. K. (2012). Assessment of motor functioning in the

- preschool period. *Neuropsychology Review*, 22(4), 402–413.
<http://doi.org/10.1007/s11065-012-9211-4>
- Piek, J. P., McLaren, S., Kane, R., Jensen, L., & Dender, A. (2012). Does the Animal Fun program improve motor performance in children aged 4-6 years? *Human Movement Science*, 43, 155–163. <http://doi.org/10.1016/j.humov.2012.08.004>
- Pineda, J. A. (2005). The functional significance of mu rhythms: Translating “seeing” and “hearing” into “doing.” *Brain Research Reviews*, 50(1), 57–68.
<http://doi.org/10.1016/j.brainresrev.2005.04.005>
- Polvi, S., & Telama, R. (2000). The use of cooperative learning as a social enhancer in physical education. *Scandinavian Journal of Educational Research*, 44(1), 105–115. <http://doi.org/10.1080/713696660>
- Poulsen, A. A., & Ziviani, J. M. (2004). Health enhancing physical activity: Factors influencing engagement patterns in children. *Australian Occupational Therapy Journal*, 51(2), 69–79. <http://doi.org/10.1046/j.1440-1630.2004.00420.x>
- Powell, L. J., & Spelke, E. S. (2013). Preverbal infants expect members of social groups to act alike. *Proceedings of the National Academy of Sciences*, 110(41), E3965-72. <http://doi.org/10.1073/pnas.1304326110>
- Prinz, W., Beisert, M., & Herwig A. (2013). *Action Science: Foundations of an Emerging Discipline*. Cambridge, Massachusetts: MIT Press.
- Provasi, J., Anderson, D. I., & Barbu-Roth, M. (2014). Rhythm perception, production, and synchronization during the perinatal period. *Frontiers in Psychology*, 5(September), 1048. <http://doi.org/10.3389/fpsyg.2014.01048>
- Provasi, J., & Bobin-Bègue, A. (2003). Spontaneous motor tempo and rhythmical synchronisation in 2½- and 4-year-old children. *International Journal of Behavioral Development*, 27(3), 220–231.
<http://doi.org/10.1080/01650250244000290>
- Quinn, P. C., Yahr, J., & Kuhn, A. (2002). Representation of the gender of human faces by infants : A preference for female, (1974). <http://doi.org/10.1068/p3331>
- Rabinowitch, T.-C., Cross, I., & Burnard, P. (2012). Long-term musical group interaction has a positive influence on empathy in children. *Psychology of Music*, 41(4), 1–15. <http://doi.org/10.1177/0305735612440609>
- Rabinowitch, T.-C., & Knafo-Noam, A. (2015). Synchronous rhythmic interaction enhances children’s perceived similarity and closeness towards each other. *Plos One*, 10, e0120878. <http://doi.org/10.1371/journal.pone.0120878>
- Racine, T. P., & Carpendale, J. I. M. (2007). The role of shared practice in joint attention. *British Journal of Developmental Psychology*, 25(1), 3–25.
<http://doi.org/10.1348/026151006X119756>
- Radke- Yarrow, M., Waxler, C. Z., Barrett, D., Darby, J., King, R., Pickett, M., & Smith, J. (1976). Dimensions and correlates of Prosocial Behavior in young Children. *Child Development*, 47(1), 118–125.
- Raichlen, D. A., Foster, A. D., Gerdeman, G. L., Seillier, A., & Giuffrida, A. (2012). Wired to run: exercise-induced endocannabinoid signaling in humans and cursorial mammals with implications for the “runner’s high”. *Journal of Experimental Biology*, 215(8), 1331–1336. <http://doi.org/10.1242/jeb.063677>
- Rainbow, E. (1981). A final report on a three-year investigation of the rhythmic abilities of preschool aged children. *Bulletin of the Council for Research in Music Education*, 66.
- Rakoczy, H. (2008). Pretense as individual and collective intentionality. *Mind & Language*, 23(5), 499–517. <http://doi.org/10.1111/j.1468-0017.2008.00357.x>
- Rakoczy, H. (2012). Do infants have a theory of mind? *British Journal of*

- Developmental Psychology*, 30(1), 59–74. <http://doi.org/10.1111/j.2044-835X.2011.02061.x>
- Ramus, F. (2002). Language discrimination by newborns: Teasing apart phonotactic, rhythmic, and intonational cues. *Annual Review of Language Acquisition*, 2, 1–14.
- Ramus, F., Nespor, M., & Mehler, J. (1999). Correlates of linguistic rhythm in the speech signal. *Cognition*, 73(3), 265–292. [http://doi.org/10.1016/S0010-0277\(99\)00058-X](http://doi.org/10.1016/S0010-0277(99)00058-X)
- Reddish, P., Bulbulia, J., & Fischer, R. (2013). Does synchrony promote generalized prosociality? *Religion, Brain & Behavior*, 4(1), 3–19. <http://doi.org/10.1080/2153599X.2013.764545>
- Reddish, P., Fischer, R., & Bulbulia, J. (2013). Let's dance together: Synchrony, shared intentionality and cooperation. *PloS One*, 8(8). <http://doi.org/10.1371/journal.pone.0071182>
- Reddy, V., Markova, G., & Wallot, S. (2013). Anticipatory adjustments to being picked up in infancy. *PLoS ONE*, 8(6). <http://doi.org/10.1371/journal.pone.0065289>
- Reid, V. M., Hoehl, S., & Striano, T. (2006). The perception of biological motion by infants: An event-related potential study. *Neuroscience Letters*, 395(3), 211–214. <http://doi.org/10.1016/j.neulet.2005.10.080>
- Reid, V. M., & Striano, T. (2005). Adult gaze influences infant attention and object processing: implications for cognitive neuroscience. *The European Journal of Neuroscience*, 21(6), 1763–6. <http://doi.org/10.1111/j.1460-9568.2005.03986.x>
- Repp, B. H. (2005). Sensorimotor synchronization: A review of the tapping literature. *Psychonomic Bulletin & Review*, 12(6), 969–992.
- Reuschlein, P., & Haubenstricker, J. (1985). *Physical education interpretive report (Michigan Educational Assessment Program)*. Lansing: Michigan Department of Education.
- Rhodes, M., & Chalik, L. (2013). Social categories as markers of intrinsic interpersonal obligations. *Psychological Science*, 24, 999–1006. <http://doi.org/10.1177/0956797612466267>
- Rhodes, M., Hetherington, C., Brink, K., & Wellman, H. M. (2015). Infants' use of social partnerships to predict behavior. *Developmental Science*, 18, 909–916. <http://doi.org/10.1111/desc.12267>
- Richardson, M. J., Marsh, K. L., Isenhower, R. W., Goodman, J. R. L., & Schmidt, R. C. (2007). Rocking together: Dynamics of intentional and unintentional interpersonal coordination. *Human Movement Science*, 26(6), 867–91. <http://doi.org/10.1016/j.humov.2007.07.002>
- Richardson, M. J., Marsh, K. L., & Schmidt, R. C. (2005). Effects of visual and verbal interaction on unintentional interpersonal coordination. *Journal of Experimental Psychology: Human Perception and Performance*, 31(1), 62–79. <http://doi.org/10.1037/0096-1523.31.1.62>
- Richman, C. L., Berry, C., Bittle, M., & Himan, K. (1988). Factors related to helping behavior in preschool-age children. *Journal of Applied Developmental Psychology*, 9, 151–165.
- Riley, A. (1987). Is creative dance responsive to research? *Design for Arts in Education*, 36–40.
- Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience*, 27, 169–192. <http://doi.org/10.1146/annurev.neuro.27.070203.144230>
- Rizzolatti, G., & Sinigaglia, C. (2010). The functional role of the parieto-frontal mirror circuit: Interpretations and misinterpretations. *Nature Reviews: Neuroscience*, 11,

- 264–274. <http://doi.org/10.1038/nrn2805>
- Roberts, W., & Strayer, J. (1996). Empathy, emotional expressiveness, and prosocial behavior. *Child Development*, 67(2), 449–470.
- Rochat, P., Neisser, U., & Marian, V. (1998). Are young infants sensitive to interpersonal contingency? *Infant Behavior and Development*, 21(2), 355–366. [http://doi.org/10.1016/S0163-6383\(98\)90012-1](http://doi.org/10.1016/S0163-6383(98)90012-1)
- Roederer, J. G. (1984). The search for a survival value of music. *Music Perception: An Interdisciplinary Journal*, 1(3), 350–356.
- Rose, P. (2014). Effects of movement, tempo, and gender on steady beat performance in kindergarten students. *International Journal of Music Education*, 19(2), 29–38. <http://doi.org/10.5406/bulcouresmusedu.192.0029>
- Rose, P., Fisher, R., & Shewmaker, S. (2012). Effects of manual/pedal movement, tempo, and gender on accuracy of steady beat in kindergarten students. *Bulletin of the Council for Research in Music Education*, 192, 29–38.
- Rosenberg, K., & Trevathan, W. (2002). Birth, obstetrics and human evolution. *BJOG: An International Journal of Obstetrics and Gynaecology*, 109, 1199–1206.
- Ross, H. S., & Lollis, S. P. (1987). Communication within infant social games. *Developmental Psychology*, 23(2), 241–248.
- Roy, K. (2011). *War, Culture and Society in Early Modern South Asia, 1740-1849*. USA: Routledge.
- Rubin, K. H., Bukowski, W. M., & Parker, J. G. (2006). Peer interactions, relationships, and groups. In *Handbook of Child Psychology: Social, Emotional, and Personality Development* (pp. 573–645).
- Rutland, A., Cameron, L., Milne, A., & McGeorge, P. (2014). Social norms and self-presentation: Children's implicit and explicit intergroup attitudes. *Child Development*, 76(2), 451–466.
- Rutland, A., Hitti, A., Mulvey, K. L., Abrams, D., & Killen, M. (2015). When does the in-group like the out-group? Bias among children as a function of group norms. *Psychological Science*, 26(6), 834–842. <http://doi.org/10.1177/0956797615572758>
- Saint-Georges, C., Mahdhaoui, A., Chetouani, M., Cassel, R. S., Laznik, M. C., Apicella, F., ... Cohen, D. (2011). Do parents recognize autistic deviant behavior long before diagnosis? Taking into account interaction using computational methods. *PLoS ONE*, 6(7). <http://doi.org/10.1371/journal.pone.0022393>
- Saltzman, W., & Maestripieri, D. (2011). The neuroendocrinology of primate maternal behavior. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 35(5), 1192–1204. <http://doi.org/10.1016/j.pnpbp.2010.09.017>
- Salvy, S., Bowker, J. W., Roemmich, J. N., Romero, N., Kieffer, E., Paluch, R., & Epstein, L. H. (2007). Peer influence on children's physical activity: An experience sampling study. *Journal of Pediatric Psychology*, 33(1), 39–49. <http://doi.org/10.1093/jpepsy/jsm039>
- Sandercock, E., Jones, W., Klin, A., & Shultz, S. (2015). Contingent smiling behavior in 2-to 5-month-old infants with and without ASD during dyadic interact. In *International Meeting for Autism Research*.
- Sanefuji, W., Ohgami, H., & Hashiya, K. (2006). Preference for peers in infancy, 29, 584–593. <http://doi.org/10.1016/j.infbeh.2006.07.007>
- Sangrigoli, S., & de Schonen, S. (2004). Recognition of own-race and other-race faces by three-month-old infants. *Journal of Child Psychology and Psychiatry*, 45(7), 1219–1227. <http://doi.org/10.1111/j.1469-7610.2004.00319.x>
- Sani, F., & Bennett, M. (2009). Children's inclusion of the group in the self: Evidence from a self-ingroup confusion paradigm. *Developmental Psychology*, 45(2), 503–

510. <http://doi.org/10.1037/a0014167>
- Scaife, M., & Bruner, J. S. (1975). The capacity for joint visual attention in the infant. *Nature*, 253, 265–266.
- Scarf, D., Imuta, K., Colombo, M., & Hayne, H. (2012). Golden Rule or valence matching? Methodological problems in Hamlin et al. *Proceedings of the National Academy of Sciences*, 109(22), E1426–E1426. <http://doi.org/10.1073/pnas.1204123109>
- Scarf, D., Imuta, K., Colombo, M., & Hayne, H. (2012). Social evaluation or simple association? Simple associations may explain moral reasoning in infants. *PloS One*, 7(8), e42698. <http://doi.org/10.1371/journal.pone.0042698>
- Schachner, A., Brady, T. F., Pepperberg, I. M., & Hauser, M. D. (2009). Spontaneous motor entrainment to music in multiple vocal mimicking species. *Current Biology*, 19(10), 831–836. <http://doi.org/10.1016/j.cub.2009.03.061>
- Schachner, A., & Hannon, E. E. (2011). Infant-directed speech drives social preferences in 5-month-old infants. *Developmental Psychology*, 47(1), 19–25. <http://doi.org/10.1037/a0020740>
- Schellenberg, E. G., Corrigall, K. A., Dys, S. P., & Malti, T. (2015). Group music training and children's prosocial skills. *Plos One*, 10(10), e0141449. <http://doi.org/10.1371/journal.pone.0141449>
- Schleuter, S. L., & Schleuter, L. J. (1989). The relationship of rhythm response tasks and PMMA scores with music training, grade level, and sex among K-3 students. *Bulletin of the Council for Research in Music Education*, 100, 1–13.
- Schmidt, M. F. H., & Sommerville, J. A. (2011). Fairness expectations and altruistic sharing in 15-month-old human infants. *PLoS ONE*, 6(10), e23223. <http://doi.org/10.1371/journal.pone.0023223>
- Schmidt, R. C., & Brien, B. O. (1997). Evaluating the dynamics of unintended interpersonal coordination. *Ecological Psychology*, 9(3), 189–206.
- Schoemaker, M. M., & Kalverboer, A. F. (1994). Social and affective problems of children who are clumsy: How early do they begin? *Adapted Physical Activity Quarterly*, 11(2), 130–140.
- Schug, M. G., Shusterman, A., Barth, H., & Patalano, A. L. (2013). Minimal-group membership influences children's responses to novel experience with group members. *Developmental Science*, 16, 47–55. <http://doi.org/10.1111/j.1467-7687.2012.01193.x>
- Schulte-Rüther, M., Markowitsch, H. J., Fink, G. R., & Piefke, M. (2007). Mirror neuron and theory of mind mechanisms involved in face-to-face interactions: A functional magnetic resonance imaging approach to empathy. *Journal of Cognitive Neuroscience*, 19(8), 1354–1372. <http://doi.org/10.1162/jocn.2007.19.8.1354>
- Schwartzman, H. B. (1978). *Transformations: The Anthropology of Children's Play*. New York: Plenum Press.
- Scola, C., Holvoet, C., Arciszewski, T., & Picard, D. (2015). Further evidence for infants' preference for prosocial over antisocial behaviors. *Infancy*, 20(6), 684–692. <http://doi.org/10.1111/infa.12095>
- Scott-Kassner, C. (1993). *Music in Prekindergarten*. Virginia: MENC.
- Seban, A. M., Pierce, S. L., Cheatham, C. L., & Gunnar, M. R. (2003). Gendered social worlds in preschool: Dominance, peer acceptance and assertive social skills in boys' and girls peer groups. *Social Development*, 12(1), 91–106. <http://doi.org/10.1111/1467-9507.00223>
- Sebanz, N., Bekkering, H., & Knoblich, G. (2006). Joint action: Bodies and minds moving together. *Trends in Cognitive Sciences*, 10(2), 70–76.

- <http://doi.org/10.1016/j.tics.2005.12.009>
- Seefeldt, V., & Haubenstricker, J. (1982). Patterns, phases, or stages: An analytical model for the study of developmental movement. In J. A. S. Kelso, J. E. Clark (Eds.), *The development of movement control and co-ordination* (pp. 309-319). New York: Wiley.
- Shantz, C. (1983). Social cognition. In J. Flavell & E. Markman (Eds.), *Handbook of child psychology: Vol. 3, Cognitive development* (pp. 495-555). New York: Wiley.
- Shaw, D. J., Czekóová, K., Chromec, J., Mareček, R., & Brázdil, M. (2013). Copying you copying me: Interpersonal motor co-ordination influences automatic imitation. *PLoS ONE*, 8(12), 1-8. <http://doi.org/10.1371/journal.pone.0084820>
- Sheskin, M., Bloom, P., & Wynn, K. (2014). Anti-equality: Social comparison in young children. *Cognition*, 130, 152-156. doi:10.1016/j.cognition.2013.10.008
- Shutts, K., Kinzler, K. D., Mckee, C. B., & Spelke, E. S. (2009). Social information guides infants' selection of foods. *Journal of Cognition and Development*, 10(1-2), 1-17. <http://doi.org/10.1080/15248370902966636>.Social
- Simner, M. L. (1971). Newborn's response to the cry of another infant. *Developmental Psychology*, 5(1), 136-150. <http://doi.org/10.1037/h0031066>
- Sims, W. L. (1985). Using children's creative movement to music: Categories of movement, rhythmic characteristics, and reactions to changes, *Contributions to Music Education*, 12, 42-50.
- Sipes, M., Matson, J. L., & Horovitz, M. (2011). Autism spectrum disorders and motor skills: The effect on socialization as measured by the Baby and Infant Screen for Children with aUtism Traits (BISCUIT). *Developmental Neuropsychology*, 14(5), 290-296. <http://doi.org/10.3109/17518423.2011.587838>
- Skinner, R. A., & Piek, J. P. (2001). Psychosocial implications of poor motor coordination in children and adolescents. *Human Movement Science*, 20(1-2), 73-94. [http://doi.org/10.1016/S0167-9457\(01\)00029-X](http://doi.org/10.1016/S0167-9457(01)00029-X)
- Slater, J., Tierney, A., & Kraus, N. (2013). At-risk elementary school children with one year of classroom music instruction are better at keeping a beat. *PLoS ONE*, 8(10), 1-9. <http://doi.org/10.1371/journal.pone.0077250>
- Slaughter, V., Dennis, M. J., & Pritchard, M. (2002). Theory of mind and peer acceptance in preschool children. *British Journal of Developmental Psychology*, 20, 545-564. <http://doi.org/10.1348/026151002760390945>
- Smith, A. L. (2003). Peer relationships in physical activity contexts: A road less traveled in youth sport and exercise psychology research. *Psychology of Sport and Exercise*, 4(1), 25-39. [http://doi.org/10.1016/S1469-0292\(02\)00015-8](http://doi.org/10.1016/S1469-0292(02)00015-8)
- Smoll, F. L. (1974). Development of rhythmic ability in response to selected tempos. *Perceptual and Motor Skills*, 39, 767-772. <http://doi.org/10.2466/pms.1974.39.2.767>
- Sodian, B., & Kristen, S. (2010). Theory of mind. In A.V. Müller, B. Glatzeder & V. Goel (Eds.). *Towards a theory of thinking*. (pp.189-202). Heidelberg: Springer.
- Sommerville, J. A., & Woodward, A. L. (2005). Pulling out the intentional structure of action: The relation between action processing and action production in infancy. *Cognition*, 95(1), 1-30. <http://doi.org/10.1016/j.cognition.2003.12.004>
- Sommerville, J. A., Woodward, A. L., & Needham, A. (2005). Action experience alters 3-month-old infants' perception of others' actions. *Cognition*, 96(1), B1-11. <http://doi.org/10.1016/j.cognition.2004.07.004>
- Sosa, A.V. & Stoel-Gammon, C. (2006). Patterns of intra-word phonological variability during the second year of life. *Journal of Child Language*, 33, 31-50.

- Sothorn, M. S., Loftin, M., Suskind, J. N. & Blecker, U. (1999). The health benefits of physical activity in children and adolescents: Implications for chronic disease prevention. *European Journal of Pediatrics*, 158, 271–174.
- Southgate, V., Johnson, M. H., El Karoui, I., & Csibra, G. (2010). Motor system activation reveals infants' on-line prediction of others' goals. *Psychological Science*, 21(3), 355–359. <http://doi.org/10.1177/0956797610362058>
- Sowell, E. R., Thompson, P. M., Leonard, C. M., Welcome, S. E., Kan, E., & Toga, A. W. (2004). Longitudinal mapping of cortical thickness and brain growth in normal children. *The Journal of Neuroscience*, 24(38), 8223–8231.
- Sparling, P. B., Giuffrida, A., Piomelli, D., Roskopf, L., & Dietrich, A. (2003). Exercise activates the endocannabinoid system. *Neuroreport*, 14(17), 2209–2211. <http://doi.org/10.1097/01.wnr.0000097048.56589.47>
- Spelke, E. (1979). Perceiving bimodally specified events in infancy. *Developmental Psychology*, 15(6), 626–636. <http://doi.org/10.1037/0012-1649.15.6.626>
- Srinivasan, S. M., & Bhat, A. N. (2013). A review of “music and movement” therapies for children with autism: embodied interventions for multisystem development. *Frontiers in Integrative Neuroscience*, 7(April), 1–15. <http://doi.org/10.3389/fnint.2013.00022>
- Staub, E. (1970). A child in distress: The influence of age and number of witnesses on children's attempts to help. *Journal of Personality and Social Psychology*, 14(2), 130–140.
- Staub, E. (1971). A child in distress: The influence of nurturance and modeling on children's attempts to help. *Developmental Psychology*, 5(1), 124–132.
- Stel, M., Van Baaren, R. B., Blascovich, J., Van Dijk, E., McCall, C., Pollmann, M. M. H., ... Vonk, R. (2010). Effects of a priori liking on the elicitation of mimicry. *Experimental Psychology*, 57, 412–418. <http://doi.org/10.1027/1618-3169/a000050>
- Stel, M., van Baaren, R. B., & Vonk, R. (2008). Effects of mimicking: Acting prosocially by being emotionally moved. *European Journal of Social Psychology*, 38, 965–976. <http://doi.org/10.1002/ejsp>
- Stenseng, F., Belsky, J., Skalicka, V., & Wichstrøm, L. (2015). Peer rejection and attention deficit hyperactivity disorder symptoms: Reciprocal relations through ages 4, 6, and 8. *Child Development*, 87(2), 365–373. <http://doi.org/10.1111/cdev.12471>
- Stevenson, H. W., & Lee, S. (1990). Context of achievement. *Monographs of the Society for Research in Child Development*, 55(1–2, Serial No. 221).
- Stewart, S. M., & McBride-Chang, C. (2000). Influences on children's sharing in a multicultural setting. *Journal of Cross-Cultural Psychology*, 31, 333–348. <http://doi.org/10.1177/0022022100031003003>
- Stivers, T., Enfield, N. J., Brown, P., Englert, C., Hayashi, M., Heinemann, T., ... Levinson, S. C. (2009). Universals and cultural variation in turn-taking in conversation. *Proceedings of the National Academy of Sciences of the United States of America*, 106(26), 10587–10592. <http://doi.org/10.1073/pnas.0903616106>
- Stockdale, D. F., Hegland, S. M., & Chiaromonte, T. (1989). Helping behaviors: An observational study of preschool children. *Early Childhood Research Quarterly*, 4, 533–543. [http://doi.org/10.1016/0885-2006\(89\)90008-2](http://doi.org/10.1016/0885-2006(89)90008-2)
- Stodden, D. F., & Goodway, J. D. (2007). The dynamic association between motor skill development and physical activity. *Journal of Physical Education, Recreation & Dance*, 78(8), 33. <http://doi.org/10.1080/07303084.2007.10598077>
- Strayer, F. F., & Strayer, J. (1976). An ethological analysis of social agonism and dominance relations among preschool children. *Child Development*, 47(4), 980–

- Strayer, J. (1993). Children's concordant emotions and cognitions in response to observed emotions. *Child Development*, 64(1), 188–201. <http://doi.org/10.2307/1131445>
- Striano, T., & Rochat, P. (1999). Developmental link between dyadic and triadic social competence. *British Journal of Developmental Psychology*, 17, 551–562.
- Striepens, N., Kendrick, K. M., Hanking, V., Landgraf, R., Wüllner, U., Maier, W., & Hurlmann, R. (2013). Elevated cerebrospinal fluid and blood concentrations of oxytocin following its intranasal administration in humans. *Scientific Reports*, 3, 3440. <http://doi.org/10.1038/srep03440>
- Strong, W. B., Malina, R. M., R Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., ... xOIS TRUDEAU, F. (2005). Evidence Based Physical Activity for School-Age Youth. <http://doi.org/10.1016/j.jpeds.2005.01.055>
- Sullivan, P., & Rickers, K. (2012). The effect of behavioral synchrony in groups of teammates and strangers. *International Journal of Sport and Exercise Psychology*, 286–291. <http://doi.org/10.1080/1612197X.2013.750139>
- Surian, L., Surian, L., Caldi, S., Caldi, S., Sperber, D., & Sperber, D. (2007). Attribution of beliefs by 13- month-old infants. *Psychological Science*, 18(7), 580–586.
- Svirydzenka, N., Sani, F., & Bennett, M. (2010). Group entitativity and its perceptual antecedents in varieties of groups: A developmental perspective. *European Journal of Social Psychology*, 40, 611–624. <http://doi.org/10.1002/ejsp>
- Swann, W. B., Jetten, J., Gómez, Á., Whitehouse, H., & Bastian, B. (2012). When group membership gets personal: A theory of identity fusion. *Psychological Review*, 119(3), 441–456. <http://doi.org/10.1037/a0028589>
- Tajfel, H. (1970). Experiments in intergroup discrimination. *Scientific American*, 223(5), 96–102.
- Tajfel, H., Billig, M. G., Bundy, R. P., & Flament, C. (1971). Social categorization and intergroup behaviour. *Experimental Journal of Social Psychology*, 1(2), 149–178.
- Tan-Niam, C. S. ., Wood, D., & O'malley, C. (1998). A cross-cultural perspective on children's theories of mind and social interaction. *Early Child Development and Care*, 144(1), 55–67. <http://doi.org/10.1080/0300443981440107>
- Tan, E. (2015). *Infants performance on sociomoral evaluation tasks predicts parent report of preschool social functioning* (Unpublished master's thesis). University of British Columbia, Canada.
- Tarr, B., Launay, J., Cohen, E., & Dunbar, R. I. (2015). Synchrony and exertion during dance independently raise pain threshold and encourage social bonding. *Biology Letters*, 11, 0–3. <http://doi.org/10.1098/rsbl.2015.0767>
- Teitelbaum, P., Teitelbaum, O., Nye, J., Fryman, J., & Maurer, R. G. (1998). Movement analysis in infancy may be useful for early diagnosis of autism. *Proceedings of the National Academy of Sciences of the United States of America*, 95(23), 13982–13987. <http://doi.org/10.1073/pnas.95.23.13982>
- Thelen, E. (1979). Rhythmical stereotypies in normal human infants. *Animal Behaviour*, 27(1952), 699–715. [http://doi.org/10.1016/0003-3472\(79\)90006-X](http://doi.org/10.1016/0003-3472(79)90006-X)
- Thomas, J. R., Chissom, B. S., Stewart, C., & Shelley, F. (1975). Effects of perceptual motor training on preschool children: A multivariate approach. *Research Quarterly*, 46, 505–513.
- Thomas, J. R., & Gallagher, J. D. (1986). Motor development and motor skill acquisition. In V. Seefeldt (Ed.), *Physical activity & well-being* (pp. 443–455). Reston, VA: American Alliance Health, Physical Education, Recreation, and

Dance.

- Thomas, J. R., Thomas, K. T. (1986). The relation of movement and cognitive function. In V. Seefeldt (Ed.), *Physical activity & well-being* (pp. 125-141). Reston, VA: American Alliance Health, Physical Education, Recreation, and Dance.
- Thompson, E. C., White-Schwoch, T., Tierney, A., & Kraus, N. (2015). Beat synchronization across the lifespan: Intersection of development and musical experience. *Plos One*, 10(6), e0128839. <http://doi.org/10.1371/journal.pone.0128839>
- Thomson, J. M., & Goswami, U. (2008). Rhythmic processing in children with developmental dyslexia: Auditory and motor rhythms link to reading and spelling. *Journal of Physiology, Paris*, 102(1-3), 120-9. <http://doi.org/10.1016/j.jphysparis.2008.03.007>
- Timmons, B. W., Naylor, P.-J., & Pfeiffer, K. A. (2007). Physical activity for preschool children- How much and how? *Applied Physiology, Nutrition, and Metabolism*, 32(S2E), S122-S134. <http://doi.org/10.1139/H07-112>
- Tinbergen, N. (1963). On aims and methods of ethology. *Zeitschrift Für Tierpsychologie*, 20, 410-433.
- Tincoff, R., Hauser, M., Tsao, F., Spaepen, G., Ramus, F., & Mehler, J. (2005). The role of speech rhythm in language discrimination: Further tests with a non-human primate. *Developmental Science*, 8, 26-35. <http://doi.org/10.1111/j.1467-7687.2005.00390.x>
- Tomasello, M. (2009). *Why We Cooperate*. Cambridge, Massachusetts: MIT Press.
- Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *The Behavioral and Brain Sciences*, 28, 675-91-735. <http://doi.org/10.1017/S0140525X05000129>
- Tomasello, M., & Haberland, K. (2003). Understanding attention: 12- and 18-month-olds know what is new for other persons. *Developmental Psychology*, 39(5), 906-912. <http://doi.org/10.1037/0012-1649.39.5.906>
- Tomasello, M., Melis, A. P., Tennie, C., Wyman, E., & Herrmann, E. (2012). Two key steps in the evolution of human cooperation. *Current Anthropology*, 53(6), 673-692. <http://doi.org/10.1086/668207>
- Tomasello, M., & Moll, H. (2010). The gap is social: Human shared intentionality and culture. In *Mind the Gap: Tracing the Origins of Human Universals* (pp. 331-351).
- Torbert, M., and Schneider, L. B. (1993). *Follow Me Too: A Handbook of Movement Activities for Three- To Five-Year-Olds*. University of Virginia; Addison-Wesley.
- Tordjman, S., Davlantis, K. S., Georgieff, N., Geoffray, M.-M., Speranza, M., Anderson, G. M., ... Dawson, G. (2015). Autism as a disorder of biological and behavioral rhythms: Toward new therapeutic perspectives. *Frontiers in Pediatrics*, 3(February). <http://doi.org/10.3389/fped.2015.00001>
- Toro, J. M., Trobalon, J. B., & Sebastián-Gallés, N. (2003). The use of prosodic cues in language discrimination tasks by rats. *Animal Cognition*, 6(2), 131-136. <http://doi.org/10.1007/s10071-003-0172-0>
- Trainor, L. J., & Cirelli, L. (2015). Rhythm and interpersonal synchrony in early social development. *Annals of the New York Academy of Sciences*, 1337(1), 45-52. <http://doi.org/10.1111/nyas.12649>
- Trehub, S. E. (2001). Musical predispositions in infancy. *Annals of the New York Academy of Sciences*, 930, 1-16. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/11458822>
- Trehub, S. E. (2003). The developmental origins of musicality. *Nature Neuroscience*, 6(7), 669-73. <http://doi.org/10.1038/nn1084>

- Trehub, S. E., & Hannon, E. E. (2006). Infant music perception: Domain-general or domain-specific mechanisms? *Cognition*, 100, 73–99. <http://doi.org/10.1016/j.cognition.2005.11.006>
- Trevarthen, C. (1979). Communication and cooperation in early infancy: A description of primary intersubjectivity, In M. Bullowa (Ed.), *Before speech: The beginning of interpersonal communication* (pp. 321–348). Cambridge: Cambridge University Press.
- Trevarthen, C. (1993). The self born in intersubjectivity: The psychology of an infant communicating. In: Neisser, U. (Ed.), *Ecological and interpersonal knowledge of the self* (pp. 121–184). New York: Cambridge University Press.
- Troseth, G. L. (2010). Is it life or is it Memorex? Video as a representation of reality. *Developmental Review*, 30(2), 155–175. <http://doi.org/10.1016/j.dr.2010.03.007>
- Tucker, P. (2008). The physical activity levels of preschool-aged children: A systematic review. *Early Childhood Research Quarterly*, 23, 547–558. <http://doi.org/10.1016/j.ecresq.2008.08.005>
- Tunçgenç, B. (2016). Commentary: A construct divided: Prosocial behavior as helping, sharing, and comforting subtypes. *Frontiers in Psychology*, 7, 1–3. <http://doi.org/10.1023/A>
- Tunçgenç, B., & Cohen, E. (2016). Movement synchrony forges social bonds across group divides. *Frontiers in Psychology*, 7, 1–12. <http://doi.org/10.3389/fpsyg.2016.00782>
- Tzu, S. (1963). *The Art of War*, (S. B. Griffith, Trans.). Oxford: Oxford University Press.
- Uddin, L. Q., Iacoboni, M., Lange, C., & Keenan, J. P. (2007). The self and social cognition: the role of cortical midline structures and mirror neurons. *Trends in Cognitive Sciences*, 11(4), 153–157. <http://doi.org/10.1016/j.tics.2007.01.001>
- Ugurel-Semin, R. (1952). Moral behavior and moral judgment of children. *Journal of Abnormal Psychology*, 47(2 Suppl.), 463–474. <http://doi.org/10.1037/h0056970>
- Ulmer-Yaniv, A., Avitsur, R., Kanat-Maymon, Y., Schneiderman, I., Zagoory-Sharon, O., & Feldman, R. (2016). Affiliation, reward, and immune biomarkers coalesce to support social synchrony during periods of bond formation in humans. *Brain, Behavior, and Immunity*. <http://doi.org/10.1016/j.bbi.2016.02.017>
- Underwood, B., & Moore, B. (1982). Perspective-taking and altruism. *Psychological Bulletin*, 91(1), 143–173. <http://doi.org/10.1037/0033-2909.91.1.143>
- Uzgiris, I. C. (1981). Two functions of imitation during infancy. *International Journal of Behavioral Development*, 4, 1–12.
- Valdesolo, P., & Desteno, D. (2011). Synchrony and the social tuning of compassion. *Emotion*, 11(2), 262–266. <http://doi.org/10.1037/a0021302>
- Valdesolo, P., Ouyang, J., & DeSteno, D. (2010). The rhythm of joint action: Synchrony promotes cooperative ability. *Journal of Experimental Social Psychology*, 46(4), 693–695. <http://doi.org/10.1016/j.jesp.2010.03.004>
- Valentini N. C., Spessato B. C., Rudisill M. E. (2007). Fundamental motor skills: A description of the most common errors demonstrated by children. *Journal of Sport and Exercise Psychology* 29, S47–48.
- Vallacher, R. R., Nowak, A., & Zochowski, M. (2005). Dynamics of social coordination: The synchronization of internal states in close relationships. *Interaction Studies*, 6(1), 35–52. <http://doi.org/10.1075/is.6.1.04val>
- van Baaren, R., Janssen, L., Chartrand, T. L., & Dijksterhuis, A. (2009). Where is the love? The social aspects of mimicry. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364, 2381–2389.

- <http://doi.org/10.1098/rstb.2009.0057>
- van Elk, M., van Schie, H. T., Hunnius, S., Vesper, C., & Bekkering, H. (2008). You'll never crawl alone: Neurophysiological evidence for experience-dependent motor resonance in infancy. *NeuroImage*, 43(4), 808–814.
<http://doi.org/10.1016/j.neuroimage.2008.07.057>
- Vanneste, S., Pouthas, V., & Wearden, J. H. (2014). Temporal control of rhythmic performance: a comparison between young and old adults. *Experimental Aging Research*, 27(1), 83–102. <http://doi.org/10.1080/03610730125798>
- van Noorden, L., and De Bruyn, L. (2009). "The development of synchronization skills of children 3 to 11 years old," in *Proceedings of ESCOM – 7th Triennial Conference of the European Society for the Cognitive Sciences of Music*, 466–472.
- Vecera, S. P., & Johnson, M. H. (1995). Gaze detection and the cortical processing of faces: Evidence from infants and adults. *Visual Cognition*, 2(1), 59–87.
<http://doi.org/10.1080/13506289508401722>
- Venetsanou, F., & Kambas, A. (2010). Environmental factors affecting preschoolers' motor development. *Early Childhood Education Journal*, 37(4), 319–327.
<http://doi.org/10.1007/s10643-009-0350-z>
- Venetsanou, F., & Kambas, A. (2011). The effect of age and gender on balance skills in preschool children. *Physical Education and Sport*, 9(1), 81–90.
- Verney, J. P. (2013). *Rhythmic Perception and Entrainment in 5-Year-Old* (Unpublished doctoral dissertation). University of Cambridge, United Kingdom.
- Vincent, M. (1968). Motor performance of girls from 12 through 18 years of age. *Research Quarterly*, 39, 1094–1100.
- Visser, J. (2003). Developmental coordination disorder: A review of research on subtypes and comorbidities. *Human Movement Science*, 22(4–5), 479–493.
<http://doi.org/10.1016/j.humov.2003.09.005>
- Volman, M. (Chiel) J. M., & Geuze, R. H. (2000). Temporal stability of rhythmic tapping "on" and "off the beat": A developmental study. *Psychological Research*, 63(1), 62–69. <http://doi.org/10.1007/PL00008168>
- von Hofsten, C. (2004). An action perspective on motor development. *Trends in Cognitive Sciences*, 8(6), 266–72. <http://doi.org/10.1016/j.tics.2004.04.002>
- Vouloumanos, A., & Werker, J. F. (2004). Tuned to the signal: The privileged status of speech for young infants. *Developmental Science*, 7(3), 270–6.
- Vukovic, M., Vukovic, I., & Stojanovic, V. (2010). Investigation of language and motor skills in Serbian speaking children with specific language impairment and in typically developing children. *Research in Developmental Disabilities*, 31, 1633–1644.
- Walden, T., Lemerise, E. A., & Smith, M. C. (1999). Friendship and popularity in preschool classrooms. *Early Education and Development*, 10, 351–371.
- Walters, D. L. (1983). *The relationship between personal tempo in primary-aged children and their ability to synchronize movement with music* (Unpublished doctoral dissertation). University of Michigan, USA.
- Wan, C. Y., Demaine, K., Zipse, L., Norton, A., & Schlaug, G. (2010). From music making to speaking: Engaging the mirror neuron system in autism. *Brain Research Bulletin*, 82(3–4), 161–168. <http://doi.org/10.1016/j.brainresbull.2010.04.010>
- Wang, Y., & Hamilton, A. F. de C. (2013). Why does gaze enhance mimicry? Placing gaze-mimicry effects in relation to other gaze phenomena. *The Quarterly Journal of Experimental Psychology*, 218(August), 37–41.
<http://doi.org/10.1080/17470218.2013.828316>
- Warneken, F. (2015). Precocious prosociality: Why do young children help? *Child*

- Development Perspectives*, 9(1), 1–6. <http://doi.org/10.1111/cdep.12101>
- Warneken, F., & Tomasello, M. (2006). Altruistic helping in human infants and young chimpanzees. *Science*, 311(5765), 1301–3. <http://doi.org/10.1126/science.1121448>
- Warneken, F., & Tomasello, M. (2007). Helping and cooperation at 14 months of age. *Infancy*, 11(3), 271–294. <http://doi.org/10.1111/j.1532-7078.2007.tb00227.x>
- Warneken, F., & Tomasello, M. (2013). The emergence of contingent reciprocity in young children. *Journal of Experimental Child Psychology*, 116(2), 338–350. <http://doi.org/10.1016/j.jecp.2013.06.002>
- Watson-Jones, R. E., & Legare, C. H. (2016). The social functions of group rituals. *Current Directions in Psychological Science*, 25(1), 42–46. <http://doi.org/10.1177/0963721415618486>
- Watson, A. C., Nixon, C. L., Wilson, A., & Capage, L. (1999). Social interaction skills and theory of mind in young children. *Developmental Psychology*, 35(2), 386–391.
- Webster, R. I., Majnemer, A., Platt, R. W., & Shevell, M. I. (2005). Motor function at school age in children with a preschool diagnosis of developmental language impairment. *The Journal of Pediatrics*, 146, 80–85.
- Weiner, B., Graham, S., Stern, P., & Lawson, M. E. (1982). Using affective cues to infer causal thoughts. *Developmental Psychology*, 18(2), 278–286. <http://doi.org/10.1037/0012-1649.18.2.278>
- Weiss, M., & Smith, A. (2002). Friendship quality in youth sport: Relationship to age, gender, and motivation variables. *Journal of Sport & Exercise Psychology*, 24(4), 420–437.
- West, S. A., Griffin, A. S., & Gardner, A. (2006). Social semantics: Altruism, cooperation, mutualism, strong reciprocity and group selection. *Journal of Evolutionary Biology*, 20, 415–32. <http://doi.org/10.1111/j.1420-9101.2006.01258.x>
- Westendorp, M., Hartman, E., Houwen, S., Smith, J., & Visscher, C. (2011). The relationship between gross motor skills and academic achievement in children with learning disabilities. *Research in Developmental Disabilities*, 32(6), 2773–2779. <http://doi.org/10.1016/j.ridd.2011.05.032>
- Whiting, B., & Edwards, C. P. (1973). A cross-cultural analysis of sex differences in the behavior of children aged three through 11. *The Journal of Social Psychology*, 91(2), 171–188. <http://doi.org/10.1080/00224545.1973.9923040>
- Whiting, B. B., & Edwards, C. P. (1988). *Children of Different Worlds: The Formation of Social Behavior*. London: Harvard University Press.
- Widen, S. C., & Russell, J. A. (2003). A closer look at preschoolers' freely produced labels for facial expressions. *Developmental Psychology*, 39(1), 114–128. <http://doi.org/10.1037/0012-1649.39.1.114>
- Wiersma, L. D., & Fifer, A. M. (2008). “The schedule has been tough but we think it’s worth it”: The joys, challenges, and recommendations of youth sport parents. *Journal of Leisure Research*, 40, 505–530.
- Wild, M. R. (1937). *The behavior patterns of throwing and some observations concerning its course of development in children* (Unpublished doctoral dissertation). University of Wisconsin, USA.
- Williams, H. M., Sievers, C. H., & Hattwick, M. S. (1933). The measure of musical development. *University of Iowa Studies in Child Welfare*, 7(1), 1-191.
- Williams, H. G., & Breihari, S. K. (1979). Motor control tasks for young children. Unpublished manuscript, University of Toledo.
- Wiltermuth, S. (2012a). Synchronous activity boosts compliance with requests to aggress. *Journal of Experimental Social Psychology*, 48, 453–456.

- <http://doi.org/10.1016/j.jesp.2011.10.007>
- Wiltermuth, S. (2012b). Synchrony and destructive obedience. *Social Influence*, 7(2), 78–89.
- Wiltermuth, S. S., & Heath, C. (2009). Synchrony and cooperation. *Psychological Science*, 20(1), 1–5. <http://doi.org/10.1111/j.1467-9280.2008.02253.x>
- Wimmer H, Perner J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition* 13, 103-128.
- Winberg, J. (2005). Mother and newborn baby: Mutual regulation of physiology and behavior - A selective review. *Developmental Psychobiology*, 47(3), 217–229. <http://doi.org/10.1002/dev.20094>
- Wirth, J. H., Sacco, D. F., Hugenberg, K., & Williams, K. D. (2010). Eye gaze as relational evaluation: averted eye gaze leads to feelings of ostracism and relational devaluation. *Personality and Social Psychology Bulletin*, 36(7), 869–882. <http://doi.org/10.1177/0146167210370032>
- Wittig, M., Jensen, K., & Tomasello, M. (2013). Five-year-olds understand fair as equal in a mini-ultimatum game. *Journal of Experimental Child Psychology*, 116(2), 324–337. <http://doi.org/10.1016/j.jecp.2013.06.004>
- Wolff, P. H. (2002). Timing precision and rhythm in developmental dyslexia, 179–206.
- Wolff, P. H., & Hurwitz, I. (1976). Sex differences in finger tapping: A developmental study. *Neuropsychologia*, 14(1), 35–41.
- Woodruff Carr, K., White-Schwoch, T., Tierney, A. T., Strait, D. L., & Kraus, N. (2014). Beat synchronization predicts neural speech encoding and reading readiness in preschoolers. *Proceedings of the National Academy of Sciences of the United States of America*, 111(40), 14559–64. <http://doi.org/10.1073/pnas.1406219111>
- Wong, A. K. Y., & Cheung, S. Y. (2006). Gross motor skills performance of Hong Kong Chinese children. *Journal of Physical Education & Recreation*, 12(2), 23–29.
- Woodard, R. L., & Surburg, P. R. (2001). The performance of fundamental movement skills by elementary school children with learning disabilities. *The Physical Educator*, 58, 198–206.
- Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, 69(1), 1–34. [http://doi.org/10.1016/S0010-0277\(98\)00058-4](http://doi.org/10.1016/S0010-0277(98)00058-4)
- Woodward, A. L., & Gerson, S. A. (2014). Mirroring and the development of action understanding. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369.
- Woodward, A. L., & Guajardo, J. J. (2002). Infants' understanding of the point gesture as an object-directed action. *Cognitive Development*, 17(1), 1061–1084. [http://doi.org/10.1016/S0885-2014\(02\)00074-6](http://doi.org/10.1016/S0885-2014(02)00074-6)
- Woodward, A. L., & Sommerville, J. A. (2000). Twelve-month-old infants interpret action in context. *Psychological Science*, 11(1), 73–77. <http://doi.org/10.1111/1467-9280.00218>
- Woodward, A. L., Sommerville, J. A., & Guajardo, J. J. (2001). How infants make sense of intentional action. *Intentions and Intentionality: Foundations of Social Cognition*, 149–169.
- Woolhouse, M. H., Tidhar, D., & Cross, I. (2016). Effects on inter-personal memory of dancing in time with others. *Frontiers in Psychology*, 7, 167. <http://doi.org/10.3389/fpsyg.2016.00167>
- World Health Organization. (2016). *Autism spectrum disorders*. Retrieved from: <http://www.who.int/mediacentre/factsheets/autism-spectrum-disorders/en/>

- Yale, M. E., Messinger, D. S., Cobo-Lewis, A. B., & Delgado, C. F. (2003). The temporal coordination of early infant communication. *Developmental Psychology*, 39(5), 815–824. <http://doi.org/10.1037/0012-1649.39.5.815>
- Yoon, J. S., Hughes, J. N., Cavell, T. A., & Thompson, B. (2000). Social cognitive differences between aggressive-rejected and aggressive-nonrejected children. *Journal of School Psychology*, 38, 551–570.
- Young, K. A., Liu, Y., & Wang, Z. (2008). The neurobiology of social attachment: A comparative approach to behavioral, neuroanatomical, and neurochemical studies. *Comparative Biochemistry and Physiology - Part C: Toxicology*, 148(4), 401–410. <http://doi.org/10.1016/j.cbpc.2008.02.004>.The
- Younger, A. J., Schwartzman, A. E., & Ledingham, J. E. (1986). Age-related differences in children's perceptions of social deviance: Changes in behavior or in perspective? *Developmental Psychology*, 22(4), 531–542. doi: 10.1037/0012-1649.22.4.531
- Zahn-Waxler, C., Radke-Yarrow, M., & Brady-Smith, J. (1977). Perspective-taking and prosocial behavior. *Developmental Psychology*, 13(1), 87–88. <http://doi.org/10.1037/0012-1649.13.1.87>
- Zentner, M., & Eerola, T. (2010). Rhythmic engagement with music in infancy. *Proceedings of the National Academy of Sciences*, 107(13), 5768–5773. <http://doi.org/10.1073/pnas.1000121107>
- Zimmerman, M. P. (2011). Musical Characteristics of Children. *Visions of Research in Music Education*, 17(1).
- Zinober, B., & Martlew, M. (1985). Developmental changes in four types of gesture in relation to acts and vocalizations from 10 to 21 months. *British Journal of Developmental Psychology*, 3(3), 293–306. <http://doi.org/10.1111/j.2044-835X.1985.tb00981.x>
- Ziviani, J., Wadley, D., Ward, H., Macdonald, D., Jenkins, D., & Rodger, S. (2008). A place to play: Socioeconomic and spatial factors in children's physical activity. *Australian Occupational Therapy Journal*, 55(1), 2–11. <http://doi.org/10.1111/j.1440-1630.2006.00646.x>
- Zivotofsky, A. Z., & Hausdorff, J. M. (2007). The sensory feedback mechanisms enabling couples to walk synchronously: An initial investigation. *Journal of Neuroengineering and Rehabilitation*, 4, 28. <http://doi.org/10.1186/1743-0003-4-28>
- Zwaigenbaum, L., Thurm, A., Stone, W., Baranek, G., Bryson, S., Iverson, J., ... Sigman, M. (2007). Studying the emergence of autism spectrum disorders in high-risk infants: Methodological and practical issues. *Journal of Autism and Developmental Disorders*, 37(3), 466–480. <http://doi.org/10.1007/s10803-006-0179-x>
- Zwicker, J. G., Missiuna, C., Harris, S. R., & Boyd, L. A. (2012). Developmental coordination disorder: A review and update. *European Journal of Paediatric Neurology*, 16(6), 573–581. <http://doi.org/10.1016/j.ejpn.2012.05.005>