Social Bonding Among Children in Joint Physically Active Play

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Abstract

Children's free play is often characterised by moderate-to-vigorous physical activity (MVPA), touch, joint action, and enjoyment. Each of these features has been associated with interpersonal affiliation in either human or non-human primates. However, no research has examined how children's joint physically active play is linked with social bonding (i.e., positive emotional states and behaviours that help create, maintain, and characterise affiliation and attachment among individuals). This thesis comprises three novel studies that were designed to explore this question. A naturalistic observation study (*N* = 50) was first conducted to assess links among physical activity (PA), smiling/laughing, touch, and prosociality in children's play behaviour during school breaks. PA levels were also measured indirectly via heart rate monitors (HRM). We found that observed-PA was associated with frequency of smiling/laughing between pairs. PA (observed and HRM) was also associated with frequency of touch. A second study (*N* = 84) experimentally tested the effect of touch on helping behaviour in the context of physically-active play. In pairs, children ran to collect felt shapes, which they placed either onto each other (touch condition) or onto a board (no-touch condition). Subsequent helping behaviour was assessed in a separate task. There was a non-significant trend towards more helping in the touch condition. The final study (N = 252) tested the effect of physical exertion on children's social bonding and behavioural inhibition. In pairs, children either ran (MVPA condition) or walked (light PA condition) around an area laid out with mats. One child could choose to stand either on the same mat as the other child and do actions together or stand on separate mats and do the actions separately. This was followed by a pictorial measure of social closeness, followed by a behavioural inhibition task in which one child was instructed to place their hand inside a box containing unknown stimuli. No significant differences were detected between the two conditions. The thesis contributes to filling in gaps within the literature on play, social bonding, and physical activity, spanning evolutionary anthropology, developmental psychology, and health, and highlights the need for more controlled experimental studies among diverse populations.

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Long Abstract

Social bonding is a pervasive feature of human life. The act of two people 'clicking' or 'hitting it off' upon first encounter may seem straightforward at first glance, but the causal mechanisms involved in generating and maintaining social bonds are complex and only beginning to be scientifically established. The research proposed here explores and tests the claim that certain forms of group movement and physical activity (PA) facilitate social bonding in children. A growing body of research on adults suggests that endogenous opioids are released during exertive PA (Boecker et al., 2008) and may facilitate social bonding when physical exercise is performed together with others (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010; Tarr, Launay, Cohen, & Dunbar 2015). Touch, a common feature of human interaction, is believed to be crucial for mother-infant bonding (Bellieni et al., 2007) with causal links to oxytocin, a neurohormone implicated in attachment and trust (Field, 2010). Enjoyment or hedonic experience may bond people who share the experience together by enhancing their positive appraisal of the experience, possibly also by an opioid-mediated mechanism (Dunbar et al., 2011). Evidence also suggests that movement synchrony may contribute to social bonding by generating self-other overlap and increasing perceptions of similarity (Wiltermuth & Heath, 2009).

PA, touch, and synchrony have all been either observationally or experimentally associated with pleasure and social bonding outcomes in adults, yet little is known about how these features of everyday life affect social bonding in children. Much of children's natural play behaviour combines these features, but play research has largely overlooked social bonding as an outcome from play and has focused, instead, on deferred social-cognitive benefits (e.g., Groos, 1901; Piaget, 1962; Vygotsky, 1967). Moreover, although much research has been dedicated to infant-caregiver bonding, relatively little attention has been paid to how young children form social bonds in general, which is surprising given the social, emotional, and physical health problems that have been associated with social isolation and exclusion (Nelson, Furtado, Fox, & Zeanah, 2009; O'Connor, Rutter, Beckett, Keaveney, & Kreppner, 2000; Bagwell, Newcomb, Bukowski 1998; Barkley, Salvy, & Roemmich, 2012), and,

conversely the benefits associated with social integration and support (Berkman, Melchior, Chastang, Niedhammer, Leclerc, & Goldberg, 2004; Eisenberger & Cole, 2012).

This project will contribute to filling this gap by asking the following questions: What is the relationship between physical exertion, touch, and social bonding in children's joint physically active play (JPAP)? Is there a causal relationship between touch and social bonding in a JPAP context? Is there a causal relationship between exertion and social bonding in a JPAP context? Chapter one provides an overview of social bonding and play, including evolutionary function, importance in child development, and consequences of social bonding deficits. Chapter one will also include a brief overview of the relevant play literature and theories before introducing JPAP in chapter two as the context for the current research, and its links to sociality in childhood. I will then review the current literature on PA and children's physical, emotional and cognitive health before examining links that have been made between PA, social affiliation and bonding in children. I briefly summarise the thesis project and rationale. Chapter three reports an observational study summarising effects of JPAP on social behaviour. This study showed significant positive relationships between PA and touch as well as between PA and enjoyment. Chapter four reports an experimental study which investigated the effect of touch on social bonding, as measured by prosocial behaviour and partner liking. Results showed a non-significant trend of more prosocial behaviour in the touch condition and no effect of condition on partner liking. Chapter five reports a second experimental study which investigated the effect of physical exertion (i.e. running vs. walking) on social bonding (measured as a choice to be together or apart during a game and distance between representative stickers in picture-making task) and behavioural inhibition. Results from the study showed no significant difference between the two conditions. Chapter six provides conclusions drawn from the project, along with a discussion of broader implications, limitations, and future directions.

1.0 Social Bonding and Play: Evolutionary and developmental perspectives

1.1 Introduction

Social bonding is a ubiquitous feature of human life. From birth, humans bond with caregivers (Feldman, Eidelman, Sirota & Weller, 2002), setting each infant on a path of socialisation that will continue throughout the lifespan. The ability to form strong social bonds is known to have lasting benefits on health and longevity in primates, highlighting the functional importance of social bonds (Silk et al., 2010). Though the benefits of social bonding are clear, the process of how one forms social bonds is less well understood, especially among children. A prime context for social bonding is during play, when children are free to associate and engage as they please. Play has been extensively researched and theoretical approaches to the function of play abound. Though many theories suggest that certain types of play contribute to the development of social skills, such as social competence, none explicitly propose to have an immediate social bonding benefit. This chapter will first introduce social bonding as an integral component of group living in the environment of evolutionary adaptedness (EEA) and will then provide an overview of how social bonding influences human development with deficits resulting in sometimes long-lasting consequences. Play will then be introduced as the context for social bonding in childhood. A theoretical account of play will be provided, along with the types of play that have been previously researched. Lastly, evidence supporting a link between play and social competence will be discussed and examined in relation to how certain types of play may hold social bonding benefits.

1.2 Evolution of Social Bonding

In primate evolution, social living is thought to have arisen from an ancestral solitary state, later followed by harems and pair-bonded groups, in part as a result from a shift in nocturnal to diurnal living (Shultz, Opie, & Atkinson, 2011). Ecological pressures would have favoured increased group size. Most notably, larger group sizes would have been beneficial in protecting against the threat of predation, while also allowing cooperation between conspecifics. Successful group living would have brought about its own challenges to cooperation, however, such as within-group competition over scarce resources (Brent, Chang, Gariépy, & Platt, 2013). Large groups of genetically unrelated individuals have a higher likelihood of encountering free-riders. This is thought to have put selective pressure

on the evolution of psychological mechanisms that allowed reliable evaluation of unrelated others as potential cooperation partners, as well as the identification of free-riders (e.g., Tooby & Cosmides, 1996). Grooming in non-human primates has been proposed as one such mechanism, whereby individuals signal their willingness to cooperate with other group members (Dunbar, Gamble, & Gowlett, 2009). Dunbar (2012) further proposed that grooming activates both psychopharmacological and cognitive mechanisms that underpin the formation of social bonds. According to Dunbar, endorphins are released during social grooming, which causes the animal to feel relaxed (psychopharmacological mechanism), thereby causing the grooming pair to spend more time with each other and establish a relationship of trust and reciprocity (cognitive mechanism) indicative of social bonding.

Intergroup tensions brought on by social living may thus have been mitigated through behaviours such as social grooming. Dunbar (1991) found a strong association between time spent in social grooming and social group size among Old World primates. Further, grooming relationships are stable and persistent, sometimes lasting years, allowing the formation of strong alliances (see Silk, 2007; Silk et al., 2010; Wittig et al., 2008). For example, among female wild gelada baboons there is a significant correlation between time spent with a grooming partner and aid shown toward the partner, such as in conflict (Dunbar, 1980; for additional perspectives, see Silk, 2002, 2007).

Given that human groups are much larger than those of Old World primates, this raises the question of what bonds them together – the same mechanisms on a larger scale, or something else? It is thought that social grooming behaviours would have been insufficient to support human social bonding, as the dyadic, time-consuming relationships maintained through social grooming would not be able to sustain the larger number of relationships that typically characterise human groups. From this point, Dunbar proposes that social laughter in humans (another mechanism for endorphin release), evolved from social grooming in primates, facilitating a similar social reward on a larger scale. Indeed, he refers to social laughter as ‘grooming-at-a-distance’ (Dunbar, 2011, 2012) and suggests that this may have contributed to social bonding in humans.

It has been well documented that primates are a social order, but humans are *hyper* social in comparison to other primates (Tomasello, 2009). One illustration of this difference between social and hyper-social is in typical behaviour at mealtimes. For example, sharing of food is routine among all human populations, but rare in other apes (Silk et at., 2005). Even among chimpanzees, our closest primate relative, collaborative foraging is common, but sharing the spoils is quite rare. Rather, it looks more like a competition for the spoils with dominance playing a major role in determining who gets how much (Gilby, 2006; Tomasello, 2014). Tomasello (2014) posits that human hyper-sociality arose during a time of ecological change, which required humans to become obligate collaborative foragers. This, he suggests, gave rise to interdependent thinking and shared intentionality, a set of psychological skills and motivations that may in part underpin social bonding, but are relatively absent in our primate relatives. Additionally, it has been suggested that, in many species, social play involves macro-level shared intentionality, including three phases - an opening (the agreement to start play), the main body (the play and maintenance of play), and the closing phase (agreement to stop) (Heesen, Genty, Rossano, Zuberbühler, Bangerter, 2017). Although some animals exhibit such macro-level shared intentionality (e.g. humans, gorillas, black bears, red-necked wallabies, red kangaroos, and Arabian babblers), a majority of animals (including chimpanzees and bonobos) exhibit only one or two of these phases. It has been suggested that cross-species comparisons of this macro-level shared intentionality within social play could help elucidate the foundations of joint action in humans (Heesen et al., 2017).

Anthropologists Hrdy (2009, 2014) and Hawkes (2013) both build on these ideas about interdependent thinking and shared intentionality, suggesting that the unique sociality of humans derives from alloparenting (also referred to as ‘cooperative breeding’ or ‘grandmothering’), which emerged in pre-human apes. According to this theory, human infants with cognitive abilities to solicit nurture from multiple caretakers had a fitness advantage over those less able to solicit such attention. Other primates continued ‘independent mothering’ and therefore did not develop the cognitive capacity for shared intentionality to the same extent. Therefore, alloparenting may have produced heightened social sensitivities, such as shared intentionality, which would have functioned to increase

survival in infancy, and, furthermore, allowed mothers to reproduce faster than independent mothering (Hawkes, 2013).

The adaptive benefits of bonding appear to continue throughout development and into adulthood. For example, in humans and non-human primates, strong social connections have been associated with stress reduction (Massen, Sterck, & De Vos, 2010; Brent et al., 2013), reduced risk of disease, and longer lifespan (Berkman et al., 2004; Holt-Lunstad, Smith, & Layton, 2010; Seyfarth & Cheney, 2012). In a meta-analysis of 148 studies with over 300,000 participants across North America, Europe, Asia, and Australia, Holt-Lunstad et al., (2010) reported a 50% increased likelihood of survival for people who had strong relationships, compared to people with poor relationships over an average of 7.5 years. They equated the magnitude of this effect to that of quitting smoking, highlighting the importance of quality social bonds for longevity and supporting an evolved fitness-enhancing function of social bonding.

This important point forms part of the basis of this study, as it emphasizes the adaptive importance of social bonds to humans and a clear need to better understand their processes and mechanisms. By identifying key contributors of social bonding early in life, policy in child education and health, for example, could be better informed to enable healthy development into adulthood. Indeed, evidence from studies of nurtured and neglected children supports this idea.

1.3 Social Bonding in Development

Human social bonding is evident from the first days of life, as seen in the form of infant-mother bonding. In infancy, cuddling and breastfeeding are important for growth and development and can invoke calm in moments of pain and discomfort (Bellieni et al., 2007). According to attachment theory, a child initially forms one primary attachment (with a primary care-giver), which provides security for exploring the world and forms a model for future relationships. If the attachment is broken or disrupted, the consequences can be severe and long-lasting (Bowlby, 1958). In an early study that refined this theory, Bowlby (1944) investigated long-term effects of maternal deprivation. He interviewed 44 teenage

delinquents (thieves), 44 teenage controls, and their parents in a child guidance clinic in London (the controls were in the clinic for emotional problems, but had committed no crimes). The study found that more than half of the delinquents had been separated from their mothers for at least 6 months during the first 5 years of their lives, while only two participants from the control group had suffered the same maternal deprivation. Of the delinquents, 32% showed 'affectionless psychopathology' (inability to care or feel for others), while none of the controls displayed this behaviour, suggesting an association between maternal deprivation and maladjustment in adolescence.

Although Bowlby's work was the foundation for attachment theory, it was Ainsworth and Witting (1969) who first devised the 'strange situation classification' method still used today to empirically identify the nature and style of attachments between young children and their mothers (or primary care takers). The procedure involves observing the child in different social situations and evaluating the child's reactions, resulting in categorisation into three possible attachment styles - secure, ambivalent, or avoidant. Secure attachment is the result of a responsive and sensitive primary care-giver, ambivalent attachment is the result of inconsistent care-giving (sometimes the child's needs are met, sometimes not), and avoidant attachment is associated with unresponsive primary care (Ainsworth, 1979). This method of assessing children's attachment behaviour is important because it establishes that children suffer negative consequences when secure initial bonds are not formed.

Negative effects of infants' and young children's social bonding and (caregiver) attachment deficits have been observed in studies on Romanian orphans. After the fall of communism, the world became aware of the dire conditions of state-run Romanian orphanages with nearly 170,000 children living in social privation with inadequate food and care, with infant to care-giver ratio around 15 to 1. Thousands of children were adopted by families in the US, Great Britain, and Canada. Weight, cognitive, and language problems improved following adoption, while problems with interpersonal relationships and executive functioning continued (Nelson, Furtado, Fox, & Zeanah, 2009). In 2000, The Bucharest Early Intervention Project (BEIP) was formed to study differences between institutionally and community raised children in Romania. One study from BEIP (2005) found that, among children who had never been institutionalised, 100% of attachments were rated as fully

developed, compared to only 3 out of 95 (3.2%) institutionalised children. Of the institutionalized children, 65% had what is termed 'disorganized attachment' (insecure attachment where the child may display depression, anger, complete passivity, or non-responsiveness) toward their favourite care-giver, while 13% displayed too little attachment to even be classified (Zeanah, Smyke, Koga, Carlson, & The Bucharest Early Intervention Project Core Group, 2005).

Further studies of Romanian institutionalised children reveal many associations between inadequate attachment formation and developmental problems (Rutter, 1998; Rutter et al., 2007). There is also evidence that significant, though not full, recovery following foster care placement or adoption into nurturing homes is possible (O'Connor, Rutter, & The English and Romanian Adoptees Study Team, 2000; Nelson, Zeanah, Fox, Marshall, Smyke, & Guthrie, 2007). Evidence from Romanian orphanages provides extreme examples, but this research highlights the importance of early attachment (the first social bonds) for subsequent relationships, cognitive development, and behavioural development throughout childhood.

Beyond the primary caregiver-infant bond, there has been less research focused on the formation of social bonds during the childhood years. Rather, researchers have explored links between childhood friendships and social and education outcomes (Ladd, 1990; Ladd, Kochenderfer, & Coleman, 1996; Bagwell, Newcomb, & Bukowski, 1998). For example, Ladd found that children with more school friends at the beginning of the year perceived school more positively by the second month, and those who sustained these relationships liked school more throughout the year. Children who made new friends performed better in school, while early peer rejection was associated with negative perceptions of school, and lower performance throughout the year (1990). Other studies have made associations between poor social bonding and maladjustment (Cowen, Pederson, Babigian, Izzo, & Trost, 1973; Roff, Sells, & Golden, 1972; Prinstein, Cheah, & Guyer, 2005; Lev-Weisel Nuttman-Shwartz, & Sternberg, 2006). Social exclusion (or peer rejection) and the loss of a friend or loved one is experienced much the same as physical pain (Eisenberger, 2012; Brent et al., 2013). Similar research has linked positive (and frequent) peer relations with protection against the threat response to social exclusion in cross-sectional studies of young adults

(Eisenberg, Taylor, Gable, Hilmert, Lieberman, 2007) and longitudinal studies of adolescents (Masten, Telzer, Fuligni, Lieberman, &Eisenberger, 2010 Eisenberger, 2012; Brent et al., 2013). These associations point to clear benefits of social bonding in childhood. However, the influences in early life that allow children to enter adulthood with the abilities to develop and maintain close social networks remain under-researched. Understanding how children form social bonds is therefore not only of importance scientifically, but may have applied utility for facilitating early relationships and ensuring that children do not feel alone and insecure in their social world.

1.4 Play[1]

One area of psychological and educational research that has received much attention in the study of children's peer-to-peer interactions is the realm of play, as most young children's socialising with peers happens during play activities. Cross-culturally prevalent and rich in social-cultural and developmental significance, children's social play seems a likely avenue for anthropological inquiry also. However, surprisingly little research on play, or even on childhood, has been conducted by anthropologists in comparison to research on adults. Notable pioneering exceptions are Mead (1930, 1933), who observed childrearing in the Pacific Islands and South East Asia, and John and Beatrice Whiting (1975) who conducted the "Six Cultures Study of Socialization". As part of a team of anthropologists and psychologists, the Whitings undertook a comparative examination of child-rearing practices. Since the 1970s, however, anthropology has largely ignored the topic of childhood (for exceptions, see Gosso et al., 2005; Bock, 2005; Lancy, 2015). Hirschfeld (2002) in his aptly titled article, "Why don't anthropologists like children?" claimed that anthropologists minimise children's role in the (re)production of culture. Rather, they have emphasised the adult role, thereby marginalising children's ability to acquire and create culture – two things they do exceptionally well, as demonstrated through play.

Although there are persistent gaps in the anthropological literature on children's play, theories of play are abundant in the wider literature, particularly in psychology. The

[1] The following three sections (1.4, 1.5, 1.6) contain information previously published in a chapter within the International Encyclopaedia of Anthropology (Tunçgenç & Jefferies, 2018)

following sections will first provide an overview of play theories and traditionally proposed functions, followed by the types of play which have been studied by play theorists and a brief explanation of how the aims and contributions of this project extend the current state-of-the-art.

1.4.1 Theoretical Approaches

Scholars have theorised about the benefits and function of play for over 100 years. Pellegrini and Smith (1998) note that common characteristics among diverse definitions of play are that play is enjoyable, players are primarily concerned with the means rather than the ends of their play activity, and the activity has no obvious technical function (Martin & Caro, 1985; Rubin et al., 1983; Smith & Vollstedt, 1985). Classic theories include Spencer's surplus energy theory of play (1873), where play is seen as a natural release of the body's pent-up energy. Surplus energy theory posits that play is a result of 'higher' animals (e.g., mammals) having plenty of nutrition and physiology that allows for physical activity (PA). This can be seen in play behaviours before and after feeding, as play increases after meals and decreases if hungry (Sharpe, Clutton-Brock, Brotherton, Cameron, & Cherry, 2002). However, although physically active play can use up substantial energy, the theory does not account for the fact that it can also have the opposite effect of being energising (i.e. Sanders et al., 2014). In addition, humans, as other primates, have large brains that are energetically expensive and this would make excess activity all the more costly. Another classic theorist, Groos (1901), proposed play as a form of preparation or practise for adult life. A classic example is play-fighting or rough and tumble (R&T) play among young boys, which has traditionally been viewed as practising skills for adult hunting and fighting (Smith, 1982). If practise were the evolutionary function of play, however, animals that do not play should be disadvantaged later in life, either by lower survival or reproduction rates. Yet, some studies suggest that play is not essential to the development of adult skills. For example, in wild meerkats, no relation was found between rate of juvenile play fighting and ability to win to winning actual fights in adulthood (Sharpe, 2005). Moreover, it has been noted that, at least among rats, play fighting does not truly mimic serious fighting or predation (see Graham & Burghardt, 2010). Thus, it seems that although some characteristics of play may sometimes prove useful in adulthood, not all play activities are relevant or necessary for full engagement in adult life (Tunçgenç & Jefferies, 2018).

In an interesting twist on play theory, Hall (1920) proposed the recapitulation theory of play, in which phylogenetic stages in evolutionary history are repeated in the developmental trajectory. Recapitulation theory views play as residual, but still developmentally relevant (e.g., fleeing or hiding from predators). However, this theory lacks any solid empirical basis and it also fails to acknowledge that ontogeny can influence phylogeny.

Freud (1955), in a psychoanalytic approach to childhood, viewed play as a means of anxiety-reduction in that the child experiences a sense of control over his or her world and has an acceptable way of acting out otherwise forbidden impulses. This theory has been adapted to later theories focusing on the role of play in facilitating safe environments for exploration and risk taking. However, Freud's theory has been rejected on the grounds of its narrowness and untestability. Neo-Freudian approaches later suggested that play functions to develop the ego, building physical and social skills that enhance self-esteem and prepare children for the social roles they will one day be expected to fulfil (e.g., Erikson, 1956). Piaget and Sutton-Smith proposed a cognitive-developmental theory of play, where play serves to consolidate learning through *assimilation* (incorporating novelty into pre-existing ways of thinking) (Piaget, 1962) and *accommodation* (adapting to the demands of the environment) (Sutton-Smith, 1978) and promote a relaxed atmosphere where new learning can take place (1978). Simply put, this means that, during play, children apply previously acquired actions to new objects and contexts in which those actions do not make literal sense. Thus, play is a form of 'autistic thought' (concerned primarily with wish fulfilment, rather than any objective reality), helping to consolidate existing skills, but to be replaced by rational thinking later in development (Piaget, 1945).

All of these cognitive-developmental theories have contributed to the study of benefits of play. However, they tend to view the benefits of play as deferred, ignoring the possibility of immediate benefits of play. Piaget and Freud suggest deferred social benefits of play, in so far as juvenile play can help develop skills necessary for social interaction. Nevertheless, they do not consider the possibility that social ties can form as a result of play and play may therefore serve a more immediate social benefit. Additionally, these cognitive-developmental theories of play assume that play stops after childhood, ignoring the

possibility that play extends throughout the lifespan as a result of normal healthy development, perhaps allowing for the retention of the qualities outlined above (Gordon, 2014; Montagu 1981). Although this thesis will focus on play in childhood, the implications of play in adults for this research will be discussed later in chapter six.

Given the widespread interest and attention focused on the study of play for more than a century, and on the aforementioned benefits of early developing social bonds in children, it is surprising that the social bonding effects of social play have not been the subject of more investigation. Indeed, in a review of the experimental play literature, I identified only one study that investigated immediate social outcomes of play (Humphreys & Smith, 1987). This study, which focused on R&T play exclusively, found an association between initiations of R&T play and time spent together following each initiation, suggesting a potential immediate bonding benefit of play. Few researchers have followed where this study left off, leaving unresolved issues of replication of findings, expansion to other areas of play, and examination of causal mechanisms. Research within play needs to address this shortcoming with studies specifically designed to identify social bonding outcomes from play situations. Results could expand and correct a traditionally narrow view on the function(s) of play. This question is developed and investigated in the following chapters of this thesis.

1.4.2 Types of Play

Several specific types of play have been identified and studied within the context of childhood. 'Locomotor play' is described by Pellegrini (1998) as activity that happens in a playful context with moderate to vigorous PA (MVPA). This type of play can include symbolic dimensions (like superhero themes) and can be solitary or social. Indeed, locomotor play can include several specific types of activities - for example, 'rhythmic stereotypies', such as rocking and foot kicking during infancy, and 'exercise play', which includes activities such as splashing in water, jumping, or swinging. Exercise play has been observed all across childhood, but peaks around 4-5 years old (Pellegrini 1990; Brown et al., 2009), with a resurgence around 7-9 years old (Pellegrini, 1998; Woods, Graber, & Daum, 2015). This increase in exercise play around middle-childhood is thought to be a result of renewed interest in sports activities, particularly among boys (Woods et al., 2015).

‘Object play' includes tool use, which is thought to incorporate some level of either pretend play or imitation, in that children see adults using objects and try to then imitate the motion or activity. Object play also includes exploration activity, which is when a child first encounters an object and ‘explores’ its properties and attributes (Burghardt, 2005). There is some debate on whether or not construction activity qualifies as play, as play theorists such as Piaget (1962) and Smith (1988) have argued that play is about the means over the ends, while construction in itself is about constructing *something*. Complicating matters further, Pellegrini states that what is considered ‘construction play’ includes not only play and construction, but also exploration and tool use and can be social or solitary. There is also ‘social play’, which, unlike locomotor or object play, is inherently social and includes anything from peek-a-boo to R&T with peers. The final category of play, and perhaps the most researched, is 'pretend play'. Also referred to as symbolic, fantasy, or dramatic play, pretend play can be solitary or social and, as mentioned previously, can be found in many of the other types of play (Pellegrini, 2013).

Although these types of play have been identified and distinguished by theorists, much play activity clearly traverses definitional boundaries, exhibiting elements of several types. The classification of some behaviours that have several elements of play, but not others, is also a challenge to strict typologies. For example, if the activity is concerned primarily with the means over the ends, does this rule out any children’s games which result in a decisive winner, as such participants would have a clear motivation to win, rather than simply ‘play’? Given the nuanced nature of children’s play and the many restrictive typologies that abound in describing it, this project will employ a broad and inclusive definition of play as any spontaneous physical or mental activity engaged in primarily for children’s enjoyment. This can include games, sports, solitary or social play, drawing, running around (apparently) aimlessly, or any other activity children may spontaneously engage in for fun. Furthermore, the previously mentioned categories of play have overlooked widely occurring joint (social), physically active play, which will be discussed later in more detail, but can be described as a combination of locomotor and social play and will serve as the play context of this project.

1.4.3 Play and social competence

A milestone for child development is the ability to initiate and maintain positive social interactions, or 'social competence'. Social competence is a critical developmental milestone during the preschool years and sets the stage for future social bonding (Ladd, 1999). Social play provides children with opportunities to develop and refine their social competence skills, thereby improving the quality of their social interactions with others (Denham et al., 2003; Creasy, Jarvis, & Berk, 1998). Across the play literature, empirical links have been drawn between different forms of social play and social competence (e.g. Fantuzzo, Sekino, & Cohen, 2004; Gagnon & Nagle, 2004; Howes & Matheson, 1992). Pretend play and PA play have received the most attention, however. Until recently, pretend play has been the primary focus of attention for development of social competence. Both Piaget (1945/1962) and Vygotsky (1967) argued that pretend play provides opportunities for children to practise 'perspective-taking', such as reading another person's emotions. Others have suggested that pretend play creates a context in which children can establish any number of possible characters or situations in which emotional states can be experienced and explored in a safe environment, contributing to emotional regulation and mastery (Fein, 1989; Howes & Matheson, 1992; Bretherton, 1989). Recent interest has also been paid to the possible effects of physically active play to the development of social competence (Pellegrini & Smith, 1998). Pellegrini and Smith suggest that exercise play may improve motor development, thus enabling children to become more adept playmates (1998). Others have suggested that PA play enables children to practise self-regulation (Flanders et al., 2010; Smith, 1989) and contributes to their understanding of the physiological origins of emotions, as they experience first-hand the links between elevated heart rate and excitement levels (Smith, 2010).

Recent empirical evidence has supported a link between PA play and social competence (Lindsey & Colwell, 2013; Veiga et al., 2017). In an attempt to test whether one form of children's social play is more important for social competence over others, Veiga and colleagues (2017) conducted a longitudinal study over the course of a school year. Seventy-three children (M = 56.48 months, SD = 4.26) were observed for specific play behaviours and wore a GPS monitoring device for each observation session over the course of 5 weeks from November to December. By May of the following year, teachers completed assessment questionnaires about each child's social competence (measured from questions about 'pro-

social behaviours' and 'peer problems'). The researchers found that social exercise play (e.g. running and climbing) was positively associated with social competence, while social fantasy play, social role play, and social R&T play were not. Few studies have sought to explore the relationship between physical play activity and social competence. These results therefore indicate a promising avenue for further exploration into children's natural play and sociality. Furthermore, the research suggests that physical play activity may not only contribute to children's sociality, but may contribute *more so* than other forms of (social) play that have been more widely researched.

1.5 Summary

The human need for social bonding is reflected in its development in the EEA and its lasting importance for human development and longevity. In childhood, social bonding may be especially important for educational outcomes and preventing social exclusion. However, compared to research on infants and adults, relatively little research has focused on how children form social bonds. Children's play has been proposed as an appropriate setting to explore children's social bonding. Although many deferred benefits of play have been suggested, and this remains a dominant framework for much current research, more research is needed to identify immediate effects of naturally occurring play that cuts across traditionally defined types, including social bonding effects. Certain behavioural elements that have known links with social bonding (i.e. PA, touch, enjoyment, and joint [and synchronous] movement) appear frequently in children's play. In the current project, I therefore propose that social bonding emerges as an immediate outcome of joint physically active play. To examine this, I will measure the amount of social bonding observed following joint physically active play, with special emphasis on the key components of play that have been shown to influence bonding in other contexts. Namely, I will focus on joint activity, exertion, touch, and enjoyment. Chapter two develops the project rationale in more detail. A closer look into the scope of children's play behaviours, such as chase, tag, push/pull, jump rope games, clapping, singing, piggy back, play fight, dance etc., reveals that joint activity, exertion, touch, and enjoyment are typical components of children's play. These attributes may be important determinants for friendship formation in childhood. This project will seek to substantiate this claim within the everyday context of joint physically active play.

2.0 Joint Physically Active Play: Components and proposed mechanistic links with social bonding

2.1 Introduction

Children's social activities often take place in a play context. Play, furthermore, often involves vigorous PA, referred to in the developmental and comparative literature as 'physical activity play', 'locomotor play', or 'exercise play' (Pellegrini, 2010). Pellegrini notes that this form of play often involves symbolic play, or games with rules, and may be played either alone or with others, but is always in a play context involving moderate to vigorous activity (1998). Following Pellegrini's description of PA play, joint physically active play (hereafter, 'JPAP') can be defined as moderate to vigorous, physically active play that is performed in coordination with others. The social nature of JPAP is what sets it apart from other types of physically active play and allows for a convergence of elements known to be associated with social bonding – primarily physical exertion, touch, enjoyment, and joint action. It is this convergence that makes JPAP an ideal context to explore social bonding in children. This chapter will introduce JPAP as the play context for this project, highlighting first the frequency and flexibility of its occurrence, then the fact that research on PA in childhood has emphasised physical, emotional, and cognitive health outcomes, while ignoring immediate social outcomes. Support for a social bonding benefit of JPAP will be discussed by examining specific components of JPAP (physical exertion, touch, enjoyment, and joint action) and each of their links with social bonding.

2.2 JPAP – When, Where, and How?

Among children, JPAP can often be seen within social and play settings such as recess at school or during free play after school. It can take many forms such as running/chasing, jumping, climbing, and play fighting (also called rough and tumble play (R&T) (Pellegrini & Smith, 1998). Descriptions of children's play within the context of education and anthropology literature often satisfy the definition of JPAP. For example, in an educational ethnographic study of Jamaican children's play behaviour, Long (2013) described children's excitement and vigour for outdoor physically active play with peers. She writes of one boy as he leaves the lunchroom and arrives to the playground:

> Once outside, he transformed. He became high-spirited, often running the length and breadth of the playground, with arms flying, loud laughter and

> being much more expressive in his mannerism. His facial expression showed excitement and the exuberant movements were mirrored by his peers (p. 132).

Throughout her study of Jamaican children's play behaviour, Long describes how the children exhibited high-energy, fast-paced, role shifting, social, and spontaneous play. Activities included running, jumping, swinging, playing on monkey bars, or riding bicycles. One activity children thoroughly enjoyed during outdoor play time at school was a fast-paced tag game called "crocodile", which was played daily and involved children being chased by one child deemed 'the crocodile' (the chaser). Another popular physical play activity was running alongside tyres, which might start as a solitary activity, but quickly ended up as a competition among children to see who could finish an agreed-upon race course first. When one child was asked why she liked playing with the tyres, she responded:

> It feels so good when I'm running free...and then sometimes my friends come and play with me and I like that...sometimes there are plenty of them, and we run up and down with the tires until we are tired...that feels so good (p. 163).

This study not only offers examples of observed JPAP among children during free play, but also captures the enjoyment children experience while engaged in these activities and when remembering them.

Playgrounds are indeed an obvious location to identify and observe free play, but they are not the only place. Indeed, even in parts of urban India where designated play space is scarce, children play a game of 'quick tag', where the child who is 'It' catches one player, making that player 'It', then they catch someone, allowing all the children to play continuously in a confined space (Oke, Khattar, Pant, & Saraswathi, 1999). This example suggests that children enjoy JPAP sufficiently that they creatively adapt their games to specific constraints of the environment. Similar JPAP activities may also be observed in informal play environments cross-culturally, such as multi-age child groups of hunter-gatherer societies, as in the !Ko and !Kung people of Southern Africa. For example, both child groups have been observed to spend much informal play in exploration activities or in chase games, where some children pretend to be animals and others pretend to be the

hunter, chasing the animal (Draper, 1976). Other examples of JPAP may include dancing and clapping games, as seen among Ghanaian children (Dzansi, 2004) and UK children (Bishop & Burn, 2013). Certain games (always non-competitive) among !Ko and !Kung hunter-gatherer children may also be considered JPAP, like a melon tossing game observed among mainly girls or, among boys, a game in which a feather and a weight are tied to a string and thrown into the air with a stick and must be caught with the same stick (Konner, 2010).

Examples from around the world show that JPAP does not always take place in a strictly play (or function-free) context. In many cultures, children work from a young age and this work can include play behaviour. As part of the Six Cultures study (Whiting & Whiting, 1975), a community of Kenyan children were found to exhibit the least amount of play compared to the five other cultures. This was attributed to relatively larger amount of work activity that filled their days, such as boys herding cattle and girls tending to infants. Nevertheless, the children (especially boys) often incorporated play-like activities into their work. For example, a group of boys was observed 'messing around' in a watering hole, swimming and laughing, while the cattle they were herding refreshed themselves (Edwards, 2000). In a separate study, Oke et al. (1999) noted that young girls in India who worked as 'rag pickers' still engaged in chase games with one another while they picked rags. These activities, though observed within the context of work, could be considered JPAP, as the children are clearly engaged in physically active play activity with each other, running, laughing and playing together, despite the work task taking place in parallel.

It is clear from this evidence that JPAP exists across cultures and settings. Even when children face environmental restrictions or are engaged in obligatory work, they make adjustments and create opportunities to engage in JPAP. Though JPAP is anecdotally documented throughout educational and anthropological observations, it has not been systematically studied. Instead, all the individual components of JPAP – joint action, PA, and play - have typically been independently examined, with PA receiving the most attention from researchers. Given the established importance of each of these features and that they often co-occur in children's daily lives as JPAP, more attention should be paid to the effects following these combined features, rather than considering them in isolation. In the next section, I will provide a summary of main research strands and findings from these

independent literatures and identify gaps that the proposed research will aim to address.

2.3 Physical Activity: Physical Health, Emotional Health, and Cognitive Findings

Questions concerning the benefits of PA have attracted increasing attention within the academic community. Research efforts have been primarily focused on physical, emotional, and cognitive outcomes, but have largely ignored social outcomes that may arise from PA. Although associations have been made between sedentary behaviour and depression, more studies are needed to examine possible links between PA and social outcomes.

2.3.1 Physical Health

In recent years, childhood obesity has become a rising health concern internationally. In light of this phenomenon, many researchers have conducted studies to investigate the effects of children's PA on health. In a recent review article by Strong et al. (2005), regular PA (30-60 minutes of moderate PA three-to-seven times per week) was shown to reduce overall body fat and adiposity in overweight youth. The review also reports improvements in triglyceride levels, insulin levels, and adiposity in overweight adolescents after an intervention program of 40 minutes of moderate to vigorous PA three times per week. Several studies correlate PA with improved skeletal health, such as improved bone mineral content and density (Baily, McKay, Mirwald, Crocker, & Faulkner, 1999; Janz et al., 2001).

Much research has focused on determining whether children are getting the recommended amount of PA (60 minutes per day of moderate to vigorous PA (MVPA), Strong et al., 2005) along with contributing factors to children's PA. Lopes, Vasques, and de Oliveira Pereira (2006) observed 6-10 year old school children in Portugal during 30 minute recess sessions. They found that children were, on average, physically active for 50% of the recess period (i.e. 15 minutes), with most PA being moderate (3.0-5.9 METs [Metabolic Equivalent Task] based on accelerometer counts). Physical activity was observed to take place in short-burst episodes with the modal episode lasting 3 seconds. This study confirmed the patterns of children's PA as transient with short bursts varying in intensity from moderate to very vigorous.

Although this research contributes data of crucial value for understanding and improving

children's physical health and well-being, the scope is very narrow. MVPA is important for physical health, but for children, MVPA may also have social benefits, which current research on physical health has overlooked. Much of children's MVPA takes place socially. Indeed, popular and pervasive chase games, such as the previously mentioned 'crocodile' or 'quick tag' games, cannot be played alone. This project will investigate the social outcomes of children's PA, potentially identifying novel social health benefits of MVPA in childhood.

2.3.2 Emotional Well-being

In addition to physical health effects, PA has been associated with improved emotional health and well-being. In a study of 147 adolescents (13-17 years old), high intensity exercise (as compared with moderate intensity, flexibility training, and no exercise) was shown to decrease feelings of anxiety/stress and depression among adolescents. Questionnaires about life events, stress levels, illness, and exercise habits also revealed that participants who reported greater frequency of exercise also reported less stress, suggesting that exercise acts as a buffer against stress and depression in adolescents (Norris, Carroll, & Cochrane, 1992). One study (Williamson, Dewey, & Steinberg, 2001) looked at mood change in 64 9-10 year old children (30 girls) after two sessions of 15-minute aerobic exercise and a "control" video-watching session (an anti-smoking video). One exercise session was spent running around the gym at school and the other was spent playing with volley balls or jump rope. Positive mood increased after both exercise conditions, while negative mood decreased significantly. Further experimental research, in which social exercise conditions are compared with control conditions, is required to isolate the mood effects and underlying mechanisms of physical exercise performed with and without others.

Three separate meta-analysis articles on mental health effects from PA (Biddle & Asare, 2011; Suchert, Hanewinkel, & Isensee, 2015; Poitras et al., 2016) have recently evaluated the published effects of PA on the mental health of children and adolescents. They concluded that PA, when compared to a no intervention approach, can reduce symptoms of depression, but the evidence is limited. Similarly, Biddle and Asare (2011) state that a small beneficial effect exists between PA and anxiety reduction in young people, however this evidence is also limited. Suchert, Hanewinkel, and Isensee (2015) point out that high levels of screen time (sedentary behaviour) are associated with lower levels of psychological well-

being, lower levels of perceived quality of life, and higher levels of internalising behaviour (i.e. social withdrawal, sadness, difficulty concentrating) . Overall PA was positively associated with psychological/social and cognitive health, but the evidence from individual studies was often inconsistent (Biddle & Asare, 2011; Suchert, Hanewinkel, & Isensee, 2015; Poitras et al., 2016). Though the PA-mental health link in children is still under-explored, evidence for a physical *inactivity*-mental health link is growing, with some evidence now suggesting a negative association between mental health and sedentary behaviour (Barkley, Salvy, & Roemmich, 2012; Suchert, Hanewinkel, & Isensee, 2015).

2.3.3 Physical Activity and Cognitive Function

Many studies have associated PA with specific aspects of brain function and cognition. For example, a review by Colcombe and Kramer (2003) analysed 18 studies of older adults (55-80 years old) and found that exercise increased cognitive performance (speed, visuospatial, controlled processing, and executive control) by half a standard deviation (a moderate effect) when compared to pre-test and control groups. Effects were greatest for tasks that required higher amounts of cognitive control. Studies on school-age children (4-18 years old) have found a positive relationship between PA and improved cognition, though memory was unaffected by PA in these studies (Sibley & Etnier, 2003; Hillman, Erickson, & Kramer, 2008). Among 8-12 year old children, aerobic running (with incremental increases in distance, interval workouts, and relay runs) has been shown to improve the cognitive flexibility and creativity (for review, see Diamond & Lee, 2011). Furthermore, among overweight 7-11 year olds, those placed in a high-dose aerobics condition improved working memory and maths skills over those placed in a no treatment condition (2011). Biddle and Asare's review (2011) concluded that studies supported an association between PA and improved cognitive functioning, classroom behaviour, and academic performance.

In 2014, the Society for Behavioral Medicine issued a statement in response to the widespread reduction of available time for school age children to spend in recess and physical education classes at school: “elementary school-based PA supports academic achievement” (Buscemi, et al., 2014, p. 436). Recent research has explored this relationship between children's PA and academic performance. The California Department of Education (2001) conducted a study to compare physical fitness levels (as measured by a field test in

aerobic capacity) against standardised test scores in mathematics and reading among school-age children. The data revealed a positive relation between test scores and physical fitness. These findings are consistent with evidence that reading and mathematics activate many of the same brain regions as PA, which some have argued supports a functional relationship between PA and cognitive functioning (Hillman, Erickson, & Kramer, 2008). Researchers suggest that some of these cognitive benefits derived from PA may be a result of increased production of Brain-derived Neurotrophic Factor (BDNF), a protein that promotes the growth and survival of new neurons in the hippocampus, a brain region vital for learning and memory. For example, BDNF is upregulated following acute bouts of PA in rats, young adults, the elderly, and patients with multiple sclerosis (Vaynman & Gomez-Pinilla, 2004; Cotman & Berchtold, 2002; Gold et al., 2003; Laske et al., 2010), while blocking BDNF signalling has been shown to abolish the positive effects on learning and memory (Vaynman & Gomez-Pinilla, 2004).

Other cognitive benefits of PA may be found in studies of behavioural outcomes from patients with autism, and epilepsy. In one study, vigorous PA was shown to reduce stereotypic autistic behaviours, while playing catch yielded no systematic changes (Kern, Koegel, & Dunlap, 1984). Eom et al. (2014) found that after participating in a therapeutic exercise program, 8-12 year old children with epilepsy reported improvements in neurocognitive domains (visual and auditory attention, undivided and divided attention, inhibition/disinhibition, and psycho-motor speeds), while parents observed decreased internalising behavioural problems and social problems with increased wellbeing.

Panskepp (2007) suggests additional support for a cognitive functioning-PA link in children with ADHD. He argues that the prevalence of children being clinically treated for ADHD (i.e. treated with psychostimulants) may be a result of a widespread lack of opportunity for children to engage in active social play, as children are often asked to sit and behave as adults do for extended periods of time at school, and play breaks are diminishing, if they exist at all in many schools. Furthermore, Panksepp predicted that daily physical play would reduce symptoms of ADHD in children. A study conducted by Verret, Guay, Berthieaume, Gardiner, and Beliveau (2010) found that, in an experimental group of 7-12 year old children with ADHD, a moderate to vigorous PA programme improved motor skills, behavioural

outcomes (as observed by parents and teachers), and information processing as compared to a control group. Furthermore, a recent review article found that a bout of 30 minutes of physical exercise improved executive functioning (i.e. impulsivity, vigilance, reaction time, inhibitory control, selective attention, and problem solving) in children with ADHD. However, only three studies met the inclusion criteria, so the findings require further replication to offer reliable support (Grassmann et al., 2014). Together, these findings suggest a causal relationship between PA and behavioural outcomes, adding substance to Panksepp's claim and further suggesting varied benefits of physical play.

In summary, the cognitive, behavioural and health and well-being benefits of children's PA have been researched from many angles. Links have been made between PA and improved physical health, cognitive functioning, and mood, while physical inactivity has been associated with depression. Comparative evidence suggests that increases in BDNF may contribute to improvements in cognition. Although PA has been associated with improved individual behaviour in children with ADHD and epilepsy, researchers have not sought to explore social outcomes from PA. The next section will explore this question by examining some core components of JPAP and their links to sociality.

2.4 JPAP and Sociality

Sociality is inherent to JPAP, as joint activity cannot happen alone. However, what is the cognitive basis for joint activity in the first place? How are humans capable of coordinating their movements and intentions and how might this relate to social bonding? This section seeks to review relevant perspectives on these questions and set the stage for JPAP as a primary context for social bonding among children. Below, I develop arguments for social bonding effects of four specific elements of JPAP - 1) physical exertion; 2) touch; 3) enjoyment; 4) joint (and synchronous) action. These are given theoretical and empirical primacy on account of their convergence and prevalence in children's JPAP and their known or hypothesised links to social bonding in the wider literature.

2.4.1 Exertive Activity

One obvious avenue in which to explore social bonding effects in PA is in the sport context. However, much of the literature focuses not on teammate social bonding, but on

psychosocial and behavioural influences from adults, such as coaches and parents (Sallis & Owen, 1999; Smith, 2003; Turman, 2003), and team cohesion in relation to performance or goals (Carron, Bray, & Eys, 2002; Evans & Dion, 1991). Furthermore, although many children participate in and enjoy sport, it has been reported that children may 'burn out' due to sustained participation and parental pressure (Coakley, 1992; Coakley, 2006; Kanters & Casper, 2008), leading to stress, boredom and sport drop-out (Coakley, 1992; Siegenthaler & Gonzalez, 1997). For these reasons, a competitive sport context will not serve as the primary context of this study.

Outside of organised sport, spontaneous play offers rich opportunities for social interaction. Though benefits from play have largely been thought of as deferred, rough and tumble play (R&T) – particularly for boys – may have an immediate function for learning and practising social signalling (Bjorkland & Pellegrini, 2000). R&T play has been observed more often in boys than girls and, among elementary boys, it has been associated with certain aspects of social competence such as peer affiliation and social problem-solving flexibility (Humphreys & Smith, 1987; Pellegrini, 1989; Pellegrini, 1995). R&T play can be viewed as a group hierarchical measure, used to establish group leadership and assess the strength of others (Pellegrini & Smith, 1998; Bjorkland & Pellegrini, 2000). For example, Fagen (1981) described R&T as 'play fighting', where players alternate between dominant and inferior roles in order to establish cohesion – a primary benefit of social play. According to Altmann (1962), R&T follows a 50/50 rule where, as long as players spend equal amounts of time in dominant and inferior roles, a fair (or cooperative) relationship among equals is established. However, if one player spends more time in the dominant position, it becomes competition, where a dominance relationship is established. This is observed more clearly across age groups, where younger boys engage in R&T as cooperative play whereas older boys (approaching puberty) engage in R&T as a display of dominance, often to victimise someone perceived as less tough (Pellegrini, 1994).

In a longitudinal playground observation study by Humphreys and Smith (1987), three age groups (7, 9, and 11 year olds) were observed during recess every school day for three six-week terms. During this time, researchers looked for instances of initiated R&T and response, which was coded as reciprocated R&T, sociable (responded with either non-R&T

social locomotor or passive act), no response, or break of contact. About a third of the R&T initiations were reciprocated, and 'stayed together' outcomes (either R&T or sociable exchanges) were 76.2% for 7 year olds, 64.4% for 9 year olds, and 80.3% for 11 year olds. Further, R&T partners reported higher ratings of liking each other than a chance pairing of classmates would have yielded at all ages (Humphreys & Smith, 1987). Indeed, these correlational observations are congruent with established findings on children's peer preferences in that reciprocity is considered an important predictor of liking, whereas aggression is a strong predictor of disliking, suggesting that engagement in cooperative R&T play may lead to greater social affiliation among peers. Although, Humphreys & Smith detailed the types of play behaviours they considered R&T, they did not specify which behaviours were associated with the highest liking ratings or 'stay together' ratings, which could indicate specific play behaviours (e.g., running side by side, playing 'tag', tug-of-war) that could serve to facilitate social bonding in the context of JPAP.

One recent study has made progress in exploring the specific play behaviours that may influence social bonding. In this study, two types of physical play activity (exercise play and R&T play) were coded and analysed from 148 preschool children in order to determine if one type of physical play better predicts social acceptance over the other (Lindsey, 2014). Individual sociometric interviews were first conducted to determine each child's level of peer acceptance. This measure was obtained by each child rating each other child's photograph by placing the photo into a box labelled as someone they like to play with 'a lot' (with a big smile on the box), 'sometimes' (with a smaller smile on the box), or 'only a little' (with a flat-mouth expression on the box). Peer acceptance scores were determined by averaging each child's score from 1 ('like to play with only a little') to 3 ('like to play with a lot'). Over the course of the year, each child was observed, on average, for 120 minutes (in 5 minute scans). Behaviours coded were 1) social involvement (alone, with peer(s), with adult(s), with peer(s) and adult(s)), 2) if with peers, whether they were same gender, other gender, or mixed gender, and 3) activity type (play [exercise or R&T], instructional activity [i.e. reading or constructing art], eating [having a snack], conversation [talking to others], on-looking [not engaged, but watching activity of others], other [activity not otherwise specified]), or no activity. If children were engaged in play, further categorization was coded as either exercise play (e.g. running, jumping, climbing, skipping, tumbling, spinning, or

swinging), and R&T play (e.g. tickling, wrestling, grappling, restraining, boxing, play fighting, kicking, hit and run, and chasing). Lastly, exercise play was further coded as either toy-mediated (i.e. with jump rope) or not. Analyses revealed that children who had higher levels of toy-mediated exercise play were more highly accepted by their peers (i.e. received more 'like to play with a lot' ratings). However, toy-mediated exercise play with mixed-gender peers was significantly correlated with peer acceptance only among girls. Non-mediated exercise play with same gender peers was significantly correlated with peer acceptance among girls, but not boys. For boys, high engagement in a) mixed gender chasing and b) same gender R&T (chasing and fighting) was significantly correlated with peer acceptance. Lindsey's study contributes to the argument that JPAP may lead to social bonding in that it supports an association between peer acceptance and PA play. However, because this study was correlational, conclusions about JPAP as a predictor for social bonding cannot readily be drawn.

A major strength of this study is that it highlights the importance of exercise play (running, jumping, climbing), which, in terms of physical activity play, has previously been overshadowed by the interest in R&T play and its links with sociality among boys. Given the frequent occurrences of exercise and R&T play and their correlations with peer acceptance, it seems plausible that PA may be an important and overlooked facilitator of social bonding among children. Furthering this idea, one recent study from adults (Di Bartolomeo & Papa, 2017) found a causal link between PA (versus a sedentary control) and pro-social behaviour (greater sharing in an economic game), suggesting a direct relationship between PA and social bonding. However, no studies in children have attempted to test this relationship directly.

Across the broad spectrum of children's social and play activity, PA seems to be an important influence on social relations among peers. Glass and Benshoff (2002) found that, after participating in a one day challenge course involving low-level PA in groups of 11-15 people, 11-14 year old children reported feeling closer to one another on a group cohesion scale. As there was no control group, however, it is possible that students simply felt closer to one another as a result of time spent together, rather than any PA effect.

Studies of children's PA have reported that children achieve higher levels of PA when engaged with close friends. For example, Jago et al. (2011) investigated the influence of perceived best friends on 10-11 year old children's PA behaviour. Boys and girls who engaged in PA with their best friend outside of school showed higher overall levels of PA than those who engaged with their best friend only at school. Boys with best friends who were more physically active engaged in higher levels of MVPA than boys whose best friends were less active. Girls who frequently participated in PA with their best friend engaged in more overall MVPA per day than girls who participated in PA with their best friend less frequently.

In a separate line of research, it has been established that children achieve higher levels of PA and enjoy physical activity more in the presence of their peers rather than alone (Sanders et al., 2014; Jago et al., 2011; Rittenhouse, Salvy, & Barkley, 2011). Sanders et al. (2014) found increases in the levels of PA achieved by children who engaged in PA with even a single friend (though the effect was greatest with a group of friends), compared to the same activities completed alone. Twenty-four children (12 girls, 12 boys) between the ages of 6 and 10 participated in three different conditions (playing alone, with a single friend and with a group of friends) on three different days. All participants were given multiple options to play with age-appropriate toys and games in a gymnasium throughout the study and activity data were collected on accelerometers attached to each child's hip. Children were instructed to play with any toy or game they preferred for 30 minutes. After the time expired, they were given the opportunity to play for an additional 10 minutes. The study found that the group condition yielded the highest PA levels in the additional 10 minutes, as measured by accelerometer counts, compared to the alone and single friend conditions. From the alone condition, only 33% of children chose to participate in the additional time at all, while 92% of children in the single friend condition and 100% of children in the group condition chose to play an additional 10 minutes, suggesting that friendship groups have a positive influence on PA. If this is the case, might there be a reciprocal relationship between PA and friendship?

There is some evidence suggesting a reciprocal relationship between PA and friendship from a descriptive study of school-based friendship networks (MacDonald-Wallis, Jago, Page,

Brockman, & Thompson, 2011). Accelerometry data and self-reported friendship data were collected and analysed from 559 10-11 year old children across 40 schools in Bristol, UK during the 2008-2009 school year. Children were found to cluster together in friendship groups with similar PA levels. Furthermore, similarity in PA levels decreased with each degree of separation. In other words, the closer the stated friendship, the more similar the PA levels. Further support comes in a longitudinal study from De la Haye, Robins, Mohr, and Wilson (2011) where 378 Australian eighth grade students were surveyed about their PA habits, preferences, and friendships at three different times during the school year. They found that students befriended peers with similar PA levels and emulated their friends' behaviours throughout the year, suggesting a reciprocal relationship between PA and friendship. This relationship speaks to the possible relevance of PA as a context for affiliation and social bonding, and vice-versa. This relationship is further demonstrated by an association of sedentary behaviour with social isolation. Barkley, Salvy, and Roemmich (2012) found that children who experienced an experimental prime of social exclusion participated in less PA compared to controls. Expanding on this study, Rittenhouse and Barkley (2013) used self-report questionnaires to measure overt (i.e. threats of physical violence) and relational (threats of harming peer relationships) peer victimisation of overweight and non-overweight boys prior to a 30 minute session of free-choice activities in a gymnasium. Activity options for the session included modified hurdles, a ski jump, jump rope, kicking a soccer ball around a series of cones, soft footballs, a flying disk, shooting a basketball, a standing long jump, and an obstacle course. Sedentary options included drawing, crossword puzzles, word finds, magazines, and the matching game “Perfection”, all located at a table with two chairs. Physical activity was measured by accelerometry data taken every 60 seconds and averaged over the 30 minute session. Overweight boys reported significantly higher levels of both types of victimisation compared to non-overweight boys, while accumulating significantly fewer accelerometry counts and significantly greater time spent in sedentary activities. These studies not only illustrate the negative impact that social exclusion can have on children’s physical health, but also support the existence of a relationship between social bonding and PA. Indeed, social bonding deficits were associated with reduced PA and increased peer victimisation.

An increasing number of studies with adults suggest that physically exertive activity may activate neuropharmacological reward and analgesic mechanisms, which are also implicated in mammalian social bonding. The two main systems are the opioidergic system, specifically beta-endorphins (commonly known as the body's endogenous morphine) and the endocannabinoid system (commonly known as the body's endogenous cannabis). Both systems are involved in pain management and pleasure. Boecker et al. (2008) provided the first direct evidence for opioidergic activation by exercise, substantiating a specific role for the endogenous opioid system in the generation of the euphoric 'runner's high' sensation (feelings of improved affect and a sense of calm often experienced during or after endurance exercise). Furthermore, Raichlen et al. (2013) found that moderately intense exercise (70-80% of maximum heart rate [HR]) yields the highest increase of endocannabinoid levels (functionally similar to endorphins, but chemically different endogenous neurotransmitters) in the bloodstream when compared to low and high intensities. Moreover, joint PA appears to further stimulate this response, as evidenced by college rowers experiencing increased pain thresholds after engaging in group synchronous rowing, as compared to rowing alone (Cohen et al., 2010). The combination of these findings suggests an association between group PA, exertion, and social bonding that works by activating neuropharmacological reward mechanisms. Indeed, there is growing evidence to support this link in the adult literature, but little is known about the activation of reward mechanisms and related social bonding effects in children's PA.

Direct neurohormonal evidence from children is lacking, as it is both procedurally difficult and ethically problematic to obtain. However, one study suggests that an exercise-induced endogenous opioid mechanism in children may be plausible. Bouix et al. (1994), conducted an experiment showing significant increases in beta-endorphin levels of pubertal and prepubertal normal short children (children presenting growth retardation) after 15 minute exercise tests on cycloergometers. Forty children (24 boys, mean age 12.85; 16 girls, mean age 10.87) cycled as intensity was gradually increased up to 90% of the participants' maximum HR. Blood samples were taken just before, just after, and 10 minutes following the exercise test. Plasma beta-endorphin concentrations were measured using radioimmunoassy. Thirty out of 40 children (75%) experienced significant increases of plasma beta-endorphins following the exercise test. Bouix et al. (1994) states:

> Although caution is needed in extrapolating our results to the general child population, it seems reasonable to hypothesize that the increase in B-endorphin which is found in both normal adults and normal short children does also occur in children of normal height (p. 197).

This study offers support for an exercise-induced opioid response in children, though there is to date no study measuring the effects of exercise on endorphin activity in the brain and associations with psychological states and social behaviours. Despite the existence of non-invasive proxy measures (e.g., via pain threshold tests), researchers have neglected further exploration of this link. This is surprising, given the observable enjoyment of play and PA displayed by children and the widespread claims within popular media that children should play and exercise, specifically because this releases endorphins (i.e. kidshealth.org, healthline.com).

Although very little is known about an underlying opioid response from PA in children, there is a vast literature from cross-species play studies, in which neuroscientists have made significant advances in understanding brain mechanisms behind R&T play of lab rats. These animals are remarkably social. Their play behaviours and motivations have become easily identifiable in lab conditions, and due to their sensitivity to social isolation, experimental observation is time efficient (Siviy & Panksepp, 2011). Studies performed on the lab rat provide strong evidence for an opiate-mediated social play reward mechanism. Trezza et al. (2011) found that exogenously administered morphine in the nucleus accumbens (a brain region known to be associated with positive social interactions in humans; Guroalu et al., 2008) stimulated opioid receptors and increased pinning and pouncing behaviour in rats, while administration of Naloxone (an opioid-receptor blocker) disrupted the play-enhancing effects of morphine. Although animal models have limited applicability to questions about human cognition and behaviour, these findings may offer support for an opioid mediated mechanism during social play. Recent experimental work among adult humans supports the opioid mediated response from exertive PA (dance) on social bonding (Tarr, Launay, Cohen & Dunbar 2015; Tarr, Launay & Dunbar 2016). Though no studies have tested this theory on child samples, these non-human and adult human studies offer promising support for a causal mechanism that could link JPAP and social bonding in children.

In addition to endorphins and endocannabinoids, some studies have implicated a role for the brain dopamine system in regulating play behaviour (Burgdorf, Wood, Kroes, Moskal, Panksepp, 2007). This system is closely associated with reinforcing value ('wanting') of addictive drugs and tasty food in humans, but also known to play a significant role in maternal behaviour in rats and pair-bonding in prairie voles (Insel, 2003). A recent study from Roemmich et al. (2008) examined the association between relative reinforcing value (RRV), liking of PA, and how much time children spend in moderate to vigorous PA (MVPA). Researchers used a combination of accelerometer data (to measure children's normal daily MVPA), liking ratings for various physical activities and television programmes, and RRV. The RRV was determined by the number of times children were willing to press a button to gain access to either preferred physical activity or preferred television programme. The RRV and liking of PA were independently associated with time in MVPA. Children who had a high RRV and high liking of PA engaged in more MVPA than other children. The RRV and enjoyment of PA may therefore influence the amount of MVPA children engage in. Given that 'liking' is associated with the opioid system and elevated mood while 'wanting' (RRV) is associated with the dopamine system and potentially social preferences (Berridge & Robinson 1998, 2003; Berridge, 2004) – at least in other mammals - there may be combined effects of an integrated opioid-dopamine network activation in JPAP, which could facilitate social affiliation and bonding.

2.4.2 Touch

Touch is commonly observed both in PA and social interactions, although the frequency with which touch is used in social interactions can vary depending on cultural region (Mazur, 1977; Thayer, 1988; Remland, Jones, & Brinkman, 1995; Dibiase & Gunnoe, 2004). Touch is a prevalent feature within the context of children's play and has been linked with mother-infant bonding (Feldman, Eidelman, Sirota, & Weller, 2002) and social aggression among children (Field, 1999a; Katsurada, 2012) and adolescents (Field, 1999b) across cultures. This is important for social bonding in children, as studies suggest that aggressive children may suffer a significant disadvantage in forming friendships. For example, Hayes (1978) found that the highest rated dimensions for "disliking" among children were 'aggression' and 'aberrant behaviour'. Even aggressive children prefer to socialize with non-aggressive

children (though this may be a result of aggressive children seeking victims) (Snyder et al., 1997; Hektner, August, & Realmuto, 2000).

There is also evidence for a negative correlation between aggressive behaviour and amount of interpersonal, physical touch. For example, in observational studies from pre-schoolers on playgrounds in Miami, USA and Paris, France, researchers compared the frequency of touch between children, their mothers, and their peers. They found that children in France touched their mothers and peers significantly more frequently than the US children did, and exhibited significantly less aggressive behaviour on the playground, compared to the US children (Field, 1999). Katsurada (2012) later followed the same model by examining the relationship between Japanese children's physical affection with their parents and their aggressive behaviour. The methodology differed from Field's observational study in that parental physical affection was measured by self-report and child aggression was measured by teacher report. In line with Field's results, it was found that children who received more physical affection from their parents were less likely to receive highly aggressive ratings from their teachers. Together, these studies offer support for an association between touch and sociality among children in that greater amounts of touch are associated with less aggression, a key contributor to social bonding in children.

In addition to associations of aggression, touch has been empirically shown to convey clear emotions -anger, fear, disgust, love, gratitude, and sympathy – which, with the exception of gratitude, are communicable even through visual observation alone (Hertenstein, App, Bulleit, Jaskolka, & Keltner, 2006). For young children observed at a day care facility, affectionate touch (hugging, kissing, and stroking) decreased from infancy into the toddler years (Field, Soliday, Lasko, Gonzalez, & Valdeon, 1994). However, frequency of affectionate touch during the first half year of life was a predictor in reciprocal communication during the second half year (Field, 2010), suggesting touch was important for social development.

It has been well documented in adults that even brief touch can influence behaviour, such as increase tipping (Crusco & Wetzel, 1984), returning lost money (Kleinke 1977), and spontaneous helping (Guéguen & Fischer-Lokou, 2003; Paulsell & Goldman, 1984). Furthermore, social touch (in the form of social grooming) is well-known as a form of social

bonding among non-human primates (Dunbar, 2010; Seyfarth & Cheney, 2011), offering further support for a social bonding function of touch from an evolutionary perspective.

Similar (and in some cases, the same) neurohormonal mechanisms linking physical exertion to social bonding have also been implicated in touch, synchrony, and enjoyment. For example, social touch has been associated with endorphin-mediated social bonding in non-human primates (Dunbar, 2010). Oxytocin, which is thought to play a crucial role in mother-infant bonding in humans and pair bonding in mammals more broadly, may also influence affective responses to social touch in humans (Light, Grewen, & Amico, 2005). Several studies have documented positive physiological and biological responses to touch, including decreased cortisol (stress hormone), increased oxytocin, and lower blood pressure and HR (see Field, 2010). It may be that social touch lowers stress, releases oxytocin, and creates a psychological environment that enables positive social interaction over time.

An additional mechanism for social bonding from touch may come from its processing through CT fibre pathways. It is know that C Tactile (CT) nerve fibres are sensitive to light mechanical stimulation (e.g., stroking) to hairy, but not glabrous (non-hairy) skin (Johansson & Vallbo, 1979; Vallbo, Olausson, & Wessberg, 1999). This produces pleasant hedonic feelings to the receiver of the touch. The speed of stroking is crucial, with 1-10 cm/s - the equivalent of a gentle caress - being most favourable for eliciting CT activation (Löken, Wessberg, McGlone, & Olausson, 2009). Furthermore, it has been suggested that specialized pathways exist for processing social or affective touch, which start at the CT fibres of hairy skin and work alongside processes in the insula and orbitofrontal cortex, which are associated with affective processing (Olausson, et al., 2008; Morrison, Loken, Olausson, 2010).

Although this specialised mechanism for social touch may be plausible for slow, gentle touch of hairy skin, it is not likely applicable to the research here, as touch normally observed among children at play or engaged in PA does not fit this description. Rather, bonding may occur via a touch-based communication mechanism. Hertenstein et al. (2006) found that distinct emotions can be conveyed by strangers through touch – even without seeing or hearing one another. In one study, participants were on either side of a curtain

with one designated as the encoder and the other the decoder. The encoder was given a number of emotions to convey to the other person by only touching their arm. The decoder then had to determine what the touch message was by choosing from a list of possible emotions. The decoders were able to distinguish distinct emotions – fear, anger, disgust, love, gratitude, and sympathy – with 48% – 83% accuracy. This ability to communicate through touch may have major implications for social bonding, as communication of emotions is important for cooperation and in the formation and perceptions of trust. Cooperation and trust, in turn, are indicators of social bonding (Loomis, 1959).

A recent study of athletes and coaches perceptions of touch provides evidence for communication as a mechanism for social bonding through touch. Interviews revealed touch to be a way to communicate support and recognition between athletes and between coach and athlete. For example, one male basketball/tennis coach described touch as "a way of congratulating somebody". He continues, "In both basketball and tennis I remember winning championships and the player coming over and hugging me. You feel close to them and there's a feeling that you accomplished what you set out to do" (Kerr, Stirling, Heron, MacPherson, & Banwell, 2015, p.59). Touch was also reported to communicate reassurance, consolation, or comfort after a loss or sub-optimal performance. Moreover, touch was reported to specifically enhance bonding between athletes and coaches by the coach patting athletes on the back, while cohesion among the team was said to be enhanced by use of high fives and fist bumps. This study supports communication and support mechanisms for social bonding through touch, specifically within a PA context. The same mechanisms are likely relevant for touch during children's play and PA. As compared with sedentary play activity, for example, JPAP is a rich context for physical communicative exchange among participants.

Cultural anthropologist Alan Page Fiske (1991, 2004) has described touch as a key element of a 'communal sharing relationship' (one of four 'basic social bonds' he describes as fundamental to all social relationships). According to Fiske, when people engage in communal sharing (such as eating or dancing together), they convey embodied cues of self-other overlap. Interpersonal touch indicates a communal sharing relationship by referring to the sharing of a common substance – the touch, itself – creating the perception of a merged

social body (Fiske 1991, 2004). Moreover, the same mechanism of self-other overlap may be shared with joint action/synchronous movement and shared enjoyment in that they all involve shared experience which can signal self-other overlap. Therefore, it may be that in addition to each of these components of JPAP contributing some element of social bonding, some components may contribute to social bonding via the same underlying mechanisms.

Several ethnographic descriptions of children's play make mention of children holding hands (Long, 2013), playing clapping games (Pellegrini, 1990; Bishop & Burn, 2013), and shaking hands in reconciliation (Evaldsson & Corsaro, 1998). However, these studies only mention these instances of touch as part of larger observations of children's playground experiences generally and have not detailed the frequency or duration of the touch, much less any resulting behavioural correlations. This project will seek to begin to fill this gap in the empirical literature by observing and measuring the links between touch and bonding in JPAP. Touch, with its communicative properties, widespread prevalence within children's play, association with less aggressive behaviours among young children, and developmental and evolutionary links to social bonding may foster friendship within the context of children's play. Friendship bonds, in turn, may predict the frequency of affiliative touch in play.

2.4.3 Enjoyment

Social bonding within JPAP may also be influenced by shared hedonic experience. Throughout the ethnographic literature on children's play, one of the most commonly reported observations is that children are having fun when engaged in play activity together. Even with the widely different definitions of play, all play theorists agree that play is *fun*. Once the fun stops or the activity is no longer enjoyable, play will often cease (Gray, 2009). Following from this, children engage in activities that they like and they like other children who like the same activities (Hayes, 1978). Therefore, enjoyment may play a mediating role in social bonding during play and other shared activities.

There is evidence that shared enjoyment of an activity or experience may have a positive impact on social bonding. According to Waugh and Fredrickson (2006), positive emotions can cause people to be more sociable and have more successful social interactions. For

example, one study found that positive emotions led to a greater likelihood of initiating conversation with a stranger (Isen, 1970). Conversely, induced social interactions between strangers has been shown to increase positive emotions, suggesting a reciprocal relationship between positive emotions and sociality (McIntyre, Watson, Clark, & Cross, 1991; Vittengl & Holt, 2000).

In addition to general enjoyment of shared experiences, enjoyment (or 'liking') is associated with PA in children (Dishman et al., 2005; DiLorenzo, Stucky-Ropp, Vander Wal, Gotham, 1998). For example, DiLorenzo et al. (1998) completed a three year longitudinal, within-subjects study to determine factors that may predict PA among youth. They used structured interviews and PA questionnaires with 54 boys and 57 girls in the fifth and sixth grade, along with their parents. The study revealed that, for the youngest group (fifth and sixth grade students), enjoyment was the most important predictor variable for PA. By the time students reached eighth and ninth grade, enjoyment was not as important as peer and family social support or personal interest in PA (self-efficacy, knowledge of sport in media, etc.). Jago et al. (2009) found enjoyment to be the most important factor for sustaining participation in physical activities, based on recorded and analysed focus group discussions from 113 children, ages 10-11. Furthermore, studies have shown that children engage in greater amounts of PA when they are with their friends than alone (Rittenhouse, Salvy, Barkley, 2011; Sanders, et al., 2014). This evidence suggests (reciprocal) links among enjoyment, PA, and sociality in children.

Enjoyment – or 'liking' – is a measure of the hedonic value of a behaviour and is thought to be mediated by opioid response (Berridge & Robinson, 1998, 2003; Berridge, 2004). Dunbar et al. (2010) suggest an endorphin mechanism for the positive affect experienced from social laughter, for example. Researchers conducted a total of 6 studies using both laboratory (watching either comedy or documentary videos) or natural (outdoor comedy festival) conditions and found that social laughter is correlated with increased pain threshold, compared to control conditions. This was thought to suggest that the enjoyable act of laughing enhances positive affect by activating the endogenous opioid system, which is believed to play a crucial role in primate bonding (Curley & Keverne, 2005; Dunbar, 2010; Machin & Dunbar, 2011) and increasingly thought to play a role in human bonding (Dunbar,

2010; Cohen et al., 2010; Tarr, Launay & Dunbar, 2014; Tarr, Launay, Cohen & Dunbar, 2015; Tarr, Launay & Dunbar, 2016). Thus, it may be that when children participate in JPAP, they facilitate shared hedonic experience by activating neurohormonal reward systems that have been associated with social bonding, suggesting that the affiliative effects of enjoyment and joint PA may extend to younger children.

2.4.4 Joint and Synchronous Activity

Joint action, which underlies much social interaction in daily life, including physically active play, is defined by Knoblich, Butterfill, and Sebanz (2011) as "when two or more people coordinate their actions in space and time to produce a joint outcome" (p.59). Coordinating one's actions with another involves the interplay of behavioural skills, motor skills, action plans, perceptions, or intentions. Representational systems enable the planning of joint actions as shared intention, and are thought to be essential for understanding coordination in joint action (Knoblich et al., 2011). Joint activity often involves a great deal of joint attention, a type of intersubjective sharing, which Tomasello (1995) defines as two people experiencing the same thing at the same time *with the awareness* that they are doing this. This can be observed in actions as mundane as walking together (Wiltermuth & Heath, 2009) or having a conversation (Harrist & Waugh, 2002) to more elaborate activities like joint music making (Loehr, Kourtis, Vesper, Sebanz, & Knoblich, 2013; Kirshner & Tomasello, 2010) or dancing together (Tarr, Launey & Dunbar, 2014; Tarr, Launay, Cohen, & Dunbar, 2015; Tarr, Launay & Dunbar, 2016). This sharing of psychological state in such joint, synchronous activities is thought to blur the distinction between the other and the self (Ehrenreich, 2006; Hove & Risen, 2009; Wiltermuth & Heath, 2009), resulting in perceptions of increased similarity and bonding among participants.

Jointly engaging with others is a natural feature of human life from the start. From birth, parents engage their infants in face-to-face interactive exchange involving motor action, cooing, gazing, touching and smiling. These affectively rich, highly arousing social interactions are thought to tune the infant to the timing and structure of dyadic exchange (Bigelow & Walden, 2009). Throughout the first few months of parent-infant dyadic interaction, infants learn to anticipate the partner's affect and behaviour, while also learning to coordinate and adjust their own attention, affect, vocalisation, and motor action

with adult partners across a range of contexts (Bronwell, 2011). It is important to note that this early version of joint action merely requires the infant to be interested in, attentive to, and responsive to the adult's effort to establish a joint action – there is no inference or conscientious sharing of goals, representations, or desires.

The social, cognitive, and motor skills necessary for joint action develop further, as children engage with others and observe their behaviours. During the second half of the first year, dyadic activity expands to include objects, such as toys (Tomasello, 1995). This transition from dyadic (person-person) to triadic interaction (person-object-person) is important for the development of higher social and prosocial skills. It is in this stage that children begin to use communicative gestures like finger pointing in order to direct adult attention to another entity of interest (Tomasello, 1995; Yu & Smith, 2013). While dyadic interactions typically involve face-to-face, vocal, and gestural exchanges between an infant and an adult, triadic interactions require the infant and adult to attend to something together, simultaneously (Scaife & Bruner, 1975; Striano & Rochat, 1999). By around 12 months, infants are capable of understanding the emotions, perceptions, intentions, goals, and plans of others, which is crucial for joint action engagement. According to Tomasello and Rakoczy (2003), this ability to understand and coordinate with intentional agents (joint attention) is "the truly momentous leap in human social cognition in the sense that it already distinguishes human beings from other primates" (p.122).

By 16 months of age, children engage in coordinated play with familiar others (Eckerman, Davis, Didow, 1989; Eckerman & Whitehead, 1999), while cooperative play with peers starts to emerge at around 20-24 months (Eckerman & Whitehead 1999; Eckerman et al., 1989), further increasing between 24-28 months (Eckerman et al., 1989). In one study, when dyads were given a task in which both children could retrieve some rewards at completion, 3.5-, but not 2.5-year-olds, engaged cooperatively throughout the task, even after they already retrieved their rewards (Hamann, Warneken & Tomasello, 2012). Some have suggested that children younger than 30 months do not seem to recognise that their behaviour can influence a peer's attempt to achieve a goal (Brownell, Nichols, Svetlova, 2005). By the third year of life, children are able to engage in cooperative play and communication with peers, taking into account their peer's actions, desires, and intentions (Ashley & Tomasello, 1998;

Smiley, 2001) as well as cultural common ground (Tomasello, 2019). Moreover, children are able to infer the full range of mental states of others (beliefs, desires, intentions, imagination, emotions, etc.) when they have formed a Theory of Mind (ToM). This developmental milestone, normally fully established by age five, refers to children's ability to take other people's mental states into account when making judgments about their behaviour (Baron-Cohen, 2001). Children's orientation toward the other is further demonstrated during this period through the development of group mindedness or 'we-ness'. For example, by age five children create their own social rules with peers during play and pass these rules on to others as normative, suggesting an early understanding that social norms are based on collective agreement (Tomasello, 2019).

These social-cognitive developments enable humans to engage, collaborate, and cooperate with each other and are the platform from which social relations are built. Throughout the first few years of life, the timing of other people's actions appears to support the formation of causal links between people's intentions and actions as well as to align their own behaviours accordingly. It is from this social-cognitive foundation that sharing intentions and engaging in joint action arises (Knoblich & Sebanz, 2008).

Joint activity may induce feelings of closeness and cooperation among participants. One recent study of 4-6 year olds found that children who clapped and tapped in synchrony to a beat exhibited more helping behaviour in a helping task than children who clapped and tapped non-synchronously (Tunçgenç & Cohen, 2016), suggesting that synchronous activity among peers may lead to prosocial outcomes – an indication of social bonding – in children. Few other studies have investigated the effects of synchrony among children. Rather, behavioural synchrony in children has been studied largely among child-caregiver dyads correlating higher amounts of synchronous interactions between children and their caregivers to more socialised children in terms of communicative competence (Harris, Kasari, & Sigman, 1996; Tomasello & Farrar, 1986; Rocissano & Yatchmink, 1983) and adjustment at school (Harrist, Pettit, Dodge, & Bates, 1994). Parent-child synchrony may also be indicative of children's ability to engage in social play. For example, Vizziello, Ferrero, and Musicco (2000) observed children (pre-schoolers and toddlers) and their parents upon separation and reunion at day care. They found that children from high

synchrony dyads most easily integrated into peer play and were more likely to act as leaders compared to low and medium-synchrony dyads. Together, these data suggest that synchrony in children does have positive social effects.

Research on movement synchrony with adults and adolescents further supports this view by linking interpersonal synchrony to social psychological effects, such as increased affiliation and cooperation (Wiltermuth & Heath, 2009; Tarr, Launay, & Dunbar, 2014; Tarr, Launay, Cohen & Dunbar, 2015; Tarr, Launay, & Dunbar, 2016; Lang et al., 2016, Lang et al., 2017; Mogan, Fischer & Bulbulia, 2017). Though considerable focus has been paid specifically to synchronous joint activity, it may be that the joint nature of children's physically active play elicits similar mechanisms for social bonding (e.g. self-other overlap and activation of endogenous opioid system) by virtue of simply playing together versus in the same physical space. For example, even though Tunçgenç and Cohen (2016) found higher levels of prosociality following synchronous versus nonsynchronous engagement, there was no condition in which children played in the same space, but separately (i.e., a non-joint condition). It has been suggested that important components of joint action – goal sharing, perspective-taking, cooperation – are all present in children's social play (Hessen, Genty, Rossano, Zuberbühler, Bangerter, 2017). Moreover, it may be that joint action is more highly present in activities involving JPAP, as children's joint physical activities often require close coordination of bodies and intentions in order to maintain the flow of play. For example, games of chase, football, and R&T play all involve the shared goal to play together in the first place, high levels of coordination with others' actions, and even reading facial expressions to confirm an implicit agreement to continue playing. Although joint action will not be directly measured or independently tested as a predictor of social bonding in this project, it does contribute to the context and definition of JPAP in that JPAP is inherently *joint action* and may therefore utilise the same social bonding pathways as have been previously reported in joint action (and synchrony) studies.

Together, these findings suggest an important role for children's JPAP in social bonding elements, and support a joint action – social bonding link from infancy into adulthood. Related research suggests that shared hedonic experiences, not unlike those found

throughout children's play experiences, can act as social glue, making pleasurable experiences even more pleasurable. Interpersonal touch in infancy and preschool has been associated with improved social development in terms of reciprocity and decreased aggression – both strong indicators of positive friendship formation among children. Physical activity, which characterises a great deal of children's play, has been associated with physical, emotional, and cognitive health, friendship networks, and social exclusion, providing a rich context for the study of children's socialisation. Thus, JAPA is a context in which these elements known to be associated with social bonding converge with high frequency. Drawing from the ubiquity and enjoyment of play, the biological requirement of PA, the naturalness of joint action, and the subtlety of touch, does JPAP facilitate social bonding in childhood?

The evidence reviewed above suggests that JPAP is a prevalent feature in children's everyday lives and that there may be a JPAP-social bonding link, hinting that JPAP may result in heightened social cohesion. However, no controlled studies have been conducted to test this hypothesis. Studies of children's physically active play have thus far not explored immediate social outcomes, focusing instead on associations with socio-cognitive skills (see chapter 1, section 1.4.3 and chapter 2, section 2.3.3) and social influences of PA (see chapter 2, section 2.3.1). Perhaps this is due to the widespread view that benefits from play are deferred (see chapter 1, sections 1.4.1). However, children's natural physical play combines exertion, enjoyment, and touch, all of which are indirectly associated with social bonding, but have not been systematically investigated for a direct relationship. Clear associations from controlled studies would produce greater understanding of the process of social bonding generally and the moment of affiliation specifically. Investigation is needed in order to elucidate underlying mechanisms involved in social affiliation, which are currently unclear. I propose to do this by studying children engaged in JPAP, which incorporates all of these characteristics. Motivated by the existing evidence for possible causal mechanisms, and by the persistent gaps in the theoretical and empirical literature, this project proposes to conduct a preliminary investigation into the social bonding effects of physical exertion, social touch, and enjoyment in children's JPAP activities. This project will potentially be followed up in the longer term with deeper probes into the range of cognitive, neural, and physiological mechanisms linking joint PA and social bonding in early life.

2.5 Summary

Ethnographic evidence reveals the widespread, cross-cultural existence of JPAP across diverse contexts. Several characteristic features of JPAP have been suggested to influence social bonding in adults - notably, physical exertion, synchronous movement, touch, and enjoyment. However, the links between these features and social bonding have not been as widely explored in childhood, despite their prevalence in children's play. Previous studies on children's play activity have largely focused on describing play generally (as in ethnographic accounts of play), or in terms of the health benefits gained (such as physical, emotional, and cognitive outcomes). Furthermore, recent research has revealed a link between children's friendships and PA. However, there has been no systematic exploration of social affiliation and bonding as a result of joint PA in children. This project seeks to explore the relationship between these pervasive characteristics of children's play and social bonding by posing the following research questions:

Does MVPA generate more social bonds in children than light or sedentary PA? What role does affiliative touch play? What role does enjoyment/fun play? What role does exercise intensity play in the relationship between physical exercise and social bonding? These questions will be investigated across three studies. In chapter three I will describe a naturalistic observational study, which was conducted to chart the play landscape in terms of the theorised elements of interest. The study quantifies a) how much JPAP children naturally engage in during freeplay, b) how much MVPA, light, and sedentary PA children naturally engage in, c) the relationship between touch and PA, d) the relationship between enjoyment and PA, and e) the relationship between PA and prosocial behaviour.

Following on from the observational study, chapter four will describe the first experimental study to investigate the relationship between touch and social bonding in a controlled JPAP context. In chapter five, I will report the final study, which investigated the relationship between PA intensity and social bonding. This controlled experimental study looked specifically at social bonding behaviours as a result of MVPA compared to light PA. This study also explored the effect of PA on inhibition to approach an unknown stimulus, in

order to assess whether any bonding effects can be attributed to a general reduction in inhibition following MVPA.

Together, these three studies offer an initial indication of the social effects of JPAP and its components – touch and exertion – among children. These specific characteristics have been positively linked with social bonding among adults, while touch has been identified as an important facilitator of infant-caregiver bonding; however, these links remain under-investigated among school-aged children. The studies described here represent an initial attempt to fill this gap by first describing the naturally occurring, spontaneous JPAP and associated social behaviours, then isolating touch and exertion in experimental designs to explore causal links with social bonding.

3. The effects of JPAP on social behaviour in children: an observation study

3.1 Overview[2]

Much research has been dedicated to the investigation of children's physical activity (PA) and associated health benefits (for a review, see Janssen & LeBlanc, 2010). Apart from physical health benefits, attention has primarily been paid to the amount of PA children engage in and factors that may influence activity levels, such as social and affective factors. For example, peer influence has been positively associated with engagement and enjoyment of PA among children (Jago, Brockman, Fox, Cartwright, Page, & Thompson, 2009; Jago, Macdonald-Wallis, Thompson, Page, Brockman, & Fox, 2011; Rittenhouse, Salvy, & Barkley, 2011; Sanders, Peacock, Williamson, Wilson, Carnes, Barkley, 2014). Although, PA is an important contributor to children's physical health, this narrow line of investigation has overlooked a potential social bonding benefit of PA in childhood.

Several common components of children's PA are potentially causally linked with social bonding. For example, a growing body of research on adults suggests that endogenous opioids – known to play an important role in primate social bonding - are released during exertive PA (Boecker et al., 2008) and may facilitate social bonding in adults (Cohen, Ejsmond-Frey, Knight, & Dunbar, 2010) and adolescents (Tarr et al., 2015). Although there is evidence for an exercise-induced opioid response to exercise in children (Bouix et al., 1994) no studies have examined how this may be linked with social bonding. However, children's PA and various aspects of sociality have been linked across a range of studies. For example, higher amounts of MVPA is associated with larger group size (Sanders, Peacock, Williamson, Wilson, Carnes, & Barkley, 2014; Roberts, Fairclough, Ridgers, & Porteous, 2013; Ridgers, Stratton, & McKenzie, 2010; Woods, Graber, Daum, & Gentry, 2015). Further, children's MVPA has been strongly correlated among close friends at school and less correlated among more distant friends (Macdonald-Wallis, Jago, Page, Brockman, Thompson, 2011). Even having a single friend present can increase the length of time children engage in MVPA, as compared to being alone (Sanders et al., 2014). Furthermore, studies have found that children enjoy PA more when they are with their friends (Rittenhouse, Salvy, Barkley, 2011;

[2] Information in this chapter is part of a recently published article in the International Journal of Comparative Psychology (Jefferies, Tunçgenç, & Cohen, 2018)

Sanders et al., 2014) and ethnographic accounts of children's spontaneous play have described the enjoyment and exuberance of children engaged in (what is referred to here as) JPAP (Long, 2013; Edwards, 2000). Indeed, enjoyment (or 'liking') has been associated with PA in children (Dishman et al., 2005; DiLorenzo, Stucky-Ropp, Vander Wal, Gotham, 1998) and may be an important factor for engagement and sustainment of JPAP. For example, Jago and colleagues (2009) found enjoyment to be the most important factor for sustaining participation in physical activities among 10-11 year old children. One longitudinal study found that enjoyment was the single most important predictor of PA among children in fifth and sixth grade (DiLorenzo et al., 1998). Furthermore, ethnographic evidence suggests that children's enjoyment from MVPA on the playground is overtly displayed by their smiling faces and physical exuberance and confirmed by their personal testimony (Long, 2013). Children even make special adjustments to their environment in order to engage in MVPA activities. For example, children in India have been observed to modify a game of 'tag' to adapt to the space constraints from an urban setting (Oke, Khattar, Pant, & Saraswathi, 1999). Even when children are engaged in work activities (such as rag-picking in India (Oke et al., 1999)) or chores (such as tending to cattle in Kenya (Whiting & Whiting, 1975; Edwards, 2000)), they find a way to incorporate MVPA, thus making otherwise routine tasks enjoyable. Generally, the experience of enjoyment is thought to be mediated by an opioid response (Berridge & Robinson, 1998, 2003; Berridge, 2004; Dunbar et al., 2010). Thus, children's engagement and enjoyment of JPAP further suggests that MVPA in children's play may facilitate enjoyment and reward mechanisms, which may mediate a link between JPAP and social bonding.

Moving together in close proximity during joint PA generates opportunities for touch, which is another important facilitator and signal of interpersonal intimacy. Touch, in the form of grooming, is known to play a role in the social bonding of primates (Dunbar, 2010; Seyfarth & Cheney, 2012; Silk, 2007; Silk et al., 2010; Wittig et al., 2008) and this role is perhaps mediated by endorphins (Dunbar, 2010). In humans, there is growing evidence of the crucial role of touch in infant-caregiver bonding (Feldman, Weller, Orna Zagoory-Sharon, Levine, 2007; Field, 2010). Oxytocin, which is thought to play an important role in mother-infant bonding in humans and pair bonding in mammals more broadly, may also influence

affective responses to social touch in humans (Light, Grewen, & Amico, 2005). It has also been suggested that touch may play a role in the development of prosocial behaviour (Su & Su, 2018). For example, several studies have associated touch in childhood with lower levels of violence and aggression in children (Field, 1994; 1999; Katsurada, 2012) and adults (Field, 2002; 2004; Prescott, 1979; 1990). However, there remains no systematic investigation into the links between touch and social bonding among children. Previous studies have found positive correlations between touch and compliance with requests from teachers and experimenters (Gueguen, 2004; Leonard, Berkowitz, & Shusterman, 2014). Studies from educational contexts support a link between teacher-directed touch (e.g., touch accompanied by praise) and increased on-task behaviour of students (Wheldhall, Bevan, & Shortall, 1986), in addition to emotional development, improved mood, and reduced stress (Owen & Gillentine, 2011). Although these studies with children have pointed to a link between touch and sociality in childhood, they have not established a specific association between touch and social bonding. Controlled experimental studies are needed in order to assess specific behavioural effects from touch. Furthermore, these studies only examined the effect of touch from adults to children. Children's daily lives are rich with peer interaction, but touch in this context has not been investigated thoroughly.

These elements of social bonding – exertion and touch - frequently combine in children's spontaneous social play activity, suggesting that in addition to maintaining physical health, joint PA may serve an important social bonding benefit. This chapter asks the following research question: Is there a relationship between PA, touch, and social bonding among children engaged in naturally occurring JPAP? An observational study was conducted to quantify the amount of PA, touch, enjoyment, and prosocial behaviour and test for relationships between PA and touch, PA and enjoyment, and PA and social bonding. It was hypothesised that higher levels of PA, and MVPA in particular, would be associated with higher amounts of touch behaviour, enjoyment, and prosocial behaviour than lower levels of PA. A new coding scheme was developed and tested in order to observationally measure children's social behaviours (social context, enjoyment, touch behaviour, and prosocial behaviour) as they relate to PA levels (measured by observational coding and objective heart rate [HR] monitoring) during children's natural spontaneous play.

3.2 Methods

3.2.1 Participants

Children from three local Oxfordshire elementary schools in Keystage 1 and 2 were recruited from March-July 2016. The minimum age for participation was set at five years old. By this age children have a fully-developed Theory of Mind, allowing them to take the mental states of others into account when making decisions about their own behaviour and judgments about the behaviour of others. Further, five year old children are capable of "group mindedness" (or "we-ness") during play, wherein children modify or invent rules based on collective agreement (Tomasello, 2019). This is important as emotional and bonding effects of JPAP may derive in part from feelings of togetherness within the collective context. The maximum age for recruitment was eight years old, as it has been reported that gender differences in physical activity levels rise around the age of nine (Lopes, Vasques, Maia, & Ferreira, 2007). Thus, the age range of five to eight ensures that children have developed socio-cognitive capacities that enable and motivate prosocial behaviour in typical JPAP contexts at the lower end that are not confounded by gender effects at the upper end.

The recruitment process consisted of approaching parents before and after school to provide them with information about the study and request their child's participation. Informed consent and child's date of birth was obtained from parents for all participants. This study received ethics clearance from the Central University Research Ethics Committee of Oxford University and departmental approval from the School of Anthropology and Museum Ethnography, University of Oxford.

3.2.2 Design

The aim of the study was to measure the relationship between PA and 1) prosocial behaviour, 2) touch, and 3) enjoyment. A playground observation study was conducted during children's regularly scheduled play breaks at school. Observation sessions were conducted outside, at each school's playground, from March – July 2016. This study used direct observation following the method of focused, momentary time sampling (McKenzie &

van der Mars, 2015). Children's social behaviours and PA levels were recorded every 20 seconds (10 seconds to observe, 10 seconds to record) across 10 minutes using an observational coding scheme adapted from the system for observing children's activity and relationships during play ([SOCARP] Ridgers, Stratton, & McKenzie, 2010). In addition to observation data, HR data were obtained by applying Polar HR monitors to each participant prior to the observation session. Average HR was obtained for each child's observation session, as HR is often used as an indicator of PA level (Wang, Pereira, & Mota, 2005; Durant, Baranowski, Davis, Rhodes, Thompson, Greaves, *et al*., 1993; Riddoch & Borham, 1995)

3.2.3 Procedure

A total of 53 participants (22 male; *M* = 6.9 years, range = 5.2 - 8.6 years) were observed during their normally scheduled play breaks outside. If weather did not permit, observation sessions were re-scheduled. Prior to being observed, each child was briefly removed from class to be fitted with a Polar HR monitor (HRM). Monitors consisted of a chest strap and wrist watch. The chest strap was applied directly to the skin and tightly secured around the child's chest, while the watch was applied to the upper arm with a piece of paper taped over the screen. The watches were applied in this way to prevent children and their playmates from tampering with them. Additionally, children were instructed to not touch the watch at any point and not to approach the experimenter unless there was a problem with the HRM. Once the HRM was applied, the child/children returned to their classroom until their usual break, when the observation session took place. Two of the three schools had their long play break directly after lunch and one had their break after a light snack. During this time, the experimenter waited on the playground for the children to come outside. Up to two children were observed in any session, one after the other. Once the first focal child came onto the playground, the experimenter started the observation session.

Each child was observed for 10 consecutive minutes with observations recorded every 20 seconds (10 seconds to observe, 10 seconds to record), for a total of 30 observations per participant. Recordings were made using pen and paper, which was secured on a clipboard that the experimenter held throughout the session. Intervals were timed on a voice-prompted recording device, which the experimenter listened to through ear phones.

Throughout each observation session, the experimenter maintained a distance of not more than 15 meters from the focal child. This allowed enough distance for the focal child to be within clear sight of the experimenter without being ostensibly close. Children were given no indication when the observations began or concluded. When the play break ended, the experimenter approached the focal child/children and removed the HRM strap and watch before the children returned to their classrooms.

Data from three children were removed from the analysis due to two children becoming unobservable for over half of the observation period and one child spending all of the time with a teacher, leaving a total of 50 participants (22 male, *M* = 6.8 years, range: 5.2 years-8.6 years). Four categories of behaviour were coded at each observation: Social context, PA, Facial expression, and Social behaviour (see Figure 1). Social context was either 'Alone' or 'Social'. This indicated whether the focal child was alone at the time of observation or if they were around at least one other child. Physical Activity was divided into three sub-categories: Moderate-to-Vigorous, Light, and Sedentary. Moderate-to-vigorous PA (MVPA) included running, jumping, rapid climbing, wrestling (R&T play), and vigorous swinging. Light activity included walking, slow climbing or crawling, and gentle swinging. Sedentary activity included standing still, lying down, or sitting.

Facial Expression was coded as Smiling, Laughing, or Neither. Social behaviour was coded into eight sub categories: 1. Positive engagement (no touch [NT]), 2. Positive engagement with touch, 3. Prosocial behaviour with prosocial touch (i.e. to help someone up or to put an arm around someone), 4. Prosocial behaviour with neutral touch (i.e. hand someone something and hands touch as a result), 5. Prosocial behaviour without touch (i.e. sharing or turn taking), 6. Antisocial behaviour with antisocial touch (i.e. aggressive push or shove), 7. Antisocial behaviour with neutral touch (i.e. take something from someone and touch incidentally), and 8. Antisocial behaviour without touch (i.e. disengage in play or yell at others). Table 1 summarises the coding scheme used by the observer.

Table 1

Initial Coding Categories for Observational Coding Scheme

Main category	Sub-categories	Examples

Social Context	1) Alone	Sit, walk, or run alone
	2) Social	Sit, walk or run with others, engage in games or sports with others, play with playground equipment with others (jump rope games, ball toss games), draw or read next to others
Physical Activity Level	1) Sedentary	Sit, read, talk, play board games, draw, stand around, lay down/recline
	2) Light	Walk, ball tossing, gently going up and down a slide, hanging on monkey bars, balancing on a beam
	3) MVPA	Fast walking, running, fast climbing, jumping rope, cartwheels, playing football, playing basketball, moving across monkey bars, R&T (wrestling, play-fighting, chasing, rolling around)
Facial Expression	1) Smiling	Closed mouth and open mouth smiles
	2) Laughing	Clear, open mouth laughter
	3) Neither	No indication of smile or laugh
Social Behaviour	1) Positive Engagement with touch	Chase games such as 'tag' or 'stick in the mud'; touch due to proximity (sitting next to each other or playing on equipment together), touch during football or basketball games
	2) Positive Engagement, no touch	Talking with others (either standing or sitting), jump rope games, walking or running together

	3) Prosocial behaviour with prosocial touch	Holding hands, one arm around someone, high-5, helping someone up, comforting touch
	4) Prosocial Behaviour with neutral touch	Sharing something and touching hands in the process
	5) Prosocial Behaviour without touch	Go to someone in distress, clap for someone else scoring a goal or other achievement
	6) Antisocial Behaviour with Antisocial touch	Aggressive physical contact such as push or shove Grab something from someone and touch as a result
	7) Antisocial behaviour with neutral touch	Disengage in play, yell at others, throw things
	8) Antisocial behaviour without touch	

3.2.4 Data Preparation

Once all the data were collected, several sub-categories were combined or omitted from analysis due to low frequencies of occurrence. Antisocial behaviour was rare (only 4 observed instances out of 1355), so this subcategory was omitted from the analysis. Due to the low frequency of laughing (21 out of 1105 observations or 1.9%), smiling and laughing were combined for analysis.

Prosocial behaviour was also uncommon (41 out of 1,355 observations, 3.03%), so the three subcategories of Prosocial behaviour (with prosocial touch, with neutral touch, and with no touch) were combined into one general prosocial sub-category called “All prosocial behaviour”. Lastly, for the purpose of analysing associations with strictly touch behaviours,

categories with touch were also combined into one sub-category called “Touch”, which includes prosocial behaviour with prosocial touch, prosocial behaviour with neutral touch, and positive engagement with touch. Social behaviour was then coded across three sub-categories: Positive Engagement (NT), Touch (prosocial or neutral) and All Prosocial Behaviour. Table 2 contains the final sub-categories for each of the four main categories.

Heart rate data were collected from 46 out of 50 participants. Four participants’ HR data were dropped (one due to losing the monitor while playing, one due to clothing interference with readings, and two due to malfunction of the monitor). PA levels were coded by giving a score (0 = sedentary, 1 = light PA, 2 = MVPA) to each of the 30 observations of a child. For analysis of observed PA levels, average PA per child was calculated. To assess associations with MVPA, in addition to the observational coding above, HR measurement was also used as an indicator of PA levels. The average participant HR was 132.23 BPM (*SD* = 20.27; males: 131.8 BPM [SD = 19.9]; females: 132.52 BPM [SD = 20.76]). We followed precedent in the literature on the correspondence between HR and PA levels to determine a threshold of 140 BPM (Fjørtoft, Kristoffersen, & Sageie, 2009; Simons-Morton, Parcel, O'Hara, Blair, & Pate, 1988; Wang et al., 2005) by which we divided the sample into two groups: those whose average HR was at or above 140 BPM (moderate-to-vigorous heart rate [MVHR]) and those whose average HR was below 140 BPM (non-MVHR).

Table 2

Combined Coding Categories for Observational Coding Scheme

Main Category	Category Codes for Analysis
Social Condition	Alone Social
Physical Activity Level	Sedentary Light MVPA
Social Behaviour	Facial expression (Smiling and Laughing or Neither) Touch (Positive engagement with touch, Prosocial behaviour with prosocial or neutral touch) Positive engagement (no touch) All Prosocial Behaviour (with and without touch)

Independent-samples t-tests were used to assess statistical differences between gender and age groups for each subcategory. Children were split into “younger” and “older” age groups

based on the median age of 6.9 years. Regression models were used to explore relationships between social behaviours and PA and enjoyment and PA (further detail given below). Significance was set at $p \leq 0.05$. All statistical analyses were run in RStudio, Version 1.0.143 (2016).

3.3 Analysis and Results

3.3.1 Descriptive Statistics

Frequencies of observations for each sub-category were calculated for each participant and averages determined for the group. Social context observations were overwhelmingly coded as social (*M* = 94.14%, *SD* = 7.21; male: *M* = 92.86%, *SD* = 8.61; female: *M* = 95.19%, *SD* = 5.62), indicating that most playground behaviour is social. For both genders, most time was spent engaged in light PA (*M* = 64.07%, *SD* = 22.87; males: *M* = 65.4%, *SD* = 21.68; females: *M* = 63.02%, *SD* = 23.7). Smiling and laughing was recorded for just under half of observations on average, and was equally frequent for both genders (males: *M* = 43.45%, *SD* = 24.06; females: *M* = 44.07%, *SD* = 24.00). Of social behaviour observations, positive engagement (NT) was most frequently observed (*M* = 77.50%, *SD* = 15.60; males: *M* = 86.68%, *SD* = 10.64; females: *M* = 70.29%, *SD* = 15.18), followed by touch (*M* = 21.69%, *SD* = 15.04; males: *M* = 13.09%, *SD* = 10.19; females: *M* = 28.7%, *SD* = 14.71), and all prosocial behaviour (*M* = 3.04%, *SD* = 4.90; males: *M* = 1.12%, *SD* = 2.20; females: *M* = 4.6%, *SD* = 5.85). Mean frequencies overall, and split by gender, are shown in Figure 1 for PA, facial expression, touch, positive engagement (NT), and prosocial behaviour.

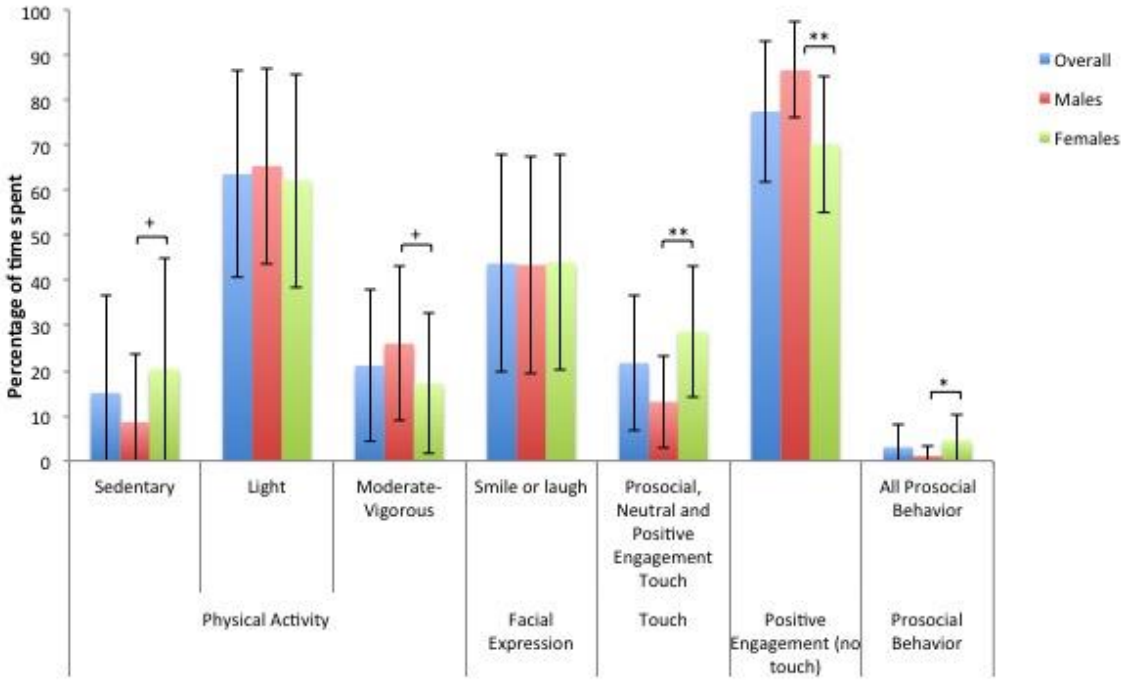


Figure 1. **Average percentage of observations for each category with vertical bars indicating standard deviation and connector bars indicating statistical significance.** $^{+}p < .08$, $^{*}p < .05$, $^{**}p < .01$.

3.3.2 Inferential Statistics

A combination of t-tests and beta regressions were used to analyse the data. T-tests were used to identify statistical differences between the mean PA level, mean prosocial behaviour, and mean touch frequency across gender and age groups. Due to the unpredictability of children's movements on the playground (e.g., the observer occasionally losing sight of the children), the number of observations differed from child to child (Range: 16-30 observations per child, *M* = 28.8, SD = 2.78, Mode = 30). Hence, beta regression was used, as it assumes values in standard unit intervals (e.g., proportions or rates). The beta distribution supports a range from 0 to 1 and can accommodate left or right skewness and heteroskedasticity in the data. Continuous proportional data is by nature anchored at 0 or 1 and is often not normally distributed. Because we were working with proportions, and our data were not normally distributed, beta regression was used to further explore the results from initial t-tests (using the betareg package in RStudio; Zeileis et al., 2016). All behavioural data were first converted from percent of observations into proportion of observations by dividing the percentages by 100. Smiling and laughing data, touch data, and

prosocial behaviour data all included at least one participant who never engaged in one of the three behaviours, resulting in a proportion of 0. Because beta regression supports a range between 0-1, but ignores values of 0 and 1, these values were transformed using an established formula: (y*(n-1) +5)/n), where n is the sample size and y is the outcome variable (see Smithson & Verkuilen, 2006). A "logit" link was used to ensure that the predicted mean stayed within the bounds of 0 and 1 (Cribari-Neto & Zeileis, 2010). Model fit was estimated using diagnostic plots within the betareg package (Zeileis et al., 2016).

Results using these methods are summarised below. In section 3.4.1, we use t-tests to compare the means of PA levels across gender and age groups, followed by analyses of gender and age on each PA level. Section 3.4.2 first uses t-tests to present the difference in means of proportion of prosocial observations across gender and age before using beta regression to analyse the influence of average PA level and average HR on proportion of prosocial observations. Then, section 3.4.3 examines the difference in the means of proportion of touch observations across gender, age, and heart rate groups, followed by a multi-level analysis of co-occurrences of touch and MVPA observations. The section concludes with beta regression analyses used to examine the influences of average HR and average PA level on proportion of touch observations. Section 3.4.4 presents results from beta regression analyses used to assess the influence of average PA level and average HR on proportion of observations for smiling and laughing. Lastly, section 3.4.5 presents results from beta regression analyses exploring the relationship between proportion of positive engagement without touch observations with average PA and average HR.

3.3.4 The influence of gender and age on average PA

Independent samples t-tests were first conducted to analyse differences in average PA levels across age groups and gender. Participants' PA levels were recorded for each observation moment on a scale of 0-2 (0 = sedentary, 1 = light PA, 2 = MVPA). Each recorded PA level was then added together and divided by the total number of observed PA levels. This resulted in an average PA level (between 0 and 2) for each participant and was used in all analyses involving average PA.

Then, for a more detailed examination of PA levels, each PA level (sedentary, light, and moderate-to-vigorous) was analysed separately across age groups and gender. Each of the three activity levels were calculated as a percentage of total PA observations (sum of each level divided by the total number of PA observations, multiplied by 100). T-tests were then used to compare the means of each PA level across gender and age groups.

The proportion of moderate-vigorous observations ($t(48.00) = .73$, $p = .47$), light ($t(47.49) = -.48$, $p = .63$), and sedentary PA ($t(46.23) = .01$, $p = 1.00$) did not differ significantly between older and younger children. There was a marginally significant gender difference in proportion of sedentary activity observations ($t(45.99) = 1.92$, $p = 0.06$), with females ($M = 19.67$, $SD = 24.82$) more often observed in sedentary behaviours than males ($M = 8.60$, $SD = 12.21$). There was also a significant difference in average PA by gender ($t(47.72) = -2.40$, $p = .02$) with males having higher average PA levels ($M = 1.17$, $SD = 0.24$)than females ($M = 0.98$, $SD = 0.34$). No significant difference in average PA was observed between the two age groups ($t(47.22) = .38$, $p = .70$).

3.3.5 Prosocial Behaviour: The effect of gender, age, PA, and HR

Prosocial behaviour was converted into proportional data by first adding the instances of prosocial observations together for each participant, and then dividing the sum by the total number of observations. Although prosocial outcomes were rarely observed, there was a significant effect of gender on mean proportion of prosocial observations ($t(36.30) = 2.73$, $p = 0.01$) with females demonstrating a higher proportion of prosocial behaviours ($M = 4.6$, $SD = 5.8$) than males ($M = 1.1$, $SD = 2.2$). Age was also found to have a significant effect on the mean proportion of prosocial behaviour observations ($t(35.49) = -2.14$, $p = .04$) with older children ($M = .04$, $SD = .06$) more often observed in prosocial behaviours than younger children ($M = .02$, $SD = .03$). Out of 42 prosocial occurrences observed in total, all but 1 involved touch.

Given the relationship between prosocial behaviour and gender and average PA and gender, a beta regression model was run to assess the relationship between PA level and prosocial behaviour, controlling for gender. Average PA was specified as a continuous dependent variable and prosocial behaviour was specified as a continuous independent variable, with

gender as a factored variable. Average PA was a marginally significant predictor of proportion of prosocial observations, when controlling for gender (β = .74, SE(.39), pseudo R2 = .2, p = .06; see Appendix A for diagnostic plots).

A separate beta regression tested whether average HR predicted prosocial observations, when controlling for gender. Average HR did not significantly predict prosocial behaviour, when controlling for gender *(*β = .006, *SE*(.006), pseudo R2 = .15, p = .30; see Appendix B for details of an additional model, which addresses the slightly bimodal distribution of HR). These findings suggest that children's prosocial behaviour is influenced by gender and age, but no significant relationship exists between prosocial behaviour and average HR or between prosocial behaviour and average PA.

3.3.6 Touch: The effects of PA, HR, Gender and Age

Touch data were first converted from raw numbers into proportion of observations. This was done by adding together all instances of touch from each participant and dividing the sum by the number of observations for each participant. Welch two sample t-tests indicated that there was no significant effect of age on mean proportion of touch observations (t(47.98) = -1.17, p = .25), but mean proportion of touch observations differed significantly by gender (t(47.20) = 4.50 , p < 0.001) with females having higher proportions of touch related behaviours (M = .29, SD = .15) than males (M = .13, SD = .10).

To assess whether touch frequency was related to PA levels, we divided the sample into two groups – those whose average HR was at or above 140 bpm and those whose average HR was below 140 bpm. The 140 bpm threshold was used, because it has been previously reported to correspond with moderate PA (Wang, Pereira, & Mota, 2005; Fjørtoft, Kristoffersen, & Sageie, 2009; Simons-Morton, Parcel, O'Hara, Blair, & Pate, 1988). Average HR was first divided into MVHR (at or above 140 bpm) and non-MVHR (below 140 bpm). A t-test was used to compare the means of touch frequency between the MV and non-MV groups. This revealed a significant difference between the two groups (t(35.20) = -2.67, p = 0.01) showing that children with MVHRs had higher mean proportion of touch (.30) than children with non-MVHRs (.18).

As MVHRs were significantly related to touch frequency, we examined whether touch co-occurred more frequently with MVPA than with non-MVPA. Because our study involved 30 repeated measures on each individual and included several instances of missing data (which are not compatible with ANOVA models), a multi-level model was used, which controlled for participant level variance of touch and MVPA. Six participants' data were removed, due to consecutive missing observations, leaving a total of 44 participants for the analysis. For each observation point across participants, we coded co-occurrence of MVPA and touch as "1" and non-co-occurrences (i.e. MVPA without touch, non-MVPA with touch, and non-MVPA without touch) as "0". Out of 258 observations of MVPA, only 50 co-occurred with touch (19.38%, *SD* = 1.98), while 208 occurred without touch (80.62%, *SD* = 4.30). A fixed-effects model was estimated with a fixed effect on the individual level to control for between individual differences. Results from the multilevel model indicate that PA level was not significantly associated with touch frequency (Est = -0.14, *SE*(.20), $p = .49$).

A beta regression was run to further assess whether average HR predicts the proportion of touch observations, when controlling for gender. Average HR was specified as a continuous dependent variable, proportion of touch was entered as a continuous independent variable, and gender was entered as a factored dichotomous independent variable. Average HR had a significant positive effect on proportion of touch observations, when controlling for gender ($\beta = .02$, *SE*(.005), pseudo-$R^2 = .45$, $p < .001$ [see Appendix C for diagnostic plots; As HR had a slightly bimodal distribution, see Appendix B for a supplementary analysis]; see Figure 2). A separate analysis was conducted to test for an interaction effect with average HR entered as a continuous dependent variable, proportion of touch was entered as a continuous independent variable, and gender was entered as a dichotomous independent variable. No interaction effect was observed between average HR and gender ($\beta = -.002$, *SE*(.01), pseudo-$R^2 = .45$, $p < 0.78$).

Next, beta regression was used to examine if average PA level predicts the proportion of touch observations when controlling for gender. In this model, average PA was specified as a continuous dependent variable and proportion of touch was entered as a continuous independent variable with gender, a dichotomous factored variable. Average PA had a significant positive effect on touch, when controlling for gender ($\beta = 1.26$, SE(.33), pseudo-R^2

= .47, p < .001 [see Appendix D for diagnostic plots]; see Figure 2). When an interaction term was included in the model, no interaction effect was observed between average PA and gender (β = -.56, SE(.77), pseudo-R^2 = .47, p = 0.47). Therefore, the main effect of average PA level on proportion of time spent touching does not appear to be influenced by gender.

3.3.7 Smiling and Laughing: The Effect of PA, HR, and Gender

To explore the effect of average PA on smiling and laughing, a beta regression model was formed with average PA specified as a continuous dependent variable, proportion of smiling/laughing specified as a continuous independent variable, and gender included as a factored independent variable. When controlling for gender, average PA had a significant positive effect on smiling/laughing (β = 1.39, SE(.46), pseudo-R^2 = 0.22, p = 0.002 [see Appendix E for diagnostic plots]; see Figure 2). An additional model was constructed to test for an interaction between gender and smiling/laughing. No interaction effect was observed between average PA and gender on smiling and laughing (β = 1.21, SE(.97), pseudo-R^2 = 0.26, p = 0.21).

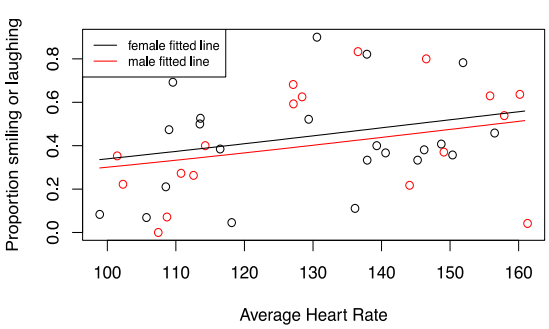
Beta regression was also used to test the effect of average HR on smiling and laughing, when controlling for gender. Average HR was specified as a continuous dependent variable, while gender and smiling/laughing were specified as independent variables – gender as a factored variable and proportion of smiling/laughing as a continuous variable. When controlling for gender, average HR had a marginally significant positive effect on smiling/laughing (β = .01, *SE*(.01), pseudo-R^2 = .09, p = .06 [see Appendix F for diagnostic plots]; see Figure 2).

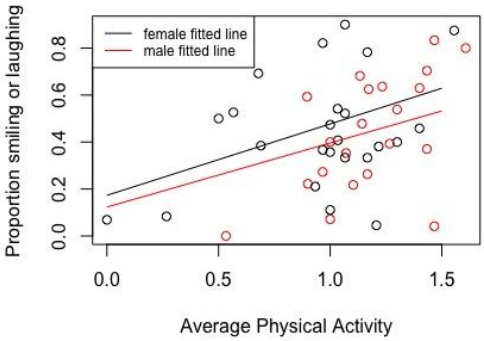
3.3.5 Positive Engagement (NT): The effect of PA and HR

A beta regression was used to assess whether average PA predicts positive engagement (NT) when controlling for gender. Average PA was specified as a continuous dependent variable, positive engagement (NT) was specified as a continuous independent variable, and gender was specified as a dichotomous factored variable. Results indicate that when controlling for gender, average PA had a significant negative effect on positive engagement (NT), (β = -1.24, SE(0.33), pseudo-R^2 = .46, p = < .001 [see Appendix G for diagnostic plots]; see Figure 2).

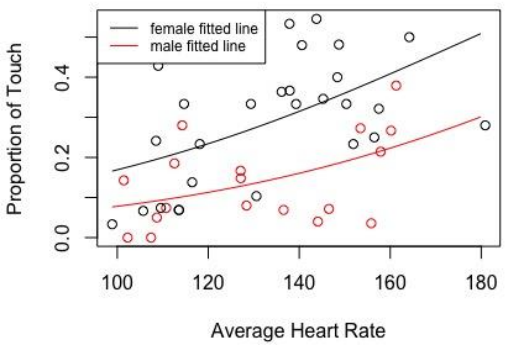
A further beta regression examined whether average HR predicts positive engagement (NT) when controlling for gender. Average HR was specified as a continuous dependent variable, positive engagement (NT) was specified as a continuous independent variable, and gender was specified as a dichotomous independent variable. Results indicate that average HR had a significant negative effect on positive engagement (NT) (β = -.02, *SE*(.005), pseudo-R^2 = .45, $p < .001$ [see Appendix H for diagnostic plots]; see Figure 2).

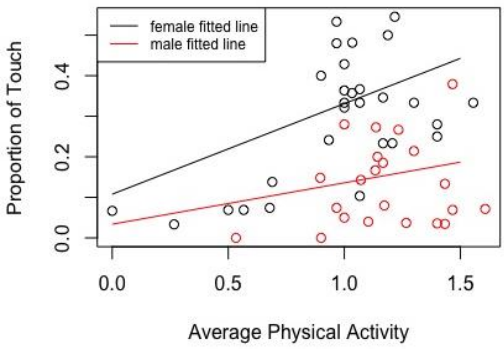
(a) Smiling/laughing



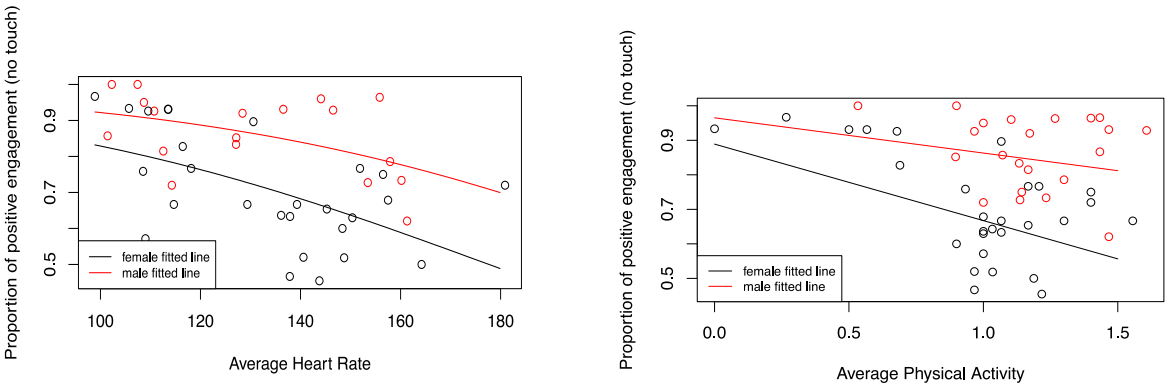


(b) Touch





(c) Positive engagement (NT)



(d) Prosocial Behaviour

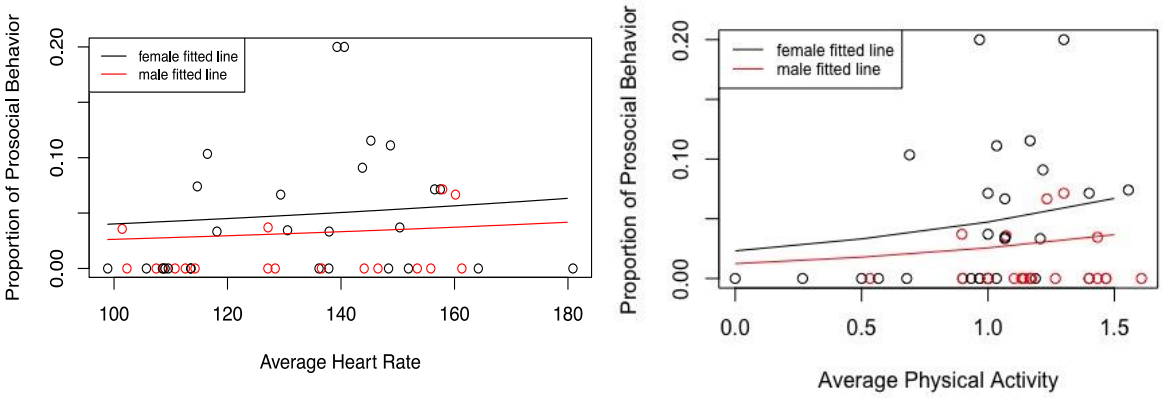


Figure 2. **Regressions for the relationship of (a) smiling/laughing (b) touch, (c) positive engagement (NT), and (d) prosocial behaviour with average HR (left panels) and observed PA (right panels), controlling for gender.**

3.4 Discussion

This observational study explored the relationship between PA levels and social bonding behaviours (as measured by the frequencies of smiling/laughing, touch, and prosocial behaviour) during children's free-play. As hypothesised, analyses revealed that higher levels of observed PA and higher average HR predicted greater amounts of smiling/laughing and touching. Conversely, lower levels of PA and lower average HR predicted more positive engagement (NT). Although prosocial behaviour was rarely observed, it was found to be more prevalent among girls than boys and more likely to occur with touch than without. The

marginal influence of PA on prosocial behaviour supports our hypothesis, but warrants further investigation with a larger sample size. The findings also reinforce previous work by showing that children's PA levels are higher among boys than girls. Confirming previous anecdotal reports (Stier & Hall, 1984), this study revealed that girls touch more often than boys during free-play.

In our study, higher levels of PA and higher average HRs predicted greater amounts of touching, whereas lower PA levels and lower HRs predicted greater positive engagement (NT). These findings support our hypothesised link between higher levels of PA and social bonding in that touch is known to be an important facilitator of social bonding (Feldman, Eidelman, Sirota, & Weller, 2002; Seyfarth & Cheney, 2011; Silk, 2007; Dunbar, 2010; Wittig et al., 2008; Kerr, Stirling, Heron, MacPherson, & Banwell, 2015). It may be that touch during higher levels of PA compensates for the time spent outside of more intimate social behaviours, such as talking together. Indeed, talking together (and specifically gossiping) has been implicated as a strong social bonding mechanism among humans (Dunbar, 2004). Furthermore, recent experimental evidence supports a communicative function of touch, even in the absence of verbal or visual cues (Hertenstein et al., 2006). Therefore, it may be that when children are engaged in higher levels of PA, there is less opportunity for talking, and more for touching, thereby allowing MVPA to further promote social bonding. In short, these results support a link between higher levels of PA and social bonding with touch as a conduit.

Though prosocial behaviour was rarely observed, it was found to be more prevalent among girls than boys and more likely to occur with touch than without. The gender bias in frequency of prosocial behaviour corroborates previous findings (see Kirshner & Tomasello, 2010; Maccoby, 2002). The marginal influence of PA on prosocial behaviour supports our hypothesis, but warrants further investigation. Given the small sample size and the small amount of prosocial behaviour observed, we cannot conclusively say that PA is a predictor of prosocial behaviour.

A link between higher PA levels and prosocial behaviours may result from children's enjoyment of engaging in higher PA levels, as observed here by smiling and laughing. Our

findings suggest that higher PA levels predict the proportion of time spent smiling and laughing. These findings suggest that children, regardless of gender, may enjoy higher-level physically active play than lower-level activities. This may, in turn, offer support for the relationship between PA and social bonding in that children playing together at higher activity levels may enjoy their interactions more and perhaps see their time spent together as more pleasurable than children engaged in lower level social activities.

One reason for this link between PA and enjoyment may be due to the opioid and endocannabinoid responses from moderate intensity PA. Recent evidence from studies in adults suggest a causal link between moderate intensity PA and increased pain threshold (measured by blood pressure cuff), which is an indirect measure of the body's release of endorphins (Boecker et al., 2008). It is known that endorphins not only act as the body's natural pain management system, but also cause feelings of euphoria (Dishman & O'Connor, 2009). Indeed, one study confirms that the act of laughing with others actually activates the endogenous opioid system, as evidenced by increased pain thresholds (Dunbar, 2012). Endocannabinoids have also been proposed as linked to exercise-induced euphoria and are activated by moderate intensity exercise (Dietrich & McDaniel, 2004). It is perhaps these euphoric feelings that may, in turn, elicit feelings of closeness to those present during the experience. At least four recent studies have identified PA intensity as a significant predictor of social bonding (Di Bartolomeo & Papa, 2017; Tarr et al., 2015; Davis, Cohen, & Taylor, 2015; Cohen, 2010). Thus, for our study, the causal relationship between higher levels of PA and higher levels of smiling/laughing could possibly be explained by an opioid/endocannabinoid response to PA.

This study successfully piloted a new protocol that could be readily conducted across a diverse range of natural play settings, and has offered promising preliminary results. Nevertheless, as an initial and observational investigation of the links among PA and social behaviour in children's play, there are limitations on inferences that can be drawn from these results. Each participant's session was coded by the main experimenter. Future applications of this coding system should employ hypothesis-blind coders to eliminate possible biases in the results. Children were also aware that they were being observed and this may have influenced their behaviours. Future studies could use more than one

observer, so that each one could have less of a visual impact on the playground. Discreetly positioned video equipment could also be used to record behaviours for subsequent coding by multiple raters, thus allowing more precise behavioural coding than real time spot-observations alone.

Prosocial behaviour, according to the coding system used, occurred very infrequently and was therefore uninformative as a potential co-variant of PA levels. The low frequency of prosocial behaviour reported here may be a result of too conservative coding, as our prosocial codes identified only 'overt' prosocial behaviours. Future studies may benefit by including behaviours such as 'cooperative play', 'turn taking', or 'engaging others' as specifically prosocial. In the current study, such behaviours were instead included as 'positive engagement'. This revision may better capture the breadth of children's prosocial behaviour and thereby provide a better estimation of how such behaviours are influenced by PA in natural play contexts.

Lastly, this observational study was limited by the small sample size, correlational nature of its design, and cultural homogeneity of the sample. Future studies using this piloted methodology should have a larger sample in order to obtain more reliable results. As an observation study, the direction of the effects cannot be established. Some of the predicted claims have been supported by the data, but only carefully controlled experiments can help determine whether and how PA levels and touch causally influence social bonding. Further, future studies should be conducted across culturally diverse samples in order to gain a better understanding of JPAP and how culture may influence the behavioural associations made in this study.

In conclusion, this study has demonstrated a novel methodology for observing and measuring children's PA and social behaviours. By employing this new method, we have confirmed previous findings that report gender differences in touch and PA levels. We also identified higher levels of PA as a positive predictor for a) touch and b) smiling and laughing and a negative predictor for positive engagement (NT). Though PA was only a marginally significant predictor of prosocial behaviour, evidence from adults suggests this preliminary relationship warrants further investigation. By delving deeper into children's PA and social

behaviours, we can potentially identify PA as an important facilitator of social bonding in children. This would have far reaching implications across fields such as health (e.g. obesity), psychology (e.g. autism, social anxiety), and education (e.g. encouraging classroom PA breaks) by improving the social lives of children

4.0 The effect of touch on social bonding

4.1 Overview[3]

Children's naturally occurring, joint, physically active play (JPAP) frequently involves touch (see chapter two, Section 2.2; Jefferies, Tunçgenç, & Cohen, 2018). Indeed, it is difficult to think of a social children's playground game that does not involve at least some degree of touch, whether by design (such as 'tag' or 'stick in the mud') or incidentally (such as a game of football or basketball). Furthermore, children's unstructured physically active playground activities frequently involve touch by both intentional (i.e. hand holding, leading by the arm, wrestling, high-five) and unintentional (bumping into/brushing against someone nearby, grabbing at the same toy) actions (see chapter three, Section 3.3.1, Figure 1). Given the established evidence for a social bonding function of touch in both non-human primates (i.e. social grooming) and human infants and caregivers, it may be that the touch that characterises children's JPAP also serves a social bonding function.

Touch is a fundamental feature of primate sociality. Based on observational accounts of non-human primates, it is thought that touch evolved a social bonding function in the form of social grooming (see Seyfarth & Cheney, 2011; Dunbar, 2010). Social grooming is an activity in which primates spend time picking off insects and dead skin from each other. Initially thought to be a purely hygienic activity, careful research has shown that time spent grooming far exceeds that needed for hygiene alone (Dunbar, 1991). Among female wild gelada baboons, there is a significant correlation between time spent with a grooming partner and aid shown toward the partner (e.g. in conflict) (Dunbar, 1980). Dunbar (2011) found a strong association between time spent in social grooming and social group size among Old World primates. Further, grooming relationships are stable and persistent, sometimes lasting years, allowing the formation of strong alliances (see Silk, 2007; Silk et al., 2010; Wittig et al., 2008).

In humans, touch is the oldest of our sense organs and develops before all others (Field 2001; Montagu, 1971). It is pervasive throughout ontogeny and appears to be important for optimal development and health throughout the lifespan. The first experience of a new-

[3] Information in this chapter has recently been published as part of an article in the International Journal of Comparative Psychology (Jefferies, Tunçgenç, & Cohen, 2018)

born baby is social touch – first being removed from the mother's body by a doctor or midwife, then handed carefully to the mother and father for cuddling and nurturing. Indeed, this cuddling and nurturing – or caregiving touch - has been shown to improve the weight gain and survival of premature infants (Field, 2010). Recent evidence even suggests that when the caregiving touch is skin-to-skin (sometimes referred to as 'Kangaroo Care'), preterm infants show improved cognitive-developmental and executive functioning (i.e. attenuated stress response, improved respiratory sinus arrhythmia, organised sleep, and better cognitive control) throughout the first 10 years of life (Feldman, Rosenthal & Eidelman, 2014). This finding suggests that the effects of touch in humans, at least early in life, can have long lasting benefits.

Not only does caregiving touch have positive effects on infant growth and development, it also enhances the mother-infant bond (Feldman, Eidelman, Lirota, & Weller, 2002). When skin-to-skin care is practised, the mother also enjoys a range of benefits such as improved positive affect, improved ability to read her infant's cues, and less depression (Feldman et al., 2002). These effects help facilitate secure attachment between the infant and mother and prepare the infant with a foundation for future social relationships.

In addition to this research describing positive effects of touch in infancy, there is growing evidence of detrimental consequences of touch deprivation. This topic was first introduced in now controversial studies conducted by Harry Harlow on baby rhesus monkeys (1958). In Harlow's studies, baby monkeys were separated from their mothers at birth and given either a) a cloth mother that dispensed milk and a wire mother that did not, or b) a wire mother that dispensed milk and a cloth mother that did not. Harlow found that monkeys only went to the wire mothers if they dispensed milk. Even then, they preferred the cloth mother outside of feeding. Interestingly, when a threatening stimulus was introduced, the monkeys overwhelmingly clung to the cloth mother, rather than the wire mother. Two control groups were reared separately, with either the wire or cloth surrogate. Both groups consumed the same amount of food and had similar weight gain, however monkeys with wire surrogates developed diarrhoea – a response Harlow attributed to the psychological stress of lack of contact comfort.

Among human children, institutionalised infants and children have traditionally received far less touch from caregivers than non-institutionalised children, which has been associated with later cognitive (MacLean, 2003), and neurodevelopmental delays (Chugani et al., 2001; MacLean, 2003; Nelson et al., 2007). Although these delays can improve once children are adopted into nurturing homes, the effects have been shown to last for many years (Beckett et al.,2006; Gunnar, van Dulmen, & IAC, 2007). Examples from non-institutionalised, cross-cultural settings also provide evidence for negative outcomes resulting from lack of touch. For example, observational research comparing American and French samples suggests that lower levels of touch are associated with more aggression among pre-schoolers (Field, 1999a) and adolescents (Field, 1999b). It has also been reported that preindustrial cultures with high levels of adult physical violence show low levels of affection towards infants, whereas non-violent cultures show high affection towards infants (Prescott, 1990). Taken together, these studies show the importance of touch in infancy for both immediate and delayed developmental health, as well as society-level outcomes.

Beyond development, much observational evidence suggests a link between touch and social behaviour in adults. For example, even brief touch to the arm or shoulder can influence behaviour, such as restaurant customers leaving bigger tips (Crusco & Wetzel, 1984; Guéguen & Jacob, 2005), strangers returning lost money (Kleinke, 1977), increased compliance with a request (Joule & Guéguen, 2007) and spontaneous helping toward the toucher (Guéguen & Fischer-Lokou, 2003; Paulsell & Goldman, 1984). Other studies on adults have explored the social perception effects of brief touch. For instance, Fischer et al. (1976) asked male and female librarians to either touch the hands of students for one-half of a second as they returned the student's library card or to not physically touch the student while returning the card. Evaluation results from 101 students found that students who were touched on the hand by a librarian were more likely to report more positive affect and more favourable evaluations of the librarian. Similarly, customers at a car showroom were more likely to rate their salesman more positively if the salesman touched them (seemingly incidentally) on the forearm for one second during their visit (Erceau & Guéguen, 2007).

Though the social effects of touch have been widely reported in adults, evidence in children is less robust. Qualitative studies from ethnographic contexts report that touch is often

combined with verbal directives from adults to monitor and guide children's behaviours (Cekaite, 2010, 2016; Meyer, Streeck, & Jordan, 2017; Goodwin & Cekaite, 2013) and to teach social norms (Burdelski, 2010). Studies from educational contexts also support a link between touch and social behaviour. For example, in a study of 115 five and six year old students, researchers examined the change from baseline in on-task classroom behaviour of students after teachers incorporated positive contingent touch (i.e. touch performed simultaneously with positive verbal reinforcement) in their classroom. On average, the time children spent in on-task behaviour during the positive contingent touch condition increased from baseline by 40% (Wheldhall, Bevan, & Shortall, 1986). Furthermore, primary school teachers in rural Ohio and O'ahu, Hawaii were asked to fill out a survey regarding beliefs about touch. In aggregate, results from the survey showed that teachers believe touch enhances emotional development (98%), improves mood (94%), reduces stress (92%), promotes on-task behaviour (83%), and improves general behaviour (80%) (Owen & Gillentine, 2011). Together, these studies suggest that touch may influence children's social behaviours; however, controlled experimental studies are needed in order to isolate and examine the behavioural effects from touch. Furthermore, these studies only put into question the effect of touch from adults to children. Children's daily lives are rich with peer interaction, but touch in this context has not been investigated thoroughly. More studies need to consider the social effects that peer-to-peer touch may have on children.

One aspect of children's life that has been shown to include high amounts of touch is that of JPAP (see chapter three, Section 3.4.3). In a naturalistic observational study, it was found that touch had a positive relationship with children's average physical activity (PA) levels. This association suggests that more engagement in physically active play than sedentary play is associated with greater touching. The study was not able to thoroughly investigate any links with social bonding outcomes. However, other studies have linked physically active play with social competence (Lindsey & Colwell, 2013; Veiga et al., 2017) and social acceptance (Lindsey, 2014), suggesting a relationship between physically active play and sociality.

One study has suggested a link between children's Rough & Tumble play (R&T) and social bonding. In a longitudinal playground observation study by Humphreys and Smith (1987),

three age groups (7, 9, and 11 year olds) were observed during recess every school day for three six week terms. During this time, researchers looked for instances of initiated R&T followed by the response, which was either reciprocated R&T, sociable (responded with either non-R&T social locomotor or passive act), no response, or break of contact. About a third of the R&T initiations were reciprocated, whereas 'stayed together' outcomes (in either R&T or sociable exchanges) were 76.2% for 7 year olds, 64.4% for 9 year olds, and 80.3% for 11 year olds. Further, R&T partners reported higher ratings of liking each other than chance pairings of classmates would have allowed at all ages (Humphreys & Smith, 1987).

Although this study does not specify the amount of touch involved in these R&T play observations, it is well known that R&T play often involves touching. Children's JPAP (which includes R&T play) often includes touch. Furthermore, results from chapter three suggest that touch and smiling/laughing are more prevalent at higher PA levels, while PA was a marginally significant predictor of prosocial behaviour. Given the many links between touch and sociality and between JPAP and sociality, it may be that the touch within JPAP influences social behaviour. Controlled experimental studies are needed in order to establish a causal relationship between touch and prosocial behaviour in children. This chapter investigates the following research question: Does peer-to-peer touch in a JPAP context result in more prosocial behaviour and greater partner liking than no peer touch? To test for causality, a controlled experimental design was implemented, which comprised touch and no-touch physically active play conditions, followed by a spontaneous helping game and a measure of self-reported partner liking. We hypothesised that in a JPAP context, peer-to-peer touch would be a significant positive predictor of a) prosocial behaviour and b) partner liking.

4.2 Methods

4.2.1 Participants

A power analysis was conducted prior to the experiment based on two previously published studies examining spontaneous helping in similar age groups in the context of synchrony/music and play (see Tunçgenç & Cohen, 2016; Kirschner & Tomasello, 2010). The power analysis was calculated using an odds ratio of 3, power of .8, alpha of 0.05 and using

the averaged proportions (no help, medium help, absolute help) from the two previous studies, resulting in a target sample size of 88 children (44 pairs). One hundred twenty-eight children (64 pairs) were recruited from public and private schools and after school programmes in the metropolitan area of Houston, Texas (USA) from October 2016 to January 2017. Houston was chosen as an appropriate site after recruitment in Oxford had proven to be too slow for the time allocated for the study. Being from Houston, I was able to secure participation from one school and one after school programme whilst in Oxford, which finalised the decision to move the study to Houston.

The final sample included 84 typically-developing children (46 girls, *M* = 6.63 years, *SD* = 0.85; range: 62.2 – 102.5 months) from mixed socio-economic backgrounds. Forty children were removed from the analysis due to equipment failure (n = 20), mismatch of age within pairs (n = 8), experimenter error (n = 6), interference of a passer-by (n = 2) and children not following the instructions (n = 4). A further two sessions were later dropped from analysis because the video recordings of these sessions were inaudible (n = 4), which prevented us from accurately assessing whether the help observed was spontaneous or solicited. The final sample for analysis included 84 typically-developing children (46 girls, *M* = 6.63 years, *SD* = 0.85; range: 62.2 – 102.5 months) from mixed socio-economic backgrounds.

Pair assignment was based on gender (same gendered pairs) and age (birthdays within 6 months), prioritizing the maximal number of pairs. Assignment to experiment condition (touch or no-touch) was random with 22 pairs in the touch condition and 20 in the no-touch condition. Teachers were asked to specify whether each pair of children were ‘best friends’ or if they ‘do not play well together’. If either were true, the pair was re-randomised. Experiment sessions were run on school campuses and at one after-school programme site. The study was approved by the University of Oxford ethics committee and permission to conduct the study was granted from the schools and organisations involved.

4.2.2 Design

The experiment procedure comprised of a warm-up activity (Animal Game) followed by two main tasks (Shape Game and Fish Feeding Game), and a single Likert-scale question (for a complete study protocol, see Appendix I). Participants were randomly assigned to two

different versions of the Shape Game, one of which comprised the Touch condition and one the No-Touch condition (between-participants independent variable, 2 levels). The dependent variable, pro-sociality, was measured by evaluating the level of help demonstrated in the Fish Feeding Game and, as a secondary measure, with a partner liking assessment (single question). For purposes of reliability-checking, all sessions were video recorded, and two researchers blind to the hypotheses and conditions coded the sessions for helping behaviour.

4.2.3. Procedure

The study took place in a room or open space in the children's school, away from other children and regular school activities. Children were brought into the study area in same sex pairs, one pair at a time. They were told that the experimenter was interested in children's games and how children play and were asked if they would like to play some fun games.

Animal Game

First, participants played a 'warm-up' game – the Animal Game - in which they were asked to 'be a bird' and 'be a frog', following the experimenter's demonstration. They then rated how much they enjoyed behaving as each animal on a 6-point Likert Scale with the range of options including really like, like, sort of like, sort of don't like, don't like, and really don't like. This game was designed (a) to introduce playful physical movement, so as to create a PA context, and (b) to teach the children how to use a liking scale to indicate how much they enjoyed the activity. The experimenter explained the scale to the children, demonstrated the meaning of each option, and checked for understanding by asking each of them to select the option that best fit a description (e.g. 'if I sort of liked being a bird, which option would I circle? […] That's right, the face with the slight smile.'). This scale was used at the end of the experiment to indicate partner liking.

After this initial warm-up phase, children were given a further task to warm up for the Shape Game. This time, they received instructions to 'be a bird' or 'be a frog', as before, but with the added instruction of 'find a bird shape' or 'find a frog shape' in a pile of cut-out shapes on the other side of the room and attach it to a board located three metres away. Once instructed to find the shape, each child would run to collect one shape. The felt-

covered board had multiple bird and frog traced lines matching the cut-out shapes, so the children knew exactly where to place their shape. The experimenter demonstrated the task first, explaining that the shapes must be securely fixed to the board, inside the traced shape lines, with a careful pressing motion for the frog and a gliding motion for the bird- not just loosely or roughly attached. This task was done in order to familiarise the children with how to retrieve and apply the felt shapes to the outlined shapes and to ensure consistency of touch in the touch condition. The children repeated the task twice (once for each shape).

Shape Game

Following this warm-up, children played the shape game. This novel game was designed for this study to assess the effect of touch (versus no touch) within a PA context. In the shape game, one child was randomly assigned (prior to each session) to be the first to wear a yellow felt jacket, which had 10 bird and 10 frog shapes covering the arms and back (see Figure 4.1). This jacket was called the 'frozen' jacket, because once placed onto the child, the child had to stand still and refrain from all movement. The child in the frozen jacket was instructed to stand next to a board covered in the same yellow material with the same shapes as the jacket. As one child stood by the board wearing the frozen jacket, the other child was instructed to run to the pile of bird and frog shapes and collect one shape at a time to attach to the corresponding shapes on the frozen jacket (for the Touch condition) or to the corresponding shapes on the board (for the No-Touch condition) (see Figure 4.1). The child fetching the shapes was told to continue running back and forth applying shapes until the experimenter said to stop, at which point the children would change turns. The moment the running child attached the 10th shape to the target, the experimenter said to stop. This ensured that both children experienced the same number of touches. Once all the shapes were attached, the experimenter said to stop and watch as the shapes were counted. This was to minimise any competition the children may have felt by taking turns and to facilitate an 'end' to the game.

(a) (b) (c)



Figure 4.1 Experiment materials: (a) jacket, (b) board for the shape game, and (c) partner liking scale.

The Fish Feeding Game

The fish feeding game (adapted from Kirschner & Tomasello, 2010) was used as the main measure of pro-social behaviour. The game set-up comprised of a small table holding coloured tubes filled with same-coloured balls ('fish food') and a separate box decorated with fish as an indication of 'hungry fish' inside the box (see Figure 4.2). The children were randomly assigned to one coloured tube each and instructed to place one ball of the same colour at a time into the tube. Once all the same coloured balls were in the tube, they were to 'feed the fish' by emptying the balls into the box. They completed one trial with my guidance. For the second trial, the red tube was set up so that the bottom cap fell off just as the children lifted their tubes to go and feed the fish. This allowed the red balls to spill out on the floor, presenting an opportunity for the child with the green tube (the 'Responder') to help the child with the red tube (the 'Victim'). The amount of help provided by the Responder was coded and measured as an indicator of pro-social behaviour (see below for coding scheme).

(a) (b)

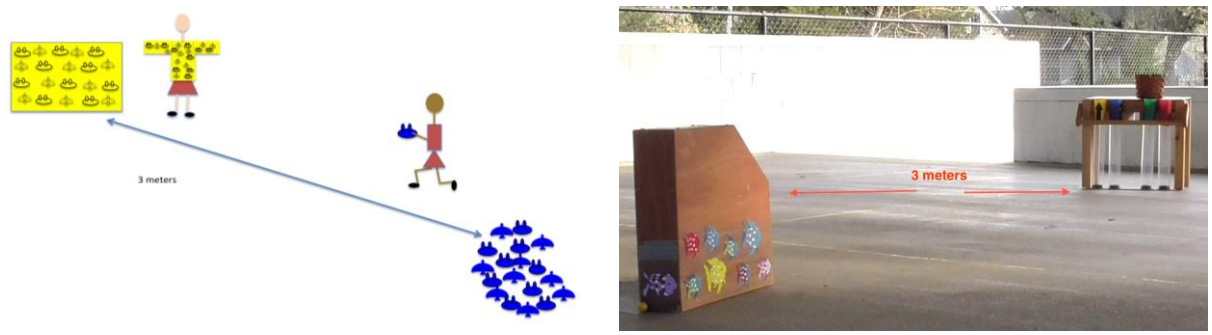


Figure 4.2. Experimental setup: (a) Shape game and (b) fish feeding game.

Note: (a) All shapes on the board, jacket, and ground were the same size

Liking Scale

After the fish feeding game, the children were asked individually to indicate how they felt about the other participant ("how much do you like the person you just played with?") on a six-point Likert scale with faces ranging from smile (i.e. "really like") to frown (i.e. "really don't like") (see Figure 4.1). This was done as a secondary measure of social bonding. Children were told not to share their answers with each other and to put the paper face down onto the floor/table after they circled the face. The duration of each session was approximately 20 minutes.

4.3 Coding

Inter-rater reliability coding was done by two individuals who were condition- and-hypothesis-blind. Instructions given to coders are included in Appendix J. The level of helping given by the responder to the victim in the fish feeding game was assessed through post-hoc video coding. First, the coders independently coded the videos, then met together to discuss discrepancies (12 videos; 27%). Two videos were dropped from analysis because the videos were inaudible (n = 2) meaning that requests for help could not be ruled out (see Table 4.1, Help Sub-Category N3 below). After discussion, coders agreed on all assessments.

Helping was coded across two categories (Yes, No) and 6 subcategories (see Table 4.1). The original coding scheme as employed by Kirschner and Tomasello (2010) was revised here. For our purposes, both costly helping (interrupting one's own goal to feed the fish in order to help the other child collect the balls from the floor) and non-costly helping (helping the other child after completing one's own fish-feeding goal) was of interest. As this study is the first of its kind, we wanted to include all possible versions of help that naturally occurred, and, as such, to differentiate between no help at all and any amount of help given. Measuring help across the spectrum of possible outcomes can potentially produce a more complete picture of the effect of touch. Therefore, we added a new subcategory of low-level helping to include those cases in which the Responder child did not see the accident before emptying their tube but who helped the Victim child subsequently on seeing their predicament (if no help was subsequently given, this was coded as "no help").

Additionally, unlike Kirschner and Tomasello (2010), we only considered instrumental help as helping. Instrumental help was defined as any active help from the Responder with the tube or balls, which assisted the Victim in completing the task. By this definition, Responder behaviour, such as waiting nearby for the Victim to fix the tube or playing with the Victim's spilt balls, was not coded as help. This was to restrict help to a purely demonstrated act and avoid making inferences from ambiguous behaviour. All statistical analyses were run using RStudio, Version 1.0.143 (2016).

Table 4.1
Study 2 coding categories and sub-categories with Kirschner & Tomasello (2010) coding included for comparison

Help Category	Current Study Help Sub-Category	Kirschner & Tomasello Help Sub-Category	Description
Y (Yes)	Y1 (High help)	High help	Helper sees toy break and helps immediately
	Y3 (Low help)	No help	Helper sees toy break, empties own tube first, then helps Victim with their tube or balls
	Y2 (Medium help)	Removed from analysis	Helper doesn't see toy break, empties own tube, then notices the accident and helps Victim with their tube or balls
N (No)	N1 (no help)	Intermediate help	Helper sees toy break, but doesn't help Victim at any point, though Responder waited/delayed emptying their tube
	N2 (no help)	Removed from analysis	Helper doesn't see the toy break, empties own tube, then notices the accident, but doesn't help at any point
	N3 (no help)	Unknown	Helper only helps at Victim's request (i.e. not spontaneous)

4.4 Results

Effect of Touch and Gender on Helping: Dichotomous Measure

Results of the helping task were analysed to determine whether Responders in the social touch condition helped Victims more than Responders in the No-Touch condition. Although patterns of helping versus not helping reflect our predictions (see Table 4.2), with children more likely to help than not in the Touch condition, but less likely to help in the No-Touch condition, a Chi Square test showed that there was no statistically significant association between touch and helping (X^2 (1, 84) = 2.5773, p = 0.11). However, there was a significant effect of gender on helping behaviour (X^2 (1, 84) = 3.8764, p = 0.05; see Figure 4.3) with girls (M = .57, SD = .51) displaying more help than boys (M = .26, SD = .45).

Table 4.2
Frequency of Responder spontaneous helping by condition (SD)

	No Help	Help
Touch	10 (.43)	12 (.46)
No-Touch	14 (.48)	6 (.35)

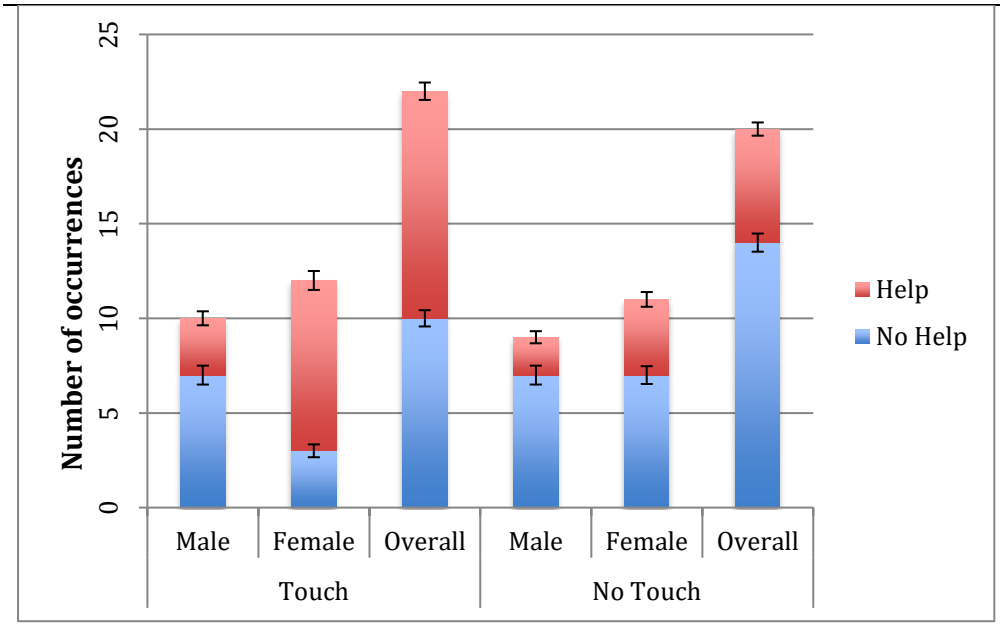


Figure 4.3. Frequency of spontaneous helping displayed by the Responder by condition. Error bars indicate standard deviation (SD).

Due to the significant association between helping and gender, a binomial logistic regression was used in R to examine whether or not touch predicts help, controlling for gender. Touch and Gender were specified as dichotomous, factored independent variables, while Help was

specified as a dichotomous dependent variable (basic assumptions of binomial logistic regression were met). Odds Ratios indicate that a one unit increase in touch (going from the no-touch to touch condition) resulted in a 3.17 unit increase in help (217% greater help), when controlling for gender (95% CI [.85, 13.4]). However, due to the confidence interval crossing one, we cannot infer a reliable statistical difference between conditions. Additionally, no interaction effect was found between gender and condition.

Effect of Touch, Gender, and Age on level of helping

Because help was measured on a scale from 0 (no help) to 3 (high help), ordinal logistic regression (OLR) was used to examine the effects of touch, gender, and age on level of helping. Helping was initially divided into 4 levels: 0 (no help), 1 (low help), 2 (medium help), and 3 (high help). However, due to there being zero occurrences of "low help" in the no touch condition, the proportional odds assumption of the OLR was not met (all other assumptions were met). For this reason, we combined the "low help" and the "medium help" categories (categories 1 and 2) and conducted OLR using three levels of helping: 0 (no help), 1 (low-medium help), and 2 (high help). Help was specified as the ordered outcome variable, age as a continuous predictor variable, and gender and touch were specified as dichotomous predictor variables.

The results of the OLR indicated that age does not influence the model (OR = .99); therefore, age was removed from the model and all further analyses. After removing age from the model, Proportional Odds Ratios indicate that for a one unit increase in condition (i.e. going from the no touch to the touch condition), the odds of high help (level 2) versus no help (0) and low-medium help (1) combined (and of high and low-medium help combined, versus no help) are 2.64 times greater (164% greater), when controlling for gender (95% CI [.76, 10.01]). However, due to the CI crossing one, we cannot infer a reliable statistical difference between touch and no touch conditions.

Gender had a significant effect on level of helping. For a one unit increase in gender (i.e. going from female (0) to male (1)), the odds of high help versus no help and low-medium help combined are .27 times less (73% less) when controlling for condition (95% CI [.07, .96]; see Figure 4.4). Once gender was removed from the model, there was no significant effect

of touch on helping, suggesting that gender was the influencing factor on level of help. No interaction effect was found between gender and condition on level of help.

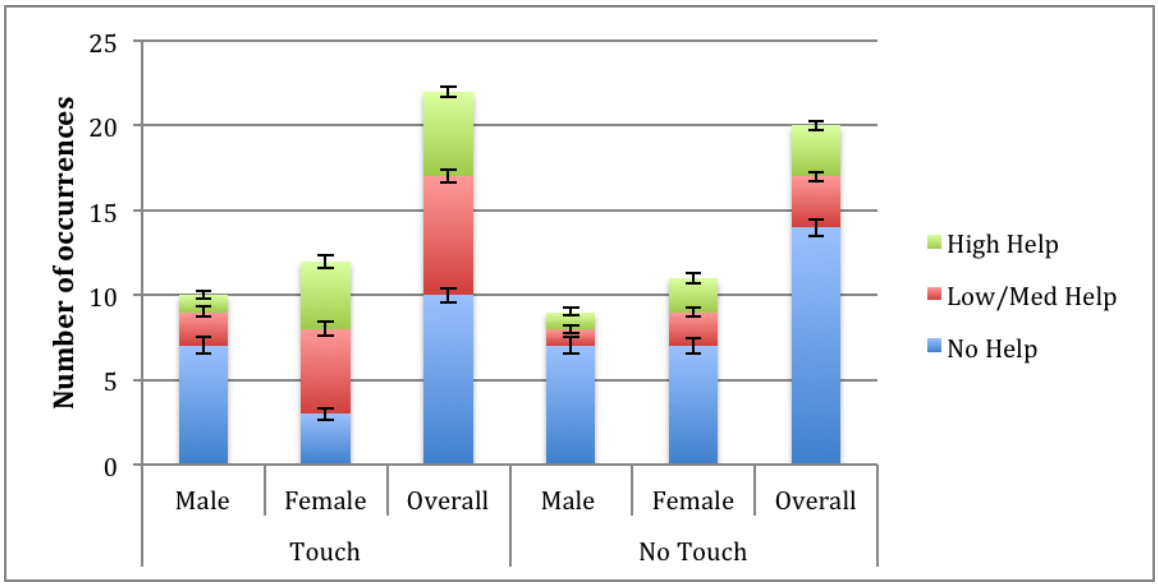


Figure 4.4. Helping behavior frequency (3 levels) by condition and gender. Error bars indicate SD.

For comparability with results generated from the original coding scheme of Kirschner and Tomasello (2010), we ran the same OLR with 3 cases removed (as Kirschner and Tomasello had dropped similar cases from their analyses). The model generated similar Odds Ratios and Confidence Interval results and can be found in detail in Appendix K.

Effect of condition on partner liking

Three different assessments of reported partner liking across the two conditions were calculated, based on the 6-point Likert scales: Partner liking reported by non-victim only (scores from 1-6), pair-wise liking (scored as an average of the two children's reported scores), and liking similarity (scored as the absolute value between the two children's reported scores). T-tests revealed that there were no statistically significant differences in the scores for touch and no-touch conditions (See Table 4.3).

Table 4.3
Mean liking scores (SD) with T-test results for touch and no-touch conditions

	Touch	No-Touch	T-test Results
Responder's reported liking	1.18 (50)	1.2 (.52)	$t(1, 39.22) = .11$, $p = .91$
Pair-wise reported liking	1.34 (.64)	1.53 (.64)	$t(1, 39.68) = .36$, $p = .93$
Liking similarity	.59 (1.18)	1.05 (1.28)	$t(1, 38.82) = 1.21$, $p = .24$

4.5 Discussion

This study sought to explore a causal link between touch and peer bonding in the context of physically active play in middle childhood. Using a naturalistic, controlled experimental design, we reaffirmed previous findings that gender predicts prosocial outcomes. However, the study did not reveal a reliable effect of touch on helping behaviour or liking among 6-8 year old children in a PA context.

Overall, girls helped more than boys and this effect was independent of condition. Gender differences in prosocial behaviours among children have been reported previously in similar studies (for review, see Maccoby, 2002). For example, in a study designed to test the prosocial effects of joint music-making (compared to a non-musical joint task) among 4-year-old children, Kirshner & Tomasello (2010) found that girls engaged in more spontaneous helping and more cooperative problem solving than boys, overall.

Social constructionist theories argue that gender-typed behaviours are primarily externally shaped by factors such as parenting, entrenched societal roles, or media. Indeed, the proximate social phenomenon of gender segregation during children's free play illustrates the association between gendered social behaviours and prosociality. For example, it has been reported that male children engage in more physically competitive playground behaviour, such as R&T play and football, while female children engage in more associative and nurturing playground behaviour such as talking and walking together (Powell, Woodfield, & Nevill, 2016; Ridgers, Carter, Stratton, & McKinzie, 2011). Social role theory sees gender differences as a result of a society's division of labour – girls will grow up to fulfil roles requiring nurturing and cooperation, while boys will grow up to occupy roles requiring aggression and competiveness. Yet, these approaches do not explain why these

particular differences arise and persist in the first place (Campbell, 2013). Another theory, social determinism, says that children are encouraged and rewarded for engaging in gender-normative behaviours, while punished for deviating from them. However, children exhibit gender normative behaviours before they are even able to differentiate the sex of other children (Ruble, Martin, & Berenbaum, 1998). Furthermore, comparative evidence from vervet monkeys shows that male vervets spent more time playing with toys preferred by human boys (police car and orange ball) than do female vervets. Conversely, female vervets spent more time playing with toys preferred by human girls (doll and red pan) than do male vervets (Alexander & Hines, 2002).

Developmental and comparative evidence more widely suggests that sex-typed toy preferences, and consequently further sex-typed behaviours, may not be entirely socially driven. Rather, evolutionary pressures likely encouraged sex differences in certain behaviours and preferences. For example, it may be that the difference found in prosociality is evolutionarily rooted in greater male variance (compared to females) of reproductive success, resulting in more dominant, competitive, and aggressive behaviours in males and more protecting and caring behaviours in females (for a review, see Pellegrini, 2004). It is therefore possible that gender differences within our helping task are a reflection of evolutionarily driven gender segregation. Although this study did not set out to address these questions, it can offer further relevant evidence for these debates

The main research question was whether or not social touch predicted prosociality (an indicator of social bonding) as measured by spontaneous helping. The null finding of social touch contrasts with similar studies on adults and children, which examine touch and social outcomes. Potential explanations for these null findings are outlined below.

First, it may be that touch does not have prosocial effects. Although this study resulted in no significant prosocial effect, this conclusion is not supported in the literature. To the contrary, touch has been repeatedly shown to have prosocial effects among both human and non-human primates (for reviews see Field, 2010 and Dunbar, 2010). It is therefore unlikely that social touch has no prosocial effects.

Another possible explanation may be that the types of touch tested in this study - brief presses and sweeps along the arms and back - do not have prosocial effects. However, abundant research has indicated that similarly brief touches can elicit prosocial effects. For example, restaurant servers who briefly touched the shoulders and backs of restaurant customers received greater amounts of tips from touched customers than non-touched customers (Gueguen, 2004; Gueguen & Jacob, 2005; Crusco & Wetzel, 1984; Stephen & Zweigenhaft, 1986; Hornik, 1992b; Lynn, Le, & Sherwyn, 1998). Furthermore, a recent study from university students showed that a brief touch to the students' forearm increased classroom volunteering and compliance with a request (Gueguen, 2004). It was therefore expected the specific types of touch used in this study were likely to elicit prosocial effects.

Most studies reporting prosocial outcomes from touch have taken place in a non-physically active setting. Thus, it could be argued that touch in a PA context does not result in prosocial outcomes. There is certainly less research on social outcomes of touch in a PA context, however support for a connection does exist. For example, one study of teams in the NBA has shown that touch among teammates improved cooperation and predicted team performance over a season (Kraus, Huang, & Keltner, 2010). The participants in that study were professional adult athletes, and most of the relevant studies on prosocial effects of touch are with adults generally. It could be that effects of touch on prosociality do not extend to the focal age group of our study sample. Unfortunately, there are no studies directly linking children's touch within a PA context to prosocial behaviours. However, one study of 7-11 year old children found that R&T play had a predominantly affiliative function on the playground (Humphrey's & Smith, 1987). R&T play is known to include different behaviours, many of which involve some degree of touch (i.e. playing 'tag'). Activities such as chasing, wrestling, pulling, climbing, hitting, were all considered R&T play. It was shown that partners who engaged in R&T tended to stay together and rated each other more positively than chance pairing of classmates would have allowed. Both of these studies suggest that touch in a PA context may result in prosocial outcomes, while Humphreys and Smith's (1987) study provides some support for this within our focal age group. Together, these studies suggest that a link between touch, PA, and social bonding and should not be dismissed.

Another possible reason for the null findings here may be that touch does not have an effect on spontaneous helping. Most studies that have measured the prosocial effects of touch have looked at aspects such as generosity (Gueguen 2004, Kleinke, 1977; Crusco &Wetzel, 1984; Stephen & Zweigenhaft, 1986; Hornik, 1992; Lynn, Le, & Sherwyn, 1998), compliance with a request (Smith, Gier, & Willis, 1982), and subsequent positive ratings of the toucher (Erceau & Gueguen, 2007), or overall experience (Fischer et al., 1976). However, evidence does exist for the effect of touch on spontaneous helping, specifically, among adults. One study examined the interaction of eye contact, touch, and voice on level of spontaneous helping (Goldman & Fordyce, 1983). For this design, students walking on a college campus were stopped and asked to participate in a survey. On completing the survey, the experimenter dropped the forms, ostensibly accidentally, creating an opportunity for spontaneous help. The experimenter's style of speaking (warm or flat voice), eye contact (made eye contact or not), and touch (touch vs. no touch) were manipulated across eight combinations and spontaneous help was measured. The study found an interaction effect between touch and eye contact with more help obtained with either no eye contact plus touch or with no touch plus eye contact.

In a very similar design, another study looked at the effect of touching different parts of the body (shoulder, upper arm, lower arm, hand) or no-touch on subsequent helping (again, with the accidental drop of papers) (Paulsell & Goldman, 1984). The study found that only participants who were touched on the upper arm (rather than shoulder, lower arm, or hand) helped significantly more than the no-touch condition. These two studies provide evidence that touch does affect spontaneous helping. However, two things must be noted. First, these studies lacked experimental control. Consequently, many other factors besides touch may have influenced the outcome. Second, the type of touch used in these two previous studies appeared (to the person touched) as spontaneous. This is an important distinction from the touch in the current study, as these participants were all aware of the touch taking place even before it happened, as it was part of the instructions for the game (in the touch condition). Not only did participants know they would be touched, they also knew by whom (their partner), why (to apply the shapes into the jacket), and where they would be touched (on the arms and back, where shapes were printed on the jacket). This is an important distinction, because touch has been experimentally shown to successfully

communicate distinct emotions in the absence of any visual or auditory signals (Hertenstein, et al., 2006; Hertenstein et al., 2009). By incorporating contrived touch, then, rather than spontaneous touch, our design may have precluded a communicative component of the touch experience that may be responsible for the previously reported prosocial outcomes. Future experimental designs would benefit by including contrived touch as a control and spontaneous touch as the independent variable. This would allow us to better understand the prosocial effects of touch more comprehensively.

Additionally, future studies may benefit by considering the sociometric status (i.e. peer acceptance) of each child, as this is known to play a role in children's peer interactions. For example, popular children are more likely than average or rejected children to be helpful or cooperative (Chen & Tse, 2008; Gazelle, 2008; Tomada & Schneider, 1997). The relationship between children's sociometric status and social behaviour may even be reciprocal, as there is evidence for positive effects on peer status from prosocial behaviour (Layous, Nelson, Oberle, Schonert-Reichl & Lyubomirsky, 2012). In the current study, children were randomly assigned to age and gender matched pairs. Teachers were asked to identify children who were best friends or who did not play well together, ensuring that they were not assigned as partners. This was done as an effort to have socially neutral pairs of children playing together while causing minimal disruption to teachers and their classes. Although this method has worked in previous experiments (Kirschner & Tomasello, 2010; Tunçgenç & Cohen, 2018) future studies could benefit by having the sociometric status of each child so that results could be more precisely interpreted.

Despite using a previously proven measure of spontaneous helping (fish feeding game) and abundant evidence for prosocial effects from touch, this study did not find the statistically significant differences that other studies have found. The pattern of helping that was observed between conditions suggests a promising trend, however (see Figure 4.3). It may be that the study did not have a large enough sample to detect an effect of touch. The sample size was based on a power analysis conducted prior to the experiment using data from two previously published studies examining the effect of synchrony on spontaneous helping in similar age groups (see Tunçgenç & Cohen, 2016 and Kirschner & Tomasello, 2010). To the best of our knowledge, there has never been a controlled experiment

investigating the effect of touch on spontaneous helping in this age group, which made it difficult to determine an appropriate sample size. It may be that, compared to the effect of touch on helping, the effect of synchrony on helping is greater. For this reason, a larger sample size could be needed in order to adjust for the small effect that touch may have on spontaneous helping in this age group. Only then can we be confident that the patterns of behaviour observed fail to reject the null hypothesis.

Touch is known to be a natural and essential characteristic of human social engagement. However, few studies have investigated social effects of touch in childhood. In primary school, children begin to face the arena of social engagement with increasing complexity. Social touch, with its communicative and reinforcing features, may be an important facilitator for forming social bonds in this arena. For example, if touch in JPAP can be shown to increase social bonding, this could have far reaching implications for mitigating the negative effects from social exclusion. If so, implementing a JPAP intervention during recess or other play breaks could improve the social bonding between socially excluded children and others.

Touch in physically active play could also have implications for clinical populations, such as children with Autism Spectrum Disorders (ASD). Defined primarily by impairments in social interactions, communication, restricted interest and repetitive behaviours, one commonly observed symptom, which has been recently added to the diagnostic criteria of ASD, is altered sensitivity to sensory stimulation, including tactile stimulation (American Psychiatric Association, 2013). Studies have found that touch therapy, which typically uses moderate pressure touch, can improve the sleep, touch aversion, social relatedness, and attentiveness of children with ASD (Field et al., 1997; Escalona, Field, Singer-Strunck, Cullen & Hartshorn , 2001; Cullen, Barlow, & Cushway, 2005). It is possible that identifying optimum amounts, contexts and pressure levels of touch and integrating this into children's physically active play could be informative for developing interventions that help facilitate social bonding in children with ASD.

In the future, more research among primary school children needs to investigate the relationship between touch and social bonding. Only then can we reliably extend observed

effects from adults to children. Although our study did not find a significant relationship between touch and social bonding in children, more studies are needed in order to confirm or refute these findings. Widespread evidence for a social bonding function of touch during infancy and adulthood is in stark contrast to the dearth of research examining the effects among school-aged children. Conclusions about the social role of touch in humans can only be made once this gap is filled.

5.0 The effect of physical activity intensity on social bonding

5.1 Overview[4]

Physical activity (PA) is well-known as being an important contributor to human health. However, there may also be immediate social benefits to joint PA, which are less well understood. Evidence from adults suggests that moderate-intensity PA may activate neurohormonal mechanisms that have been implicated in social bonding (Davis, Taylor, & Cohen, 2015; Cohen et al., 2010; Boecker et al., 2008). Experimental studies with adults and adolescents also suggest that moderate intensity PA may promote prosocial behaviour (Davis et al., 2015; Di Bartolomeo & Papa, 2017; Tarr et al., 2015). However, this link has not been explored in younger children, even though children's joint physically active play (JPAP) often involves moderate PA (see chapter three). It has also been reported that children spend more time engaged in PA in the presence of friends (Sanders et al., 2014; Jago, et al., 2011; Rittenhouse et al., 2011). Furthermore, Study 1 (chapter three) found that children exhibit more enjoyment (i.e., smiling and laughing) and touch – two characteristics known to be associated with social bonding (see chapter two, section 2.4) - at higher levels of PA. It may be that moderate PA during children's JPAP facilitates enjoyment and, when experienced with others, these positive feelings are extended to those who are present. Thus, it may be that there is an immediate causal relationship between PA and social bonding in children.

Research with school-aged children has shown that PA, and moderate-to-vigorous PA (MVPA) in particular, is associated with positive physical and cognitive health (Álvarez-Bueno et al., 2017; Boddy et al., 2014; de Greeff, Bosker, Oosterlaan, Visscher, & Hartman, 2018; for a summary, see section 2.3). However, existing literature on children's PA also suggests links between engagement in MVPA and social behaviours relevant to bonding. For instance, a comprehensive observational study across 40 schools (involving 747 children) in the UK investigated correlations between the everyday MVPA levels of friends. Children wore accelerometers, yielding objective PA readings for five consecutive days. Spatial autocorrelation was used to analyse the relationship between children's MVPA and

[4] Information presented in this overview is part of a larger publication in the International Journal of Comparative Psychology (Jefferies, Tunçgenç, & Cohen, 2018).

friendship ratings based on self-declared friendship ranking (children nominated and ranked up to four peers as friends). Mean daily MVPA levels were positively correlated among immediate and second-degree friends. Similarity in mean MVPA decreased with each degree of separation (Macdonald-Wallis, Jago, Page, Brockman, Thompson, 2011).

Other research on children's PA and sociality has shown that higher amounts of MVPA are associated with larger group sizes (Sanders et al., 2014; Roberts, Fairclough, Ridgers, & Porteous, 2013; Ridgers, Stratton, & McKenzie, 2010; Woods, Graber, Daum, & Gentry, 2015). Even the presence of a single friend can increase children's PA almost threefold (measured in accelerometer counts) compared to being alone (Sanders et al., 2014). Furthermore, some studies have found that children enjoy PA more when they are with their friends, rather than alone (Rittenhouse, Salvy, Barkley, 2011; Sanders, et al., 2014) and that during children's free play, enjoyment levels (i.e., smiling and laughing) are positively correlated with higher levels of PA (see chapter three; Jefferies, Tunçgenç, & Cohen, 2018), thus adding quantifiable substance to ethnographic reports describing children's JPAP as fun and enjoyable (see Long, 2013). A recent study found that for 8- to 12-year-old children, time spent in MVPA was associated not only with the children's reported liking of PA, but also with how motivated they were to engage in their favourite PA relative to a sedentary activity (i.e., watching their favourite cartoon [Roemmich et al., 2008]). These behavioural findings on children's play suggest that greater PA engagement and enjoyment are observed when children are in the company of friends, and that increased enjoyment levels are associated with higher PA engagement. This supports the idea that facilitated reward and enjoyment mechanisms mediate the relationship between PA and social bonding.

Investigating neurobiological mechanisms of PA provide further support for this proposal. The endogenous opioid system (e.g., endorphins) and the endogenous cannabinoid system (e.g., endocannabinoids (eCB)), which play crucial roles in pain management and reward processing (Leknes & Tracey, 2008), are also thought to be implicated in mammalian social bonding (Inagaki, Ray, Irwin, Way, & Eisenberger, 2016; Machin & Dunbar, 2011; Keverne, Martensz, & Tuite, 1989; Fattore, Melis, Fadda, Pistis, Fratta, 2010). Importantly, research with adults suggests that sustained moderate intensity PA (but not low- or high-intensity PA) elevates levels of endorphins (Boecker et al., 2008) and eCBs (Raichlen et al., 2013) and

increases resistance to pain (Cohen et al., 2010). One study in adults found that engagement in moderate PA (compared to low PA) predicted greater cooperation in a public goods game (Davis, Taylor, & Cohen, 2015). Another study found similar results in a public goods game when comparing 30 minutes of PA (e.g., skipping and squats) to a sedentary control (e.g., writing), however PA levels were not measured (Di Bartolomeo & Pappa, 2017). A recent study with adolescents assessed participants' pain thresholds before and after performing either high or low exertion dance movements with others. The study revealed that participants in the high exertion dance conditions had significantly higher pain thresholds and social bonding (i.e., self-reported social closeness) as compared to those in the low exertion conditions (Tarr, Launay, Cohen, & Dunbar, 2015). These findings support the idea that PA facilitates social bonding in part via the release of endogenous opioids and/or eCBs.

There is also some evidence for an exercise-induced opioid response in younger children. For example, one study investigated the influence of puberty on the β-endorphin response to exercise among pre-pubertal and pubertal children. Children completed a single 15-minute cycling session on an ergometer with increasing workload. In the last 5 minutes, all children were cycling at 90% of their maximal HR value. Blood samples were taken just before the session commenced, just after the session, and after a recovery period of 10 minutes. There was a significant increase in plasma β-endorphin levels immediately after the cycling and levels remained significantly elevated after the 10-minute recovery period (Bouix et al., 1994). This study suggests that there may be a similar opioid response to exercise in children as in adults. However, no studies to date have extended this work to explore central nervous system opioidergic activity or a possible relationship with social bonding.

Research across species provides further insights into the neurohormonal response to physical play in social animals, such as rats. For instance, Trezza, Damsteegt, Achterberg, & Vanderschuren (2011) found that exogenously stimulating opioid receptors in the nucleus accumbens (a brain region associated with positive social interactions in humans; Güroğlu et al., 2008) increased pinning and pouncing behaviour in rats, while blocking the opioid receptors in this region disrupted these enhancement effects. In addition to opioids, studies with rats suggest a role for the brain's dopamine system in regulating play behaviour

(Burgdorf, Wood, Kroes, Moskal, & Panksepp, 2007). The dopamine system is closely associated with reinforcing value ("wanting") of, for example, addictive drugs and tasty food in humans, but is also known to play a significant role in maternal behaviour in rats (Lee, Clancy, & Fleming, 2000; Mattson, Williams, Rosenblatt, & Morrell, 2001) and pair-bonding in prairie voles (Gingrich, Liu, Cascio, Wang, & Insel, 2000; Wang et al., 1999). Although animal models have limited applicability for questions about human cognition and behaviour, these findings suggest possible underlying mechanisms by which MVPA and social behaviour may be linked.

Prior behavioural, neurobiological, and comparative research suggests strong associations between PA engagement, enjoyment, and social bonding. However, there is a lack of experimental evidence to demonstrate a causal link between PA and social bonding in children. This chapter poses the following research question: Do children engaged in moderate intensity PA exhibit more affiliative behaviour than children engaged in low intensity PA? In a controlled experimental study, PA intensity was manipulated in a fun game designed to test the following hypothesis: Children engaged in moderate-level PA (i.e., running) will exhibit more affiliative behaviour than children engaged in low-level PA (i.e., walking). A (non-social) behavioural inhibition task was included to explore whether effects may be associated with inhibition differences generally following high- vs. low-energy play.

5.2 Methods

5.2.1 Participants

A power analysis was conducted prior to the experiment using power of 0.7, effect size of 0.5 and significance threshold of 0.05, which resulted in a sample size of 204 children (102 data points). Two-hundred and sixty-six children from public and private schools and after-school programmes in the metropolitan area of Houston, Texas (USA) were recruited from November 2017 to May 2018. Plans for an initial pilot study in Oxford were aborted after no schools agreed to take part. Given the large sample size needed, Houston was chosen as an appropriate study site, as one school and one after-school programme – both of which had also participated in Study 2 – agreed to participate well in advance; there was an overlap of 22 participants between the samples of the two studies.

The final sample included 126 gender- and age-matched (age difference within a pair < 6 months) pairs of typically-developing children (130 girls, M_{age} = 7.6 years, *SD* = 0.63; range: 76.77 – 113.28 months) from mixed socio-economic backgrounds. Fourteen children were removed from the analysis due to not following instructions (n = 8), mismatch of age within pairs (n = 2), and experimenter error (n = 4). Assignment to experiment condition (walk vs. run) was random with 62 pairs in the run condition and 64 in the walk condition. As in Study 2, teachers were asked to specify whether each pair of children were 'best friends' or if they 'do not play well together'. If either were true, the pair was re-randomised. Experiment sessions were run on school campuses and at one after-school programme site. The study was approved by the University of Oxford ethics committee and permission to conduct the study was granted from each school and after-school programme.

5.2.2 Design

The experiment procedure comprised of a physically active game (mat game) as the main task, followed by a picture making task and an inhibition task (mystery box game). A two minute warm-up phase helped to familiarise the children with the experimenter and the actions used in the session. This was followed by a six minute training phase, which served as practise for the mat game. Participants were randomly assigned to either the Run or Walk condition of the mat game (between-participants independent variable, two levels). The dependent variable, social choice, was measured by evaluating whether one participant chose to stand together and do an action with the other participant or stand apart and do the action independently. This was chosen as a measure of social bonding, because each action involved brief touch (about two seconds either on the hands, shoulders, or wrists). Interpersonal touch is an indicator of close social relationships (Monsour, 1992; Fiske, 2004) and, as we found in Study 1 (chapter three), is more likely to occur at higher PA levels during children's natural play. Thus, if children experience an immediate social bonding effect from MVPA, they will choose to be together and engage in actions that involve touching the other person, rather than standing alone. As a secondary measure, social bonding was assessed by a picture making task in which children were told to complete a picture by placing stickers representing themselves onto a piece of paper displaying two trees (one on either side), grass (for the ground), and the sun. The distance between the stickers placed on the paper was measured as an indication of felt social closeness. Drawing tasks have

previously been used as indirect measures of relationship quality (Harrison, Clarke, & Ungerer, 2007; Fury, Carlson, & Stroufe, 1997; Madigan, Ladd, & Goldberg, 2003) and affiliation (Song, Over & Carpenter, 2015). Rather than allowing the children to draw freely, children were give two stickers with which to make a picture. This was modified, because we were only interested in the distance placed between the two figures as a measure of social bonding and stickers would allow for more experimental control and precise measurement, as compared to freely drawn figures.

The final task was a measure of behavioural inhibition adapted from previous studies on fear in children (Field & Lawson, 2003). With this task, we aimed to capture the effect of MVPA on facilitating approach (as opposed to avoidance) response to novel non-social stimuli. In the mystery box game, children were told to place one hand inside a box containing an unknown stimulus. The time taken to place the hand inside the box was used as a measure of behavioural inhibition. For purposes of reliability-checking, the mat game and mystery box tasks were video recorded and two researchers blind to the hypotheses and conditions coded the sessions for social choice (mat game) and behavioural inhibition (mystery box).

5.2.3 Procedure

The full study protocol can be found in Appendix L. The study took place in a room or open space at the children's school, away from other children and regular school activities. Children were brought into the study area in same-gender pairs, one pair at a time. They were told that the researcher was interested in children's games and how children play and were asked if they would like to play some fun games.

Mat game

First, in the warm-up, participants were introduced to the specific actions used in the game, which were called 'high-clap', 'wrist-rock', and 'shoulder-duster' (see Figure 5.1). Each action was demonstrated as the participants watched. Each action was then called out to the participants and they demonstrated the moves. If there were any mistakes in the demonstrations, further actions were called out until the children successfully demonstrated all actions without issue.

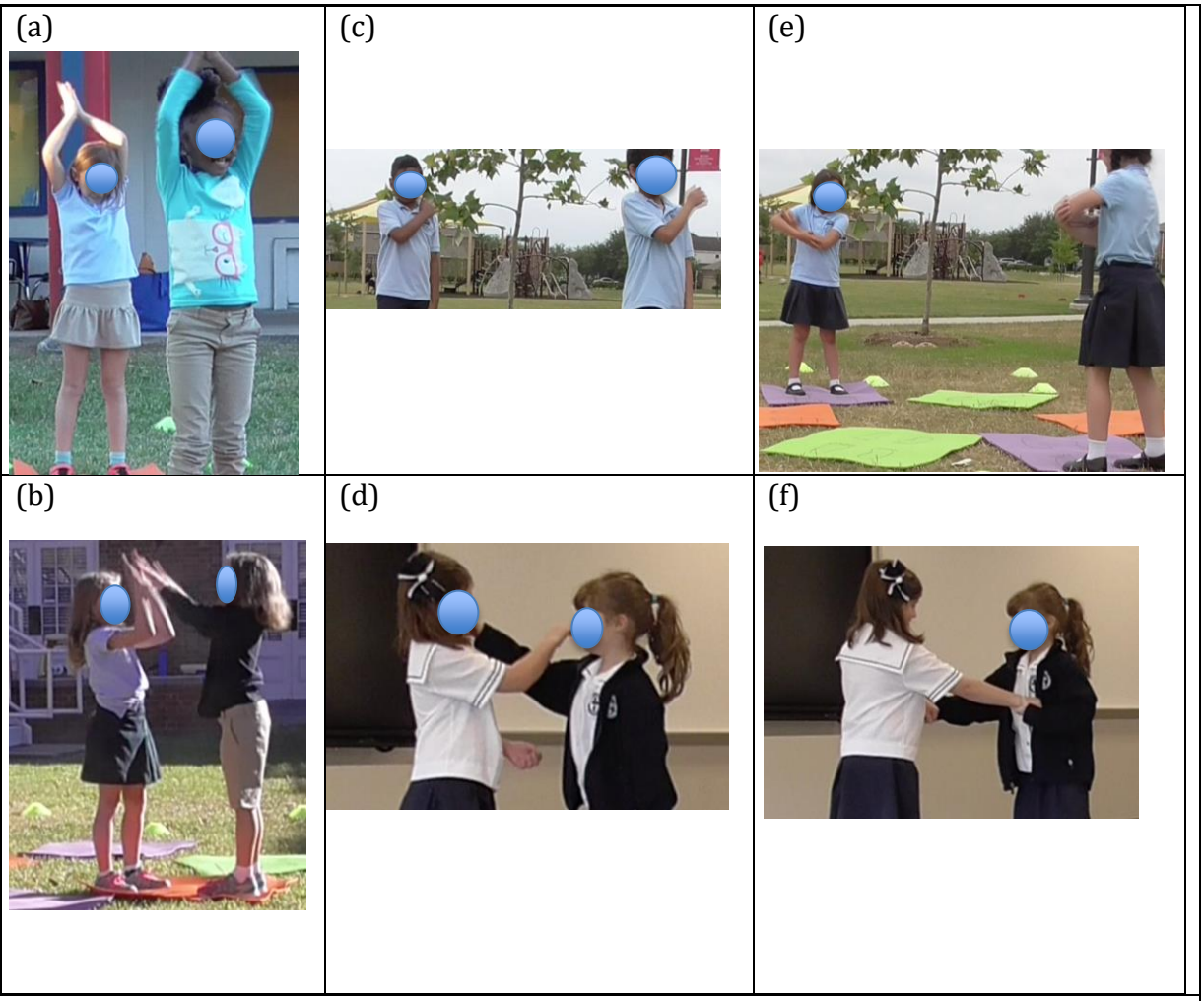


Figure 5.1 Actions for the mat game: (a) High-clap separately, (b) high-clap together, (c) shoulder-duster separately, (d) shoulder-duster together, (e) wrist-rock separately, (f) wrist-rock together

Once children successfully demonstrated all the moves, they were randomly assigned as the 'Colour-matcher' (hereafter 'CM') or 'Place-maker' (hereafter 'PM') by rolling a dice. Next, children were taken to an area where six mats of three different colours (orange, green, and purple) were arranged in a circle. The mats were enclosed by two separate circles composed of yellow cone markers and separated by a distance of one meter (see Figure 5.2 below).

Training Phase. The CM was instructed to stand



Figure 5.2 Mat game setup with start cones (as indicated by arrows)

next to the inner cone (between the inner and outer cones) labelled, 'START' and the PM was instructed to stand next to the outside edge of the outer cone labelled, 'START'. Depending on the condition, the participants were first told to run (or walk) alongside the cones in opposite directions without stepping on or over the cones. Once the CM completed one lap around the cones, they were both instructed to come back to the start cones. Next, they were instructed to run (or walk) along the cones, again, but this time to wave at each other when they crossed paths. Once they completed one lap and waved at each other, they were told to return to their start cones. Then, they were instructed to run (or walk) along the cones, again, until the experimenter called out a colour (orange was used for all practice trials) to the CM, at which point the CM would stop running (or walking) around the cones and go straight to an orange mat, placing their feet inside footprints drawn onto the mat (see Figure 5.2). The PM was instructed to continue running (or walking) along the cones after the command was given to the CM and to not stop until told to do so. This trial was necessary in order to train the PM to listen for their specific instruction and not to follow the same instruction as the CM. Once the PM continued running (or walking) around the cones while the CM went to a mat, the PM was instructed to stop and both participants were asked to go back to their start cones.

For the next two trials, the participants were instructed to do the same as before, but this time with additional instructions. The PM was instructed to go to a specific mat (in counterbalanced order across pairs) – either the mat where the CM was standing or the one where no one was standing - and do a specific action (the high-clap action was used for all practice trials in the training phase). If the PM was instructed to go to the same mat as the CM, the instructions were to place their feet inside the footprints opposite the CM and do the high clap with the CM's hands (as in a 'high five'). If the PM was instructed to go to the other mat of the same colour where the CM was not standing, the instruction was to place their feet in one of the pairs of footprints, and for both children to do the high clap with their own hands. After each trial, participants were told to return to the start cones. This trial was completed twice – one for each scenario.

Once both participants successfully completed both trials, the instructions for the final practice trial were introduced. For this trial the CM, again, chose an orange mat on which to stand, but this time the PM chose on which mat to stand. This was explicitly stated to the PM as being their choice. The PM was then reminded that, "If you choose the mat where the colour-matcher is standing, you will do the high clap with the colour-matcher. If you choose the mat where no one is standing, you will do the high clap with your own hands and so will the colour-matcher. It's up to you – it's your choice." This practice trial was completed once, unless the PM went to a mat of the wrong colour, in which case the instructions were restated and the trial started over. Once the PM successfully chose an orange mat and both participants did the high-clap, they were told to return to their start cones. This concluded the warm-up phase of the mat game.

The experimental phase of the mat game began after the participants were told that they would repeat the game "a few more times" and that for each trial, the PM could always choose which mat to go to – either the same mat as the CM or the mat where no one was standing – as long as it was the colour that was specified. For each trial, a timer was used to ensure that the PM was running or walking for five seconds from the point the CM chose a mat until it was the PM's turn to choose a mat. When the PM was equidistant to both possible mat choices, the PM's command was given. There were four trials in total and for experimental control each session followed the same sequence of mat colour and action

combination (i.e., purple mat/wrist-rock, green mat/shoulder-duster, purple mat/shoulder-duster, and green mat/wrist-rock). The whole task, including warm-up, took about 12 minutes.

Picture task

After the completion of the mat game, participants were taken to a separate space within the experimental area to complete a picture-making task. Each participant was given a pair of gender-specific stickers and a sheet of paper displaying two trees (one at either side), a sun, and a green line representing grass (see Figure 5.3). Participants were told to "make a picture of you and your partner by placing the stickers anywhere in the grass on the picture". Further instructions were given to ensure they did not place stickers anywhere else besides the green line. Participants were seated facing away from each other to avoid visual access to each other's papers. Once both participants completed their pictures, they were taken to another area within the experimental space for the final task.

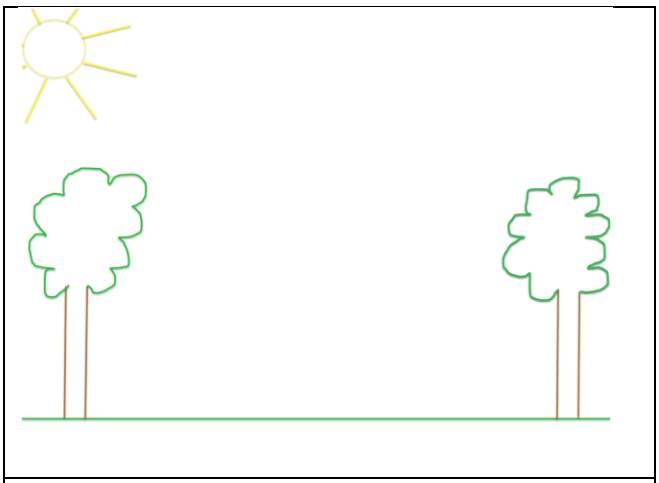


Figure 5.3 Picture task template

Mystery box task

For the mystery box task, the participants were taken to an area in which a box was positioned on a chair and covered with brown cloth (see Figure 5.4a). There were two strips of brightly coloured material – one orange and one purple - laid on the ground, in front of the box. The purple strip was placed directly in front of the box at a distance of two metres. The orange strip was positioned next to the purple strip at a slight angle, also at a distance of two metres from the box. Participants were told to stand together on the orange strip

and face the experimenter. The box remained covered by the brown cloth as the instructions were given. Participants were told that underneath the cloth was a mystery box and that the contents were unknown. They were told that anything could be inside – even an animal.

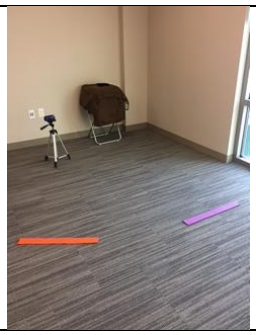
a)  b) 

Figure 5.4 The mystery box task (a) setup and (b) mystery box

It was then explained that one of the participants would place their hand inside the box and describe what they felt to the other participant, so the other participant could guess the contents. They were told that a name would randomly be drawn from a bag that contained the names “place-maker” and “colour-matcher” (the roles from the first task). Whoever had the role of the selected name would place their hand inside the box. To ensure the PM in the first task would be selected to place their hand into the box, the bag contained only PMs.

Once the name was selected from the bag, the PM was told to stand at the purple line and the other participant to stay at the orange line. After a check for understanding, the brown cloth was lifted and the mystery box – a box covered with black, furry material, with a yellow opening – was revealed (see *Figure* 5.4b). The PM was then told, “When you’re ready, put your hand inside the box”. A video camera was set up just beside the box to film the time taken from the end of the given instruction for the child to put their hand into the box, up to the wrist. Once the PM described the item inside the box, they were told to remove their hand. The CM was then given an opportunity to guess what was inside before it was disclosed as being a teddy bear. All participants then received a sticker for participation and were taken back to their classrooms. In total, each session lasted about 20 minutes.

5.3 Coding

Inter-rater reliability coding was done by two individuals who were condition-and hypothesis-blind. Detailed instructions given to coders are included in Appendix M. In the mat game, several behaviours were assessed through post-hoc video coding. First, PM mat choice was coded as either "Apart" or "Together" for each of the four trials. Second, raters coded "Participant behaviour". This was the behaviour of the CM and PM as they ran (or walked) around the mats in each trial. Six behaviours were coded by numeric identifier: talking(1), singing(2), laughing(3), gesturing(4), silent(5), and touching(6) (see Table 5.1 for examples) and more than one behaviour could be coded for each observation. In addition, CM behaviour was coded from the time the CM chose a mat to the time the PM made the mat choice. Three CM behaviours were coded, also by numeric identifier: CM encourages PM to join the mat(1); CM discourages PM from joining the mat(2); or CM neither encourages nor discourages PM to join the mat(3). To confirm compliance with the instructions, it was also coded whether the children were walking or running.

Table 5.1 Mat Game participant behaviour

Behaviour	**Numeric Identifier**	**Description**
Talking	1	Talking to oneself, the other child, each other, or the experimenter
Singing	2	Singing either alone or with each other
Laughing	3	Laughing either alone or with the other child
Gesturing	4	e.g., making motions with hands and/or arms to signal to the other person
Silent	5	i.e., not talking, singing, or laughing
Touching	6	Touching the other child e.g., high-5, pushing, kicking

The same video coders also coded the mystery box task. For these videos, coders recorded the frame number when the experimenter finished giving the instructions to the participants and the frame number corresponding to the moment the PM's hand entered the box, up to the wrist (see Figure 5.5). The coders also coded for PM's reactions following the experimenter's instructions up to the moment when their wrist entered the box.

Possible, non-exclusive reactions included in the coding scheme were: the child verbally expresses fear(1); child questions or comments to the experimenter(2); child tries to look inside(3); child starts to place hand in box, but then retracts before the wrist was in(4); child laughs(5); or child goes straight to box and places hand inside(6). The final code was to determine if each child placed their hand into the box. This was coded simply as 'yes' or 'no'.

a) b)

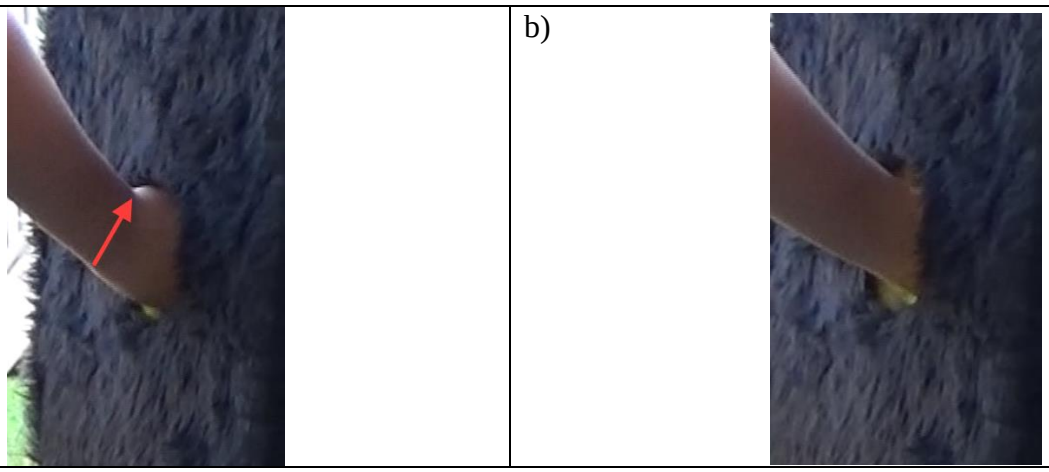


Figure 5.5. Still frame images of child's arm (a) before hand is fully inside the box (wrist indicated by red arrow) and (b) with hand – up to the wrist - inside the box. The 'Stop' frame was recorded when the child's arm appeared as in image (b).

Mat Game Reliability Coding

First, the raters independently coded all the videos, then met together to discuss discrepancies (91 mat game videos, 73%[5]; 48 mystery box videos, 38%). After discussion, inter-rater reliability for participant behaviour across the four trials ranged between $\kappa = .926$ and .959, $p < .001$. Inter-rater reliability for the two coders data was compared to my coding, yielding three-way reliability results ranging from $\kappa = .906$ to $\kappa = .917$, $p < .001$ for participant behaviour.

[5] The high amount of discrepancies (and low agreement) in the mat game videos can be attributed to the amount of coding in each video. There were nine possible behavioural codes for each video (and more than one coding option could be selected for six out of nine behaviours) and perfect agreement required that codings matched across all nine codes.

CM behaviour was coded with very little variability between the coders, which can distort kappa scores. For this reason, chi-square tests were used to determine inter-rater reliability for CM behaviour, resulting in post-discussion scores of X^2 (1, N = 125) = 0, p = 1 across all four trials (see Table 5.2 for full inter-rater reliability scores). Three way reliability results ranged from κ = .725 to κ = .809, p < .0001 for CM behaviour (though Trial 1 used Chi-square due to lack of variability: X^2 (2, N = 125) = 0, p = 1). The majority coding (between myself and the two coders) was used for the final mat game coding of all behaviour, resulting in an agreement of 100% of all codes for all videos. There was total agreement (100%) on PM mat choice across all trials.

Mystery Box Reliability Coding

One mystery box video was removed from analysis after both coders agreed that the view was too obstructed to tell whether the child's hand went into the box or not. PM behavioural scores from the mystery box game after discussion were also very reliable (κ = .911, p < .001). Inter-rater reliability for the two coders data was compared to my coding, yielding three-way reliability results of κ = .853, p < .001 for PM behaviour in the mystery box game. Three-way reliability for time taken for the PM to place the hand inside the box was very reliable with the average measure ICC at .975 with a 95% confidence interval from .879 to .934 (F(113, 228) = 31.2, p < .001. Due to time being continuous data in the mystery box videos, it was not possible to use majority coding as in the mat game. Thus, only one external coder's mystery box data was used for the analysis. To determine which to use, the two sets of code were compared to my own and the one most similar to mine was used for analysis.

Picture Task Coding

The picture task was coded by measuring the distance between the stickers placed onto the page by the PM. This was completed by me and measured in millimetres from the centre of the body of each sticker. All statistical analyses were run using RStudio, Version 1.0.143 (2016).

Table 5.2 Inter-rater reliability for coding in Mat Game and Mystery Box Game

	2-way IRR	**2-way IRR, post-discussion**	**2-way X^2**	**2-way X^2, post-discussion**	**3-way IRR**	**3-way X^2 (Trial 1, from CM behaviour only)**	**2-way ICC**	**3-way ICC**
Mat Game								
Participant behaviour	k = .52-.60, p < .001	k = .926-.959, *p* < .001			k = .906 - .917, *p* < .001			
CM Behaviour	[Trials 2-4] k = .24 - .30, p < .001		[Trial 1] X^2 (1, N = 125) = 0, *p* = 1.00	X^2 (1, N = 125) = 0, *p* = 1.00	k = .725 - .809, *p* < .001	X^2(2, N = 125) = 0, *p* = 1.00		
Mystery Box								
PM behaviour	k = .47, *p* = 0	0001k = .911, *p* <. 001			k = .853, *p* < .001			
Time							.986, CI(.98-.99), F(116, 117) = 140, *p* < .001	.975, CI(.879-.934, (F(113, 228) = 31.2, *p* < .001

5.4 Results

Mat Game: Effect of condition on social choice

Results of the mat game were analysed to determine whether PMs in the running condition chose to be together with the CMs more often than PMs in the walking condition (see Table 5.2 and 5.3). The number of times PMs chose to be with CMs were calculated for each condition (see Table 5.2). A Chi-square test revealed no significant differences between the two groups in the frequency of choosing to be together (running condition M = 50.40, SD = .50, walking condition M = 47.62, SD = .50; X^2 = .21, df = 1, p = .65). A t-test was also conducted to compare the mean social choice 'scores' between conditions. The social choice score was calculated for each PM by first assigning a value of "1" for choosing the same mat as the CM and "0" for choosing a different mat. The total for each PM was then divided by the number of trials, resulting in an average score. This score was used to conduct a t-test in order to test for a difference in the mean scores between conditions (M_{walk} = .47 (SD = .27), M_{run} = .50 (SD = .30). The test revealed no significant difference between conditions (t[121.26] = -0.54, p = .59).

Table 5.2 Frequency of PM social choice by condition

	Together	Apart
Running	125	123
Walking	120	132

The outcome variable for this analysis (Mat Choice) was binary (together or apart). As such, a repeated-measures mixed-effects logistic regression model fit by maximum likelihood was employed to analyse the effect of trial, condition, gender, and age on mat choice. To do this, the R package "lme4" for generalised mixed linear models was used. Trial, condition, gender, and age were all entered as fixed effects in the model and participant ID was entered as a random effect. As Trial had 4 levels, Trial 1 was used as the baseline reference category and Trial 2, 3, and 4 were entered as fixed effect into the model (see Table 5.3). Of all the predictor variables, age was the only statistically significant predictor of mat choice (see Table 5.3; see Appendix N for full model details).

Table 5.3 Parameter estimates for fixed effects on social choice in mixed logistic regression and associated standard errors and probabilities				
Effect	Estimate	Standard Error (SE)	z-Value	Pr(>|z|)
(intercept)	-0.28	.26	-1.105	.269
Trial 2	.14	.27	.511	.609
Trial 3	.06	.27	.233	.816
Trial 4	.43	.28	1.552	.121
Condition	.10	.23	.460	.646
Gender	.02	.23	.109	.913
Age	-.27	.11	-2.351	.019

Picture task: effect of condition on perceived closeness

As a secondary measure of social bonding, perceived social closeness was measured as the distance PMs placed between self-representative stickers of themselves and the other child on a picture. Linear regression was at first chosen as the appropriate method of analysis to test the effect of condition on perceived closeness. However, the dependent measure of distance was not normally distributed and there were several outliers in the data. Attempts to transform the data using Box-Cox power transformation (Box & Cox, 1964) and logarithmic transformation failed to normalise the distribution. Thus, Robust ANCOVA (analysis of covariance) was selected as the method for analysis, as it makes no assumption of normality and can detect outliers without transforming the data. This method compares trimmed means between two groups at five different points along the covariate where the slopes are the same between the two groups (Wilcox, 2005; Field, Miles, & Field, 2012). Robust ANCOVA only allows for one covariate in the model, so the data were split by gender and analysed separately – a solution that also maximises the robustness of the model (R. Wilcox, personal communication, October 29, 2018). Using the function “ancova” in R package WRS (Wilcox & Schönbrodt, 2014; Wilcox, 2005), the model for each gender was constructed by entering the distance for the walking condition as the first dependent variable and age for the walking condition was entered as the first covariate. Distance for the running condition was entered as the second dependent variable and age for the

running condition was entered as the second covariate. Of the five points analysed, none showed a significant difference between the means of the two conditions (see Tables 5.4 and 5.5).

Table 5.4 Robust ANCOVA results for males in picture task

Age (months)	Difference in distance (between the two groups)	Standard Error	Confidence Interval (low)	Confidence Interval (high)	*p* -value
83.88	1.46	7.78	-20.54	23.46	.853
86.16	-.67	8.09	-23.64	22.31	.935
92.63	-12.23	11.81	-45.29	20.82	.312
99.48	-9.98	15.13	-53.94	33.98	.519
103.56	-14.83	15.30	-59.86	30.20	.349

Table 5.5 Robust ANCOVA results for females in picture task

Age (months)	Difference in distance (between the two groups)	Standard Error	Confidence Interval (low)	Confidence Interval (high)	*p* -value
81.72	4.93	19.70	-54.73	64.58	.807
86.04	10.40	14.75	-31.84	52.64	.490
88.80	14.56	9.66	-13.37	42.50	.151
96.23	1.00	15.93	-43.99	45.99	.951
100.32	-3.07	19.09	-59.16	53.03	.875

Mystery box task: effect of condition on inhibition

Multiple linear regression was chosen as the method of analysis to predict the effect of condition, age, and gender on behavioural inhibition. The outcome variable, time, was not normally distributed and a Box-Cox power transformation was employed to normalise the data (Box & Cox, 1964). The transformed time was used as the outcome variable in the model; condition, age, and gender were entered as independent variables, and interaction

terms of age and condition, gender and condition, and gender and age were included (full details of the model can be found in Appendix O). The model was significant (F[6, 114] = 2.78, p = .01), with an R^2 of .12. Results indicate there was a significant effect of gender on time (β = -0.12, *SE*(.06), adjusted R^2 = .08, p = .05) and a significant interaction of age and gender (β = .001, SE(.0006), adjusted R2 = .08, p = .03). Age was removed as a main effect from the model, along with the interaction terms for age and condition and gender and condition. Thus, the final model included time as the outcome variable, gender as the predictor variable, and an interaction term of age and gender. This simplified model was significant also (F[4, 116] = 3.96, p = .005), with an adjusted R^2 of .09. Results confirm a significant effect of gender on time (β = -0.12, *SE*(.06), adjusted R^2 = .09, p = .04) and a significant interaction of age and gender (β = .001, *SE*(.0006), adjusted R2 = .09, p = .03; see Figure 5.6). The interaction reveals that the effect of age on behavioural inhibition depends on gender; only males showed an effect of age on time taken to place the hand inside the box, such that older boys were quicker to put their hand in the box than younger boys. As there was no apparent effect of condition on social behaviour and affiliation, and no apparent condition-wise effect on behavioural inhibition, possible associations between these two measures were not investigated.

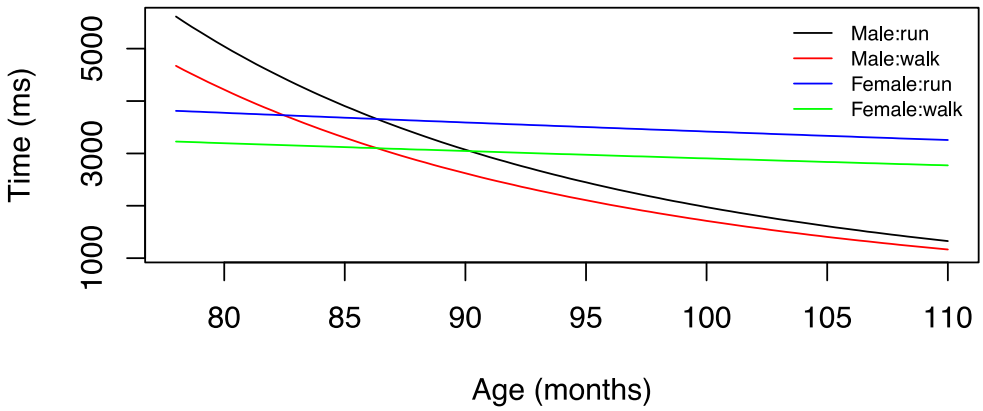


Figure 5.6 Interaction effect of age on time.

5.5 Discussion

The current study investigated whether level of physical exertion has an effect on social bonding (i.e. social choice and perceived closeness) and behavioural inhibition of 6-to-8-year-old children in a JPAP context. Previous research on adults and adolescents has shown

that physical exertion facilitates social bonding (Davis et al., 2015; Di Bartolomeo & Papa, 2017, Tarr et al., 2015). Similarly, prior studies with children support an association between PA and social relationships (Macdonald-Wallis et al., 2011; Sanders et al., 2014; Roberts et al., 2013; Ridgers et al., 2010; Woods et al., 2015) and PA and enjoyment (Rittenhouse et al., 2011; Sanders et al., 2014; Jefferies et al., 2018). Yet, no causal links in childhood have been explored. This study attempted to expand the causal links from adults to middle childhood by experimentally testing for a causal relationship between physical exertion and social bonding among children engaged in JPAP.

It was found that level of exertion had no effect on children's social bonding or behavioural inhibition. There was a main effect of age on social choice, as younger children chose to be together more often than older children. There was also an effect of gender on behavioural inhibition, as females took longer to complete the task than males. Lastly, there was an interaction effect of gender and age on behavioural inhibition in that males had a significant negative relationship between age and time taken to place the hand inside the box.

The main research question was whether or not physical exertion increases social bonding, as indicated by social choice (i.e., choosing to be together or apart) and proximity (i.e., distance placed between self-representative stickers on a picture). The null findings in both tasks are inconsistent with our expectations and prior literature from adults and adolescents. Potential explanations for these findings are outlined below.

First, it may be that exertion does not have a social bonding effect in 6-8 year-old children. Although there is a large body of research that links children's PA with social relationships (Macdonald-Wallis et al., 2011; Sanders et al., 2014; Roberts et al., 2013; Ridgers et al., 2010; Woods et al., 2015) there is a lack of evidence from controlled experimental studies that can assess causality. Other supporting literature suggests a causal link between moderate intensity PA and prosocial behaviour in adults and social bonding in adolescents. These studies specifically suggest a neurohormonal response to moderate-intensity exercise that has been linked to social bonding in non-human primates in the form of social grooming and humans in activities such as social laughter (Dunbar et al., 2011) and music-making (i.e. vigorous singing, dancing and drumming [Dunbar, 2012]; for a review see Tarr,

Launay, & Dunbar, 2014). However, these studies from adults and adolescents tested the effect of prolonged PA (30 minutes in adults, 10 minutes for adolescents), while our experiment used short bursts of MVPA, similar to children's real-world physically active play. Each mat game session lasted no more than 10 minutes (including the training period) with only about 3 minutes of continuous MVPA in total during the test period. Therefore, it may be that there was not enough sustained MVPA to elicit the same neurohormonal effect found in adults and adolescents. Future studies investigating social effects of MVPA in children should aim to use sufficiently prolonged MVPA (i.e. 10-30 minutes) in order to have a more precise design for comparison.

Second, the outcome variables used to indicate social bonding (i.e. social choice and perceived social closeness) may have been problematic. For example, in the mat game, the participants were both aware that the PM would be choosing either the mat where the CM was standing or the other mat of the same colour. This may have inadvertently put pressure on all PMs to be neutral and not pick a majority one way or the other. It has been reported/claimed that young elementary school children tend to make social judgments based exclusively on equality, rather than on merit, need, or personal attributes (Turiel, 2008). Experimental evidence supports this claim, as children from 3-4 years old have been found to prefer selfish outcomes in economic games whereas by age seven, the majority of children's preferences are egalitarian (Fehr, Bernhard, & Rockenbach, 2008). Other related research has found that among 6–8 year-olds, there is a tendency to make sacrifices in order to be fair, indicating a preference for egalitarianism (Blake & McAuliffe, 2011; Shaw & Olson, 2012). Considering children's emerging sensitivities to inequality in this age range, our design might benefit from silent (or otherwise inconspicuous) instructions to the PM, so that the CM would be unaware of the PM's options for each trial. This would in turn free the PM of any concern related to CM perspective-taking and yield purely PM preference-based decisions for each trial. Furthermore, rather than a dichotomous measure for social choice (i.e. alone or together), it may be more informative to have a general 'proximity' measure (see Tunçgenç & Cohen, 2016). For example, by adding one more mat of each colour, the CM could pick from three mats of the same colour. Thus, the CM could choose to be on the same mat as the PM, the next closest mat to the PM, or the mat most distant from the PM.

This small change in design would allow the data to better capture a nuanced effect of affiliation that a dichotomous measure might obscure.

The picture task may have also had a design limitation in that children were not given creative freedom. Children were simply told to make a picture of themselves with their partner, using the page and two stickers they were given. Previous picture-making tasks have had children draw their own pictures with minimal restrictions. Our task comprised of only stickers and a page with pre-drawn images of the grass, two trees, and the sun. By doing this, we improved the level of experimental control and reduced the time taken to complete the task; however, we diminished each child's natural expression of how they perceived the other child. We were willing to accept this trade-off, as the study design comprised of three separate outcome measures with this task as a secondary measure. However, future studies using only a drawing task as an outcome measure should carefully consider allowing children's natural creative depictions to capture the full range of expression that drawings may convey.

Study location is another factor to consider. This study took place in the US, which is generally considered a so-called "non-contact culture", as is northern Europe and Asia (Mazur, 1977; Thayer, 1988; Dibiase & Gunnoe, 2004). This is compared to contact cultures, such as Latin America, southern Europe, and the Middle East, where social interactions are markedly more tactile. Observational accounts also support these generalisations, as it has been reported that Greeks and Italians engage in more touch during dyadic social interactions than English, French, or Dutch (Remland, Jones, and Brinkman, 1995). It has also been reported that young adult Italians engage in more non-hand touching (e.g., hugging, kissing) in public than Czechs and Americans, although Czechs engaged in more hand touching in public than Italians, who engaged in more hand touching than Americans (Dibiase & Gunnoe, 2004). Furthermore, experimental evidence from adults in the US shows that touch conveys distinct emotions, even in the absence of verbal or visual cues (Hertenstein, et al., 2006). Taken together, these studies suggest that touch may be an important sensory mode to convey meaning and that the frequency with which it is employed may be culturally dependent. Thus, in the absence of a message to convey, children in the US may simply prefer not to touch others, when given a choice. If this were

the case, we would expect a much higher proportion of PMs choosing to be apart in both conditions. However, due to the mat choice data being near evenly split between together or apart in both conditions, it is unlikely that cultural touch-aversion was a significant factor in mat choice. Future studies should include cross-cultural samples to explore the effect of culture on social bonding during JPAP.

A significant effect of age, independent of condition, was found in the mat game, as younger PMs chose to be on the same mats as CMs more often than older PMs. This may be due to older children being more aware of social conventions relating to personal space. It has been suggested that between the ages of 8-11, children develop the cognitive skills that allow for more selective interactions with others (Ellis, Rogoff, & Cromer 1981). For example, one naturalistic observation study found consistent age differences of proxemic behaviour (i.e., the use of interpersonal space [Hall, 1959, 1966]) increasing from grade one to grade seven, which then levelled off from grade seven to 11 (Aiello & Aiello, 1974). Other studies support this developmental trend as continuing up to the early 20s (Hayduk, 1983).

In addition to awareness of personal space, there may be age differences in the number of friends children have. For example, one longitudinal study from Canada on friendship formation and stability as it relates to victimisation and aggression found that at the start of the study older children (seventh (M_{age} = 12.39 (SD = .4)) and eighth graders (M_{age} = 13.39 (SD = .36)) had more mutually nominated friends (i.e. children named each other as friends) than younger children (i.e. fifth (M_{age} = 10.42 (SD = .35) and sixth graders (M_{age} = 11.42 (SD = .33)) and that younger children were more likely to be friendless (Ellis & Zarbatany, 2007). It may be that younger children place greater importance on initiating social interactions and the benefits of those interactions materialise over time into stable relationships. Older children, then, may not initiate social interactions as often as younger children, as they may already have enough stable friendships.

In the drawing task, girls placed the self-representative stickers closer together than boys and this effect was independent of condition. Similar gender differences have previously been reported from a study of the affiliative effects of ostracism, in which children were asked to draw a picture of themselves and a friend after watching either two priming videos

of ostracism or two control videos. Researchers asked adults to evaluate children's drawings in terms of how affiliative they were. The drawings depicted the girl or boy who made the picture and a friend of theirs. Although the distance between the two children in the picture were similar for girls and boys, the adults perceived the girls' drawings as more affiliative (Song, Over, & Carpenter, 2015).

Lastly, the mystery box game found a significant effect of gender on behavioural inhibition, as males completed the task faster than females. This is in contrast to previous studies from similar age groups using a similar task to test the effect of fear information on children's behavioural avoidance (Field & Lawson, 2003; Remmerswaal, Muris, & Huijing, 2013). This may be due to differences in how the children were primed for fear. In our design, children did not know what was inside the box. They were told that anything could be inside the box, followed by several examples (e.g., something slimy, something hot or cold, or an animal). In the previous studies, children were primed with either positive or negative information about a specific Australian mammal. Thus, it may be that when children are primed with unknown, rather than known stimuli, females become more behaviourally inhibited than males.

Regular PA is known to be an important predictor of health and well-being throughout the lifespan; however, the social effects of PA are not well understood. Much research on children's physically active play has formed associations with PA and social relationships, but only insofar as social relationships may influence children's PA levels and enjoyment of PA. Importantly, that research was primarily motivated by reducing childhood obesity through increasing children's PA. Children's free play is primarily social (see chapter three) and therefore has the potential to shed light on not only PA patterns, but also social outcomes. Given the mounting support for associations between children's PA and sociality and the experimental support from studies on adults and adolescents, the null findings reported here should not preclude further investigation of these links. As this was the first attempt to empirically test this relationship in middle childhood, more studies are needed to fully understand the effect that PA may have on children's social lives.

6.0 General Discussion and Conclusion

6.1 Introduction

Children's physically active play is a prevalent feature of everyday life in childhood. Physically active play has been the subject of much investigation into children's daily PA and of programmes aimed at increasing children's daily MVPA. Studies have found associations between friendship groups and PA enjoyment and engagement, and between MVPA and children's social-cognitive development, which suggests a relationship between PA and sociality (see chapter two. However, no studies have explored children's JPAP as a cause of social bonding. This project aimed to fill this gap by exploring the relationship between JPAP and social bonding. Three primary research questions were examined: Are there positive associations between PA and touch, PA and enjoyment, and PA and social bonding (chapter three)? Does touch, as compared to no-touch, facilitate prosocial behaviour in a JPAP context (chapter four)? Does MVPA, as compared to low PA, facilitate social bonding in a JPAP context (chapter five)? This chapter will first provide a brief summary of the thesis followed by a discussion of the implications and limitations of the work, recommendations for future work, and concluding remarks.

6.2 Brief Summary

In chapter one, I provided the motivation for studying social bonding in children within a play context. I outlined the importance of social bonding in human evolution and development and argued that there is a lack of research on social bonding in children. Play was introduced as a relevant context for children's social bonding, as children's social lives often revolve around play. The function of play was discussed and I proposed that in addition to the many deferred benefits of play, there may also be an immediate benefit of social bonding. Chapter two introduced JPAP as a context within which children's social bonding may take place. I argued that most research within children's physically active play has sought to either quantify the amount of MVPA children engage in while playing or to identify behaviours and social factors that influence children's MVPA. Although this research has established relationships between PA and sociality, it has neglected to consider that there may be a causal relationship between PA and social bonding. Key features of JPAP include MVPA, touch, enjoyment, and joint action. Each of these features has been

independently linked with social bonding among non-human primates, adults or very young children. Little is known, however, about their effects on school-age children. I also argued that controlled experimental studies are especially needed in order to establish a causal link between these behaviours and social bonding in children.

The primary objective of chapter three (Study 1) was to explore the relationship between children's PA, touch, enjoyment (i.e. smiling and laughing), and prosocial behaviour during natural play. It was found that nearly all of children's play behaviour was social and most of children's play was physically active (i.e. light or MVPA), though most PA was light. Positive, significant relationships were found between PA and touch and PA and enjoyment. A negative significant relationship was found between PA and positive engagement (not involving touch). A marginally significant relationship was found between PA and prosocial behaviour. Prosocial observations were very rare, however, and consequently, no reliable conclusions could be drawn. Due to the prevalence of touch and exertive PA found in children's free play, there was clear motivation to experimentally test relationships between touch and social bonding and PA and social bonding.

Chapter four (Study 2) built on chapter three by testing the effect of touch on children's prosocial behaviour (as an indicator of social bonding). In a between-subjects experimental design, children were assigned to either a touch or no-touch condition and played a fun, physically active game in which they either placed felt shapes onto each other (touch condition) or onto a board (no-touch condition). Subsequent helping was measured in a game where one child's toy was designed to break, prompting an opportunity to spontaneously help. Helping was measured and compared between the two conditions. Results from the touch study suggest a significant gender difference in that girls helped more than boys and this effect was independent of condition. However, we did not find a significant effect of touch on children's prosocial behaviour, despite a trend of more helping in the touch condition. This trend suggests that a larger sample size may be needed in order to detect a small, rather than medium, effect from touch.

Chapter five (Study 3) also built from chapter three (Study 1) by testing the effect of PA exertion on social bonding (i.e. social choice and perceived closeness) and behavioural

inhibition. Exertion was manipulated as a fun game in which children either ran (MVPA condition) or walked (light PA condition) around coloured mats and, when prompted, one child chose to stand either on the same mat as the other child and do an action together or stand on separate mats and do an action separately. No significant relationships were found between PA and social bonding or PA and inhibition. However, there was a significant effect of age on social choice in that younger children chose to be together more than older children and this effect was independent of condition.

6.3 Implications

Taken together, the results of these studies suggest positive relationships between PA and touch and PA and enjoyment. However, once tested experimentally, causal effects of PA on social bonding were not apparent or consistent. Possible implications for these studies are discussed below.

6.3.1 For Methodology

The aim of this project was to explore and test the relationship between PA, touch, and social bonding in children. This project was successful in achieving this aim by designing new methodologies for systematic observation and controlled experimental designs. The observational method was adapted from a previous system designed to explore influential behaviours of children's PA. The system was modified for this project in order to include touch behaviour, prosocial behaviour and facial expressions in addition to PA level and social context. Once tested, this proved to be a successful method for capturing the full range of social bonding behaviours that children often exhibit during free play – prosocial behaviour, touch, and smiling/laughing. These behaviours were easily coded and analysed with PA to assess the hypothesised associations, suggesting that implementation of this new method in future observational studies could facilitate further understanding of children's social behaviours and PA during play.

In addition to a new observational method, this project also tested new experimental methods for investigating social bonding effects of touch and exertion. No previous research with children has explored links between touch and social bonding or exertion and social bonding. Therefore, no precedent had been set for how to test these relationships. Several

dependent measures for social bonding (i.e. 'Fish Feeding Game' and Likert-scale question from the touch study and the 'Picture task' from the exertion study) were adapted from previous studies. However, the independent measure from the touch study (i.e. 'Shape Game') and the main dependant and independent variable in the exertion study (i.e. 'Mat Game') were completely novel and offer practical models for how future studies can experimentally test the links between touch, exertion, and social bonding in children.
The results of the observational study offer the first evidence of a relationship between PA and touch and PA and enjoyment (as indicated by smiling/laughing). The results of the experimental studies suggest a non-significant trend toward more prosocial behaviour in the touch condition as compared to the no touch condition and no significant difference in social bonding between the MVPA and low PA conditions. Together, these studies demonstrate the importance of the combination of naturalistic observations and controlled experimental studies in the exploration of human behaviour. Observational data alone cannot control for the multitude of external influences that are present in human interaction. For example, the observational study reported here found positive relationships between PA and enjoyment, PA and touch, and PA and prosocial behaviour. However, when this link was experimentally tested to extend to social bonding, no relationship was found. It may be that the relationship between touch and PA goes in the opposite direction, such that more touch leads to higher levels of PA, or that additional factors not accounted for in the observational coding scheme and/or the subjective nature of observational studies made it more likely to yield positive results. Future studies within cognitive and evolutionary anthropology should consider both ecological validity and experimental control in exploring questions of human behaviour.

6.3.2. For Child Development

Children's physically active play has received much research attention throughout educational and health psychology. However, questions around children's social bonding during physically active play have received comparatively little attention (for exceptions, see Humphreys & Smith, 1987; Lindsey, 2014). Studying children's social bonding is particularly important, because social life becomes increasingly more complex as children progress through school. Indeed, bullying and peer victimisation become more prevalent during transitional times at school (e.g. going from elementary school to middle school [Pellegrini

2002]) and having quality friendships has been associated with protection from both (Goldbaum, Craig, Pepler & Connolly, 2008; Bollmer et al., 2005; Rigby, 2005; Boulton, Trueman, Chau, Whitehead & Amatya, 1999). Furthermore, studies have highlighted the detrimental consequences of social isolation and the importance of early social bonds for healthy social development (see chapter one). The findings from this project do not support a causal relationship between JPAP and social bonding. However, results from the observational study combined with the theoretical support in chapter two suggest that the relationship between JPAP and social bonding should be further considered and explored.

6.3.3. For the function of play

Finally, in hypothesising a social bonding function of JPAP, this thesis also proposed an additional, immediate benefit of children's play. As discussed in chapter one, much of play theory has focused on deferred benefits of play, such as developing the social skills to successfully interact with others (Piaget, 1962; Erikson, 1956) or learning to explore and take risks (Sutton-Smith, 1978). Although this thesis did not attempt to elucidate the function of play, it did provide a theoretical argument in support of an immediate, rather than deferred, social bonding benefit from JPAP. The findings from the observational study in chapter three offer some initial support for this in that children were found to engage in more behaviours associated with social bonding (i.e. peer to peer touch, smiling/laughing, and prosocial behaviour) at higher PA levels. However, the findings from empirical chapters four and five did not detect causal relationships. Thus, more observational and empirical research is needed in order to fully explore an immediate social bonding benefit of play.

Although most research on play has concentrated on childhood, JPAP in particular can persist into adulthood in forms that bear a striking similarity to those seen in childhood, for example in sport and dance, and has been associated with social bonding in adults (Tarr et al., 2015; 2016; Davis, Cohen & Taylor, 2015; see chapter two). Thus, it is possible that the associations between JPAP and bonding, and other outcomes such as creativity or improved mood, observed in childhood persist across the lifespan. Unlike ontogenetic adaptations that serve a specific purpose at a single point in development and then disappear (such as breast-feeding during infancy), many forms of play, including JPAP, may serve adaptive functions into adulthood. All adaptation is environmentally contingent at some level,

however, with much of this adaptation happening in ontogeny, including in response to local resource ecologies and cultural norms (Klien, Shamsudheen, & Broesch, 2018; Bjorklund, 2015). Thus, we would expect individual and population-level variation in the extent to which children engage in JPAP (e.g., in response to energetic trade-offs between growth and physical activity (see Said-Mohamed, Pettifor, & Norris, 2016)), and the extent to which a relationship with social bonding exists (e.g., according to differences in normative instruction about teamwork, sharing, etc.).

6.4 Limitations and Future Directions

This thesis is the first attempt to hypothesise a link between children's JPAP and social bonding. Data from chapters three through five suggest relationships between children's PA and touch and children's PA and enjoyment, however no causal links were found between peer to peer touch and social bonding or exertion and social bonding. As with all novel research, there are limitations to these results. Addressing these limitations could improve future designs and contribute to a more clear understanding of the hypothesised links between PA, touch, and social bonding.

6.4.1 Sample Size

The studies reported in chapters three and four are limited by their small sample sizes. The observational study (chapter three) was designed to pilot a new observation methodology for exploring children's JPAP and social behaviours. Thus, a sample of 54 participants was considered appropriate for this aim. The study reported in chapter four used a sample size calculation based on that of similar studies that tested the effect of behavioural synchrony using the same dependent measure (i.e. fish feeding game). Based on the abundance of support in the literature for a link between touch and social bonding (see chapters two and four), there was no reason to think the effect of touch would be smaller than the effect of synchrony. Thus, future studies investigating the effect of touch on children's prosocial behaviour should use a large sample size in order to detect a small effect.

6.4.2 Cultural setting

This research included samples from the UK (chapter three) and the USA (chapters four and five) – two WEIRD (Western, Educated, Industrialised, Rich, Democratic) societies. It has

previously been noted that most research involving human subjects takes place in WEIRD societies and is therefore not informative of the worldwide population (Henrich, Heine & Norenzayan, 2010). In addition to being WEIRD, the UK and USA are known to have higher rates of childhood obesity and lower PA levels compared to many other societies (Roman-Vinas et al, 2016; Abarca-Gomez et al, 2017; Wang & Lim, 2012). Lastly, the US and UK have been described as non-contact cultures, as opposed to contact cultures such as Latin America, Southern Europe, and the Middle East (Mazur, 1977; Thayer, 1988; Remland, Jones, & Brinkman, 1995; Dibiase & Gunnoe, 2004). Thus, a future direction of this research would be to conduct investigations across diverse societies to find out if the results differ based on societal influences.

6.4.3 Design

The studies reported in chapters three through five include novel observational and experimental designs. The observational study design (chapter three) was adapted from a previous method to include behaviours such as touch, facial expression, positive engagement, and prosocial behaviour. These additions to the coding scheme were used to quantify general social bonding behaviours that may be associated with children's JPAP. However, in some cases the categories may have been too general for meaningful analysis. Specifically, prosocial behaviour was only noted if overt prosocial acts were observed (e.g. physically helped someone up; high-five; hug). However, other, less physical, prosocial behaviours (e.g. cooperative play (i.e. turn-taking); initiating positive engagement with another child; verbal encouragement) may have been present, but included as positive engagement. Furthermore, the results from the touch study (chapter four) suggest that touch without communicative meaning may not elicit social bonding between children in a JPAP context. This suggests that communicative touch may have been an important, yet undetected form of touch in the observational coding system. If significant differences in social bonding behaviours could be reliably observed between communicative and non-communicative touch in children's JPAP, this would better inform experimental studies. Indeed, the touch study may have also been limited by its design in the use of strictly touch or no-touch conditions. If non-communicative touch has no effect on social bonding in children, perhaps communicative touch does have an effect. A future direction then could be to include these specific types of touch and prosocial behaviours in observational study

designs and then experimentally test the effects of no-touch, communicative touch, and non-communicative touch on social bonding in a JPAP context.

6.5 Concluding Remarks

The studies reported in this thesis do not support a causal link between children's JPAP and social bonding. However, they do offer further motivation to explore this hypothesised relationship. Positive relationships were found between PA and touch and PA and enjoyment in the observational study, however these relationships did not extend to social bonding when tested using experimental designs and standard measures. The theoretical motivation for this project, combined with the observational results and a trend of more helping in the touch condition of the touch study suggest a need for more exploration into the relationship between children's JPAP and social bonding.

From early in development humans need stable social relationships to survive and thrive. However, the specific causal mechanisms that promote social bonding remain in question. If such mechanisms can be identified in childhood, benefits could range from educational to clinical outcomes and span throughout the lifetime ultimately leading to a more cooperative and peaceful world.

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Appendix A

Key for interpreting diagnostic plots for Appendices A through G:

Residuals vs. indices of observations: This scatter plot looks for trends in the data by measuring the distance of the predicted vs. observed values. The plot should appear random with no clear pattern (Ferrari & Cribari-Neto, 2004).

Generalised leverage vs. predicted values: This plot looks at the influence of each point on the overall model. High leverage values indicate possible influential points on overall model fit (Wei, Hu, & Fung, 1998; Ferrari & Cribari-Neto, 2004).

Residuals vs. linear predictor: The plot should appear random with no clear pattern to the data (Ferrari & Cribari-Neto, 2004).

Half-normal plot of deviance residuals: The plot looks at the positive half of the model residual distribution. The closer the points are to the dotted line, the better the fit (Atkinson, 1985; Neter, Kutner, Nachtsheim, & Wasserman, 1996; Ferrari & Cribari-Neto, 2004).

Predicted vs. observed values: This plot looks at how well the observed values match the predicted values. The better the fit of the model, the more the points will fall along the line. As long as there is positive correlation in the plot, the data are considered a reasonable fit (Ferrari & Cribari-Neto, 2004).

Diagnostic plots of beta regression for physical activity as a predictor of proportion of prosocial behaviour, controlling for gender

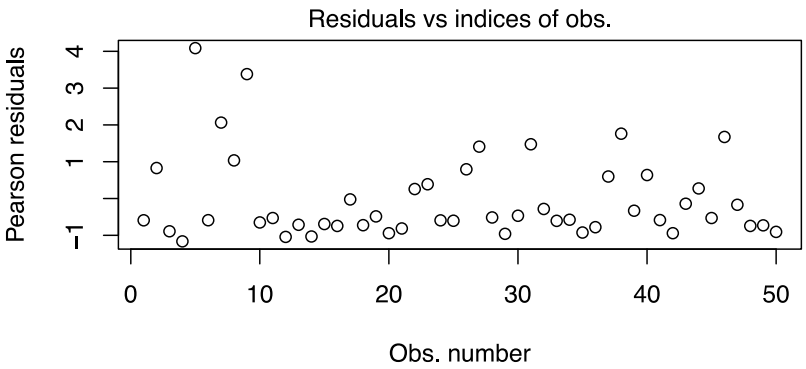


Figure A1. Diagnostic plot of model residuals vs. indices of observations.

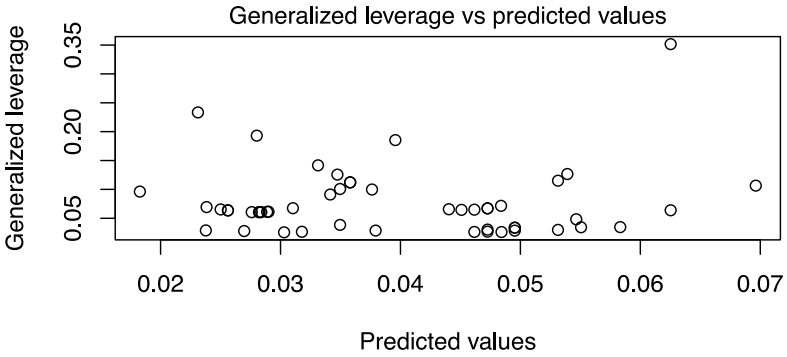


Figure A2. Diagnostic plot of generalized leverage vs. predicted values of the model.

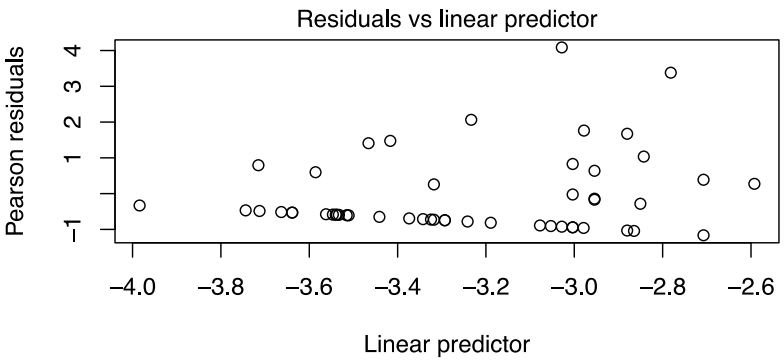


Figure A3. Diagnostic plot of model residuals vs. linear predictor.

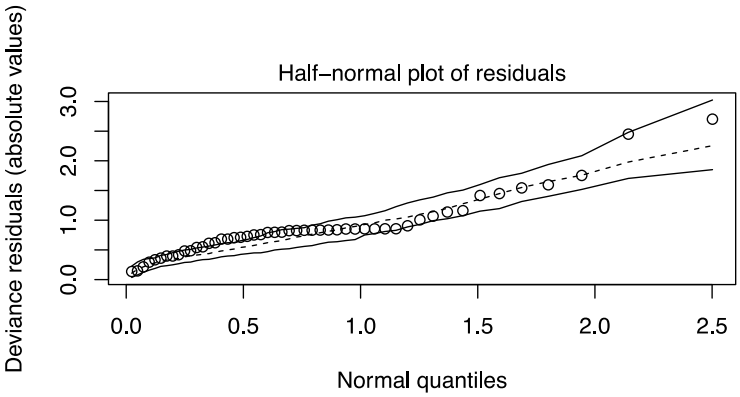


Figure A4. Half-normal plot of deviance residuals.

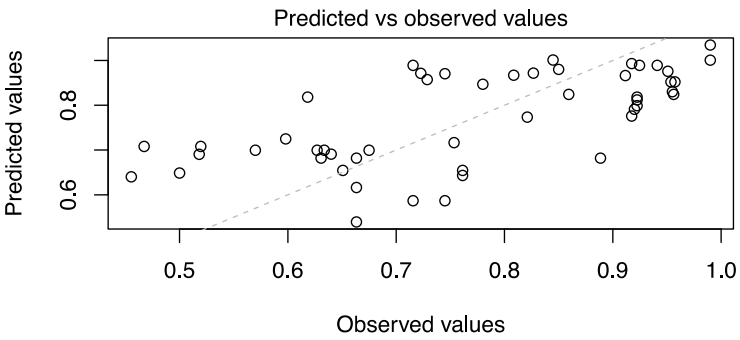


Figure A5. Diagnostic plot for predicted vs. observed values.

Appendix B

Heart Rate:

The distribution of average heart rate appeared to be slightly bi-modal with one peak at 110 bpm (95-120) and the other at 135 (120-180). When these two ranges were analysed separately, only lower heart rates yielded significant results. Lower heart rate significantly predicted touch frequency (β = .07, SE(.03), pseudo-R^2 = .25, p = .03) and marginally significantly predicted prosocial behaviour (β = .04, SE(.02), pseudo-R^2 = .14, p = 0.07). We treat these results with caution, however, due to the small sizes of the split sample.

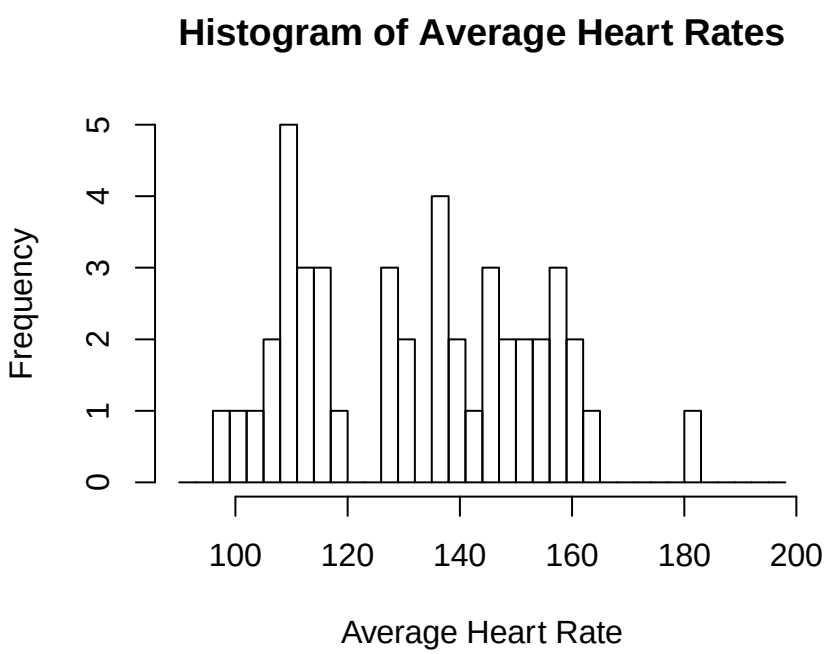


Figure H1. Histogram of average heart rate

Appendix C

Diagnostic plots for beta regression of average heart rate as a predictor of proportion of touch, controlling for gender

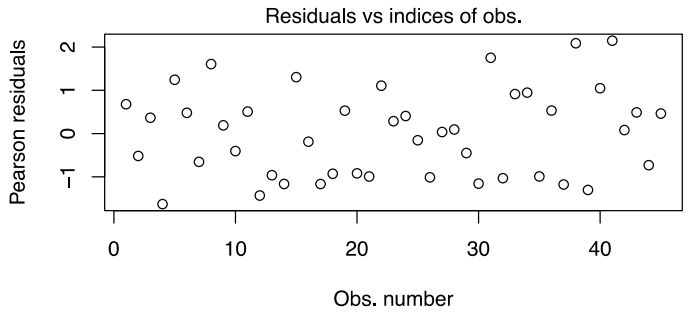


Figure B1. Diagnostic plot of model residuals vs. indices of observations.

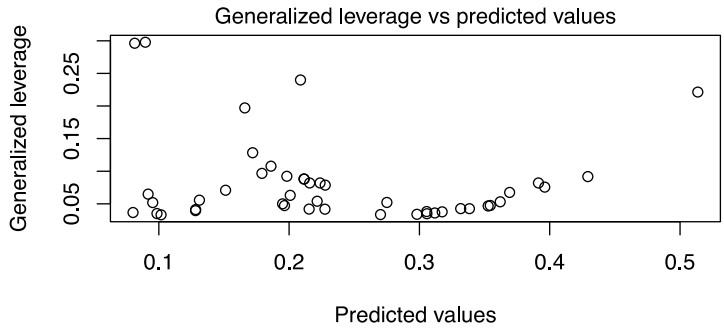


Figure B2. Diagnostic plot of generalized leverage vs. predicted values.

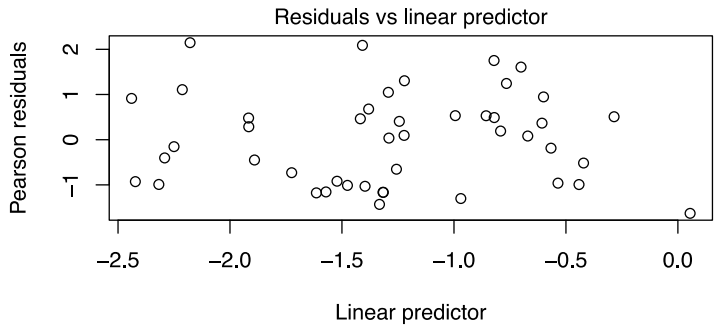


Figure B3. Diagnostic plot of model residuals vs. linear predictor.

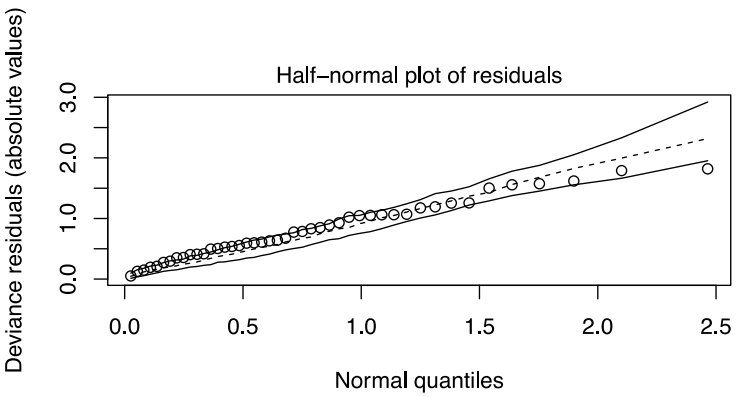


Figure B4. Diagnostic plot of model deviance residuals vs. indices of observations.

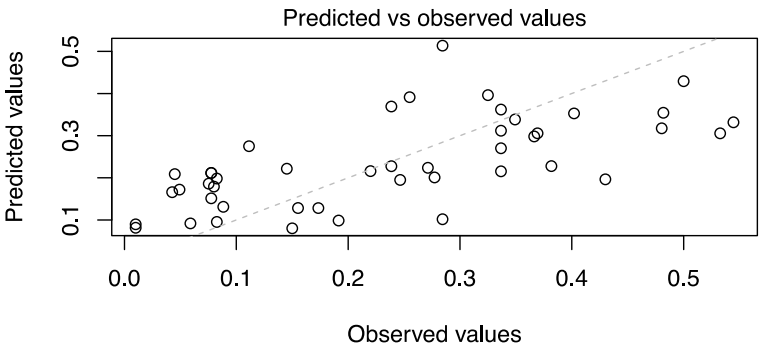


Figure B5. Diagnostic plot of predicted vs. observed values

Appendix D

Diagnostic plots for beta regression of physical activity as a predictor of proportion of touch, controlling for gender

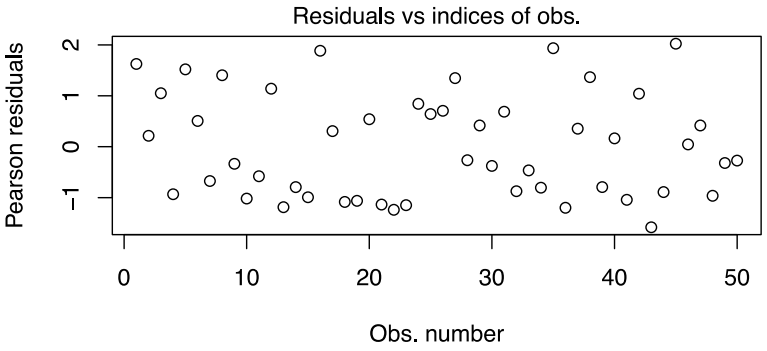


Figure C1. Diagnostic plot of model residuals vs. indices of observations.

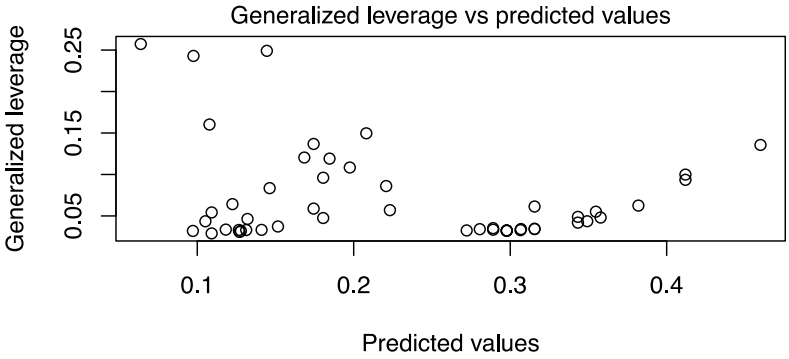


Figure C2. Diagnostic plot of generalized leverage vs. predicted values.

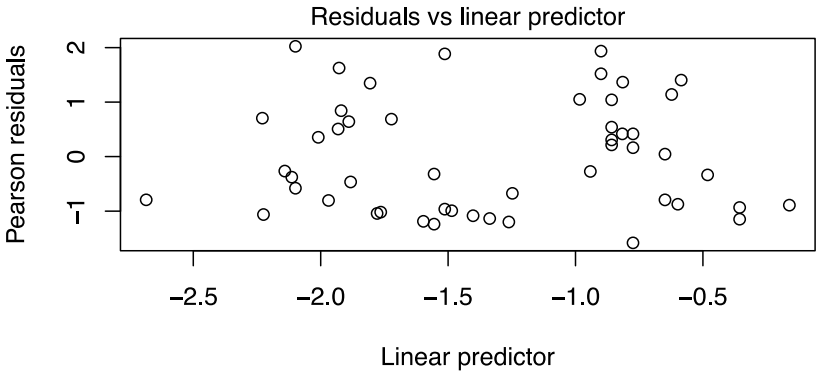


Figure C3. Diagnostic plot of model residuals vs. linear predictor.

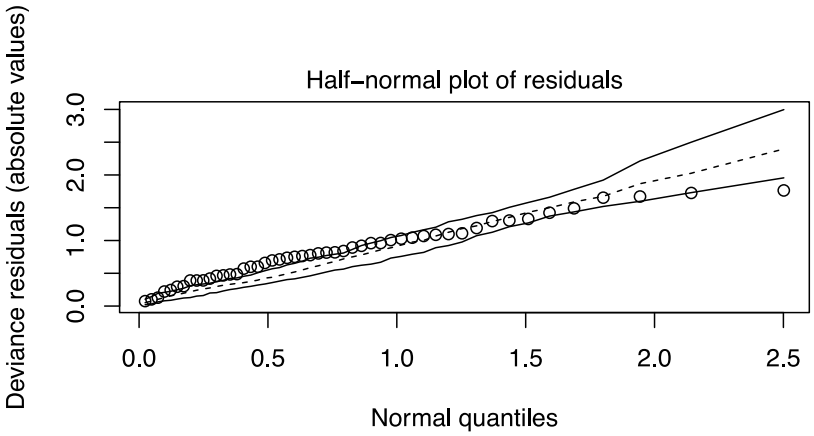


Figure C4. Diagnostic plot of model deviance residuals vs. normal quantiles.

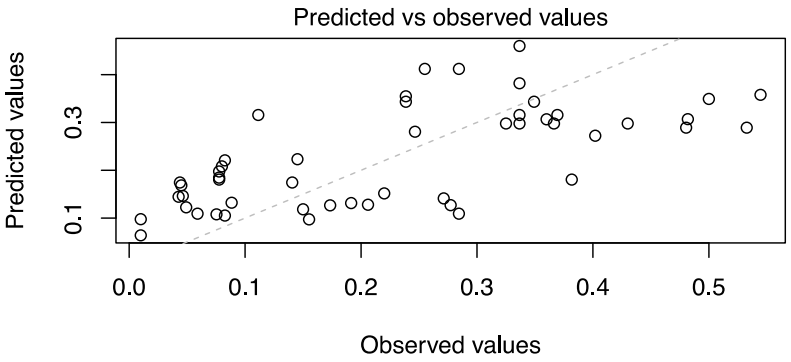


Figure C5. Diagnostic plot of predicted vs. observed values.

Appendix E

Beta regression for the relationship between average physical activity and smiling/laughing, controlling for gender

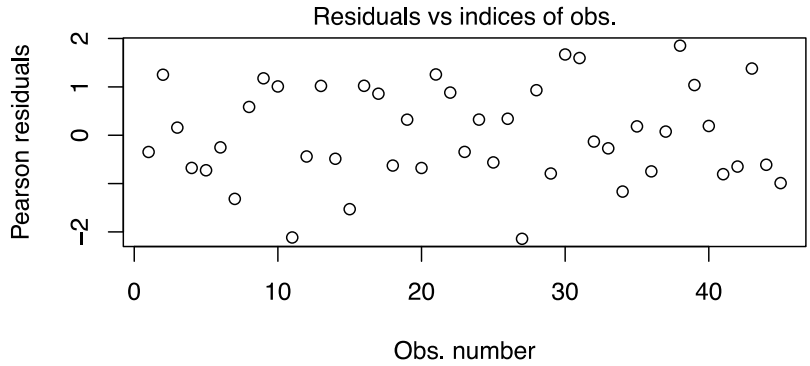


Figure D1. Diagnostic plot for model residuals vs. indices of observations.

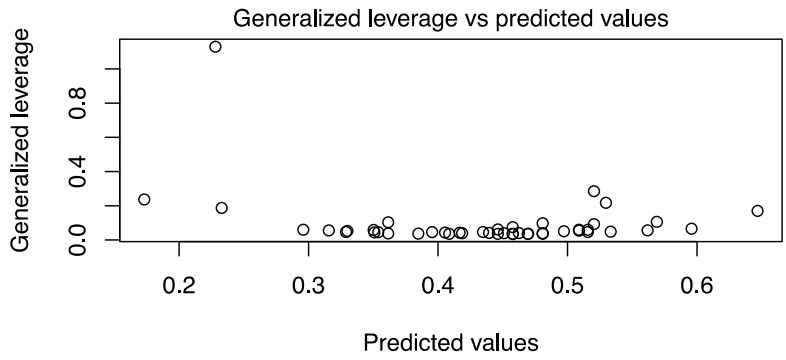


Figure D2. Diagnostic plot for generalized leverage vs. predicted values.

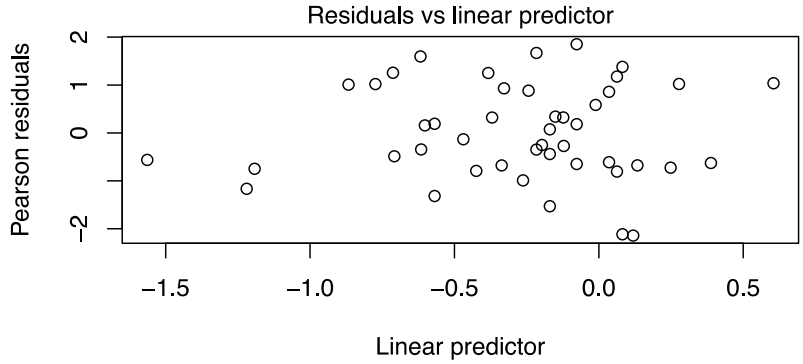


Figure D3. Diagnostic plot for model residuals vs. linear predictor

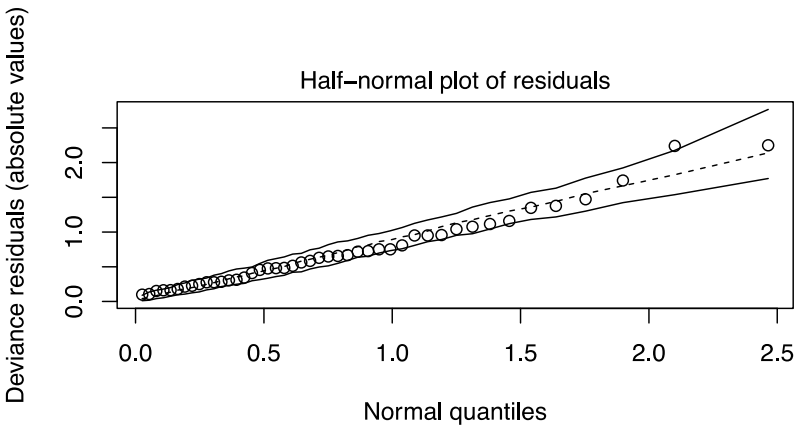


Figure D4. Diagnostic plot for deviance residuals vs. normal quantiles.

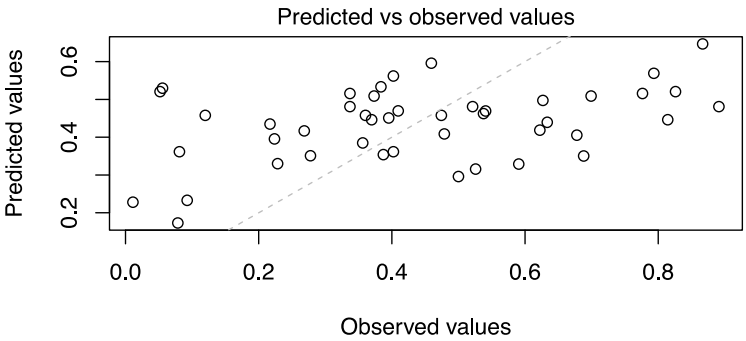


Figure D5. Diagnostic plot for predicted vs. observed values.

Appendix F

Beta regression for the relationship between average heart rate and smiling/laughing, controlling for gender

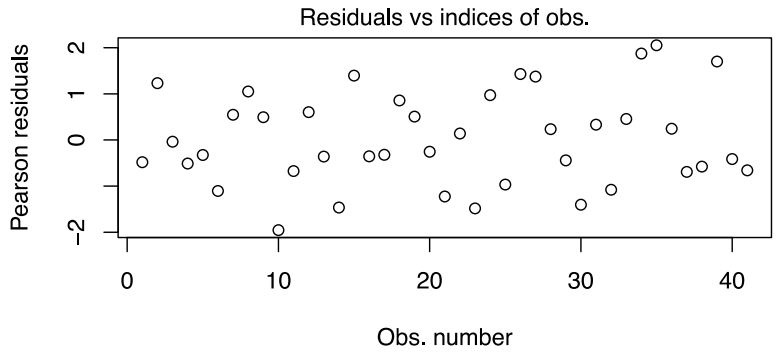


Figure E1. Diagnostic plot for model residuals vs. indices of observations.

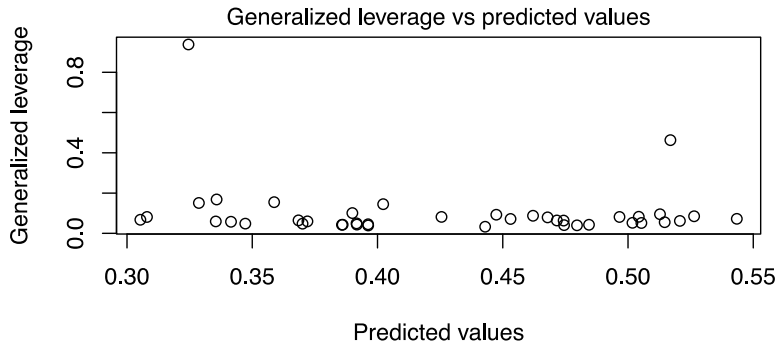


Figure E2. Diagnostic plot for generalized leverage vs. predicted values

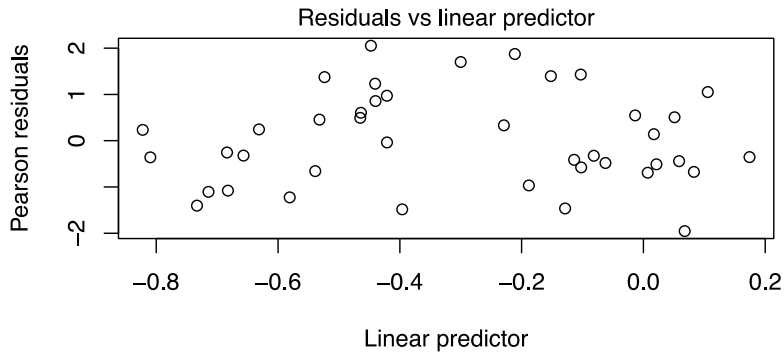


Figure E3. Diagnostic plot for model residuals vs. linear predictor.

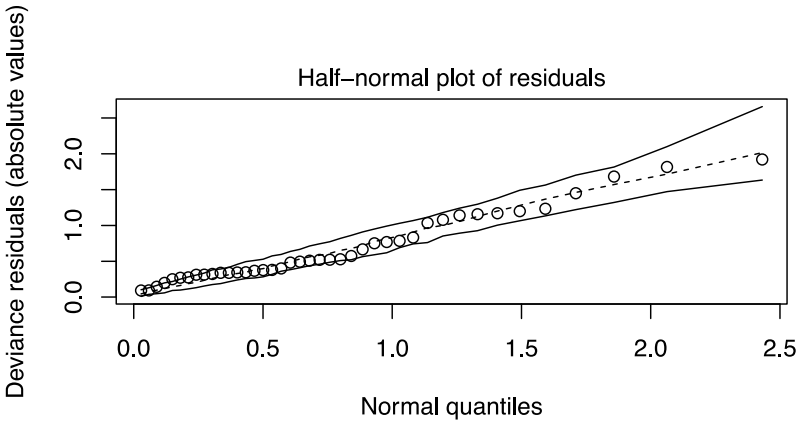


Figure E4. Diagnostic plot for deviance residuals vs. normal quantiles.

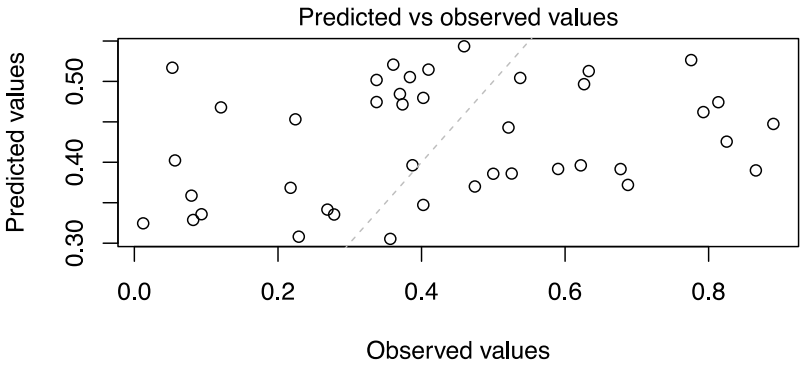


Figure E5. Diagnostic plot for predicted vs. observed values.

Appendix G

Beta regression for the relationship between average physical activity and positive engagement (no touch), controlling for gender

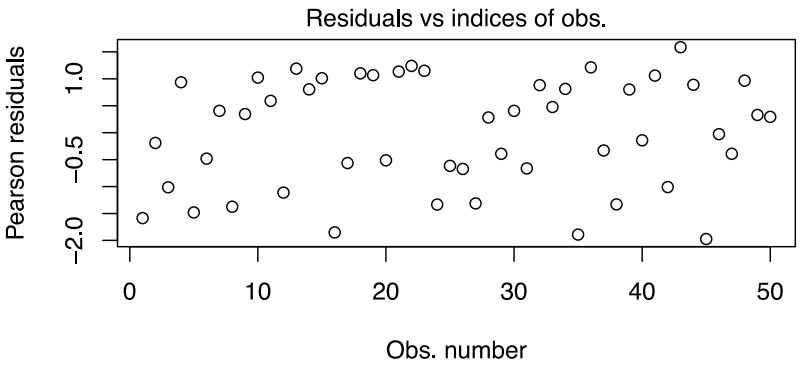


Figure F1. Diagnostic plot for model residuals vs. indices of observations.

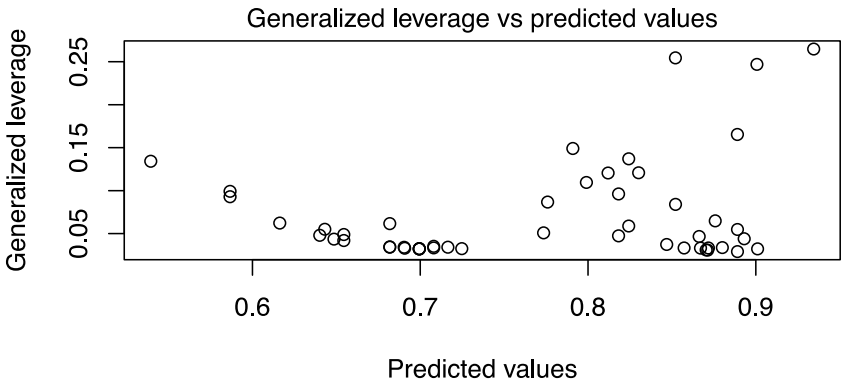


Figure F2. Diagnostic plot for generalized leverage vs. predicted values.

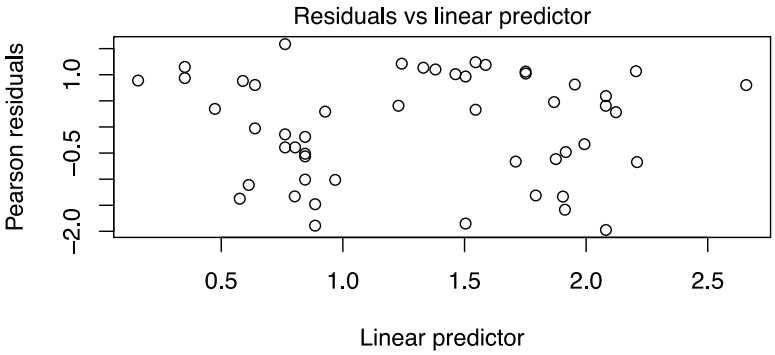


Figure F3. Diagnostic plot for model residuals vs. linear predictor.

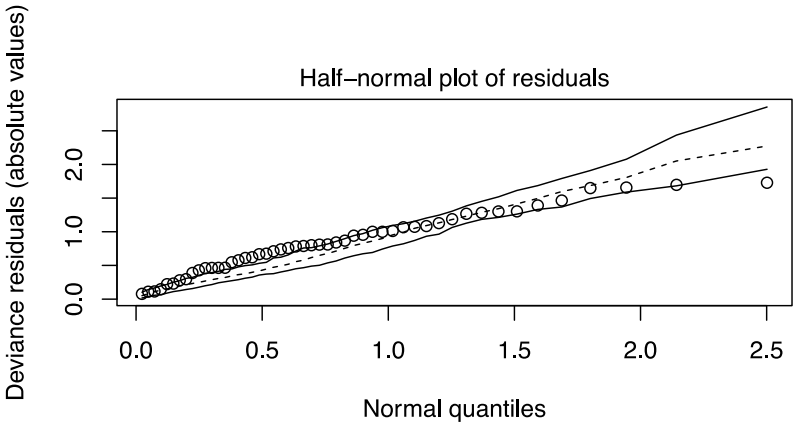


Figure F4. Diagnostic plot for deviance residuals vs. normal quantiles.

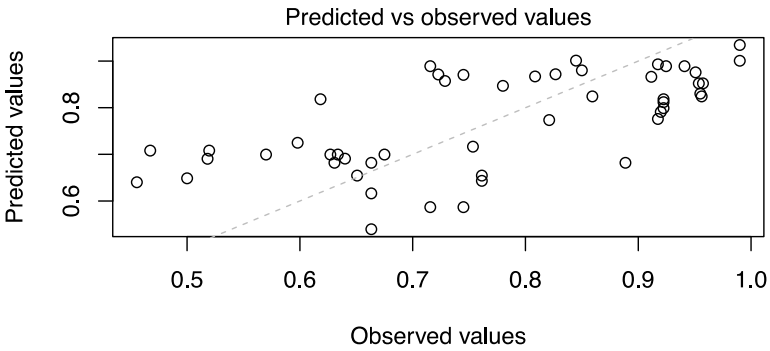


Figure F6. Diagnostic plot for predicted vs. observed values.

Appendix H

Beta regression for the relationship between average heart rate and positive engagement (no touch), controlling for gender

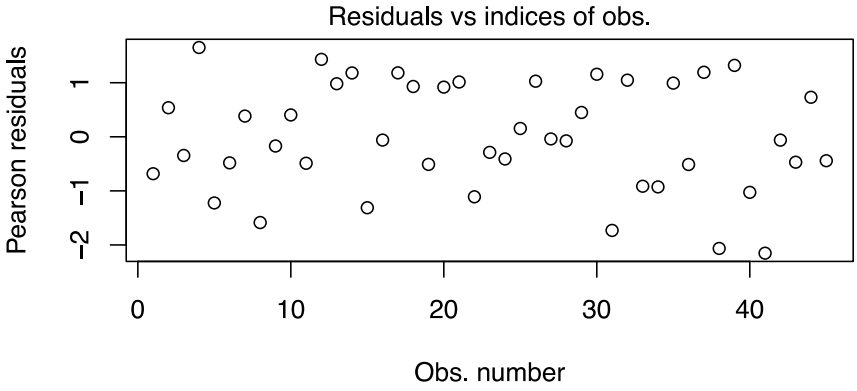


Figure G1. Diagnostic plot of model residuals vs. indices of observations.

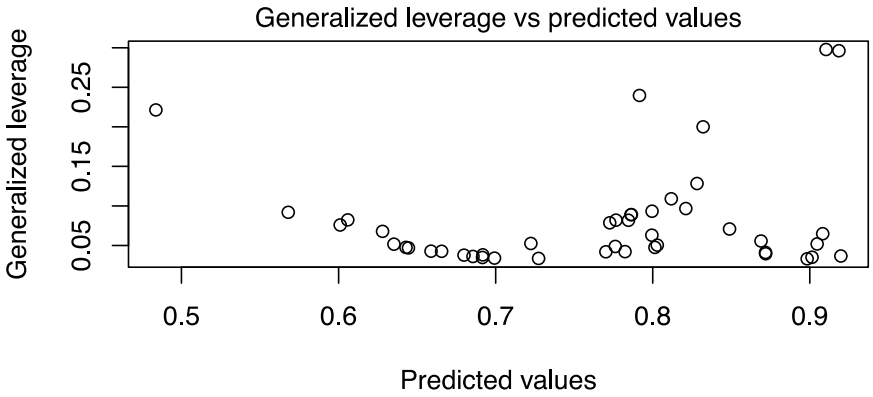


Figure G2. Diagnostic plot of generalized leverage vs. predicted values.

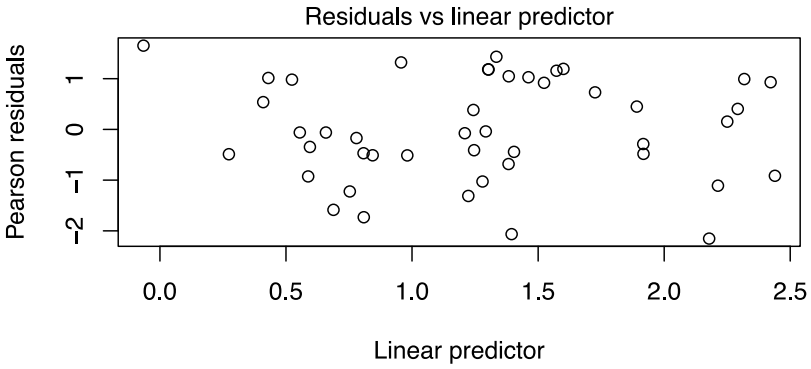


Figure G3. Diagnostic plot of model residuals vs. linear predictor.

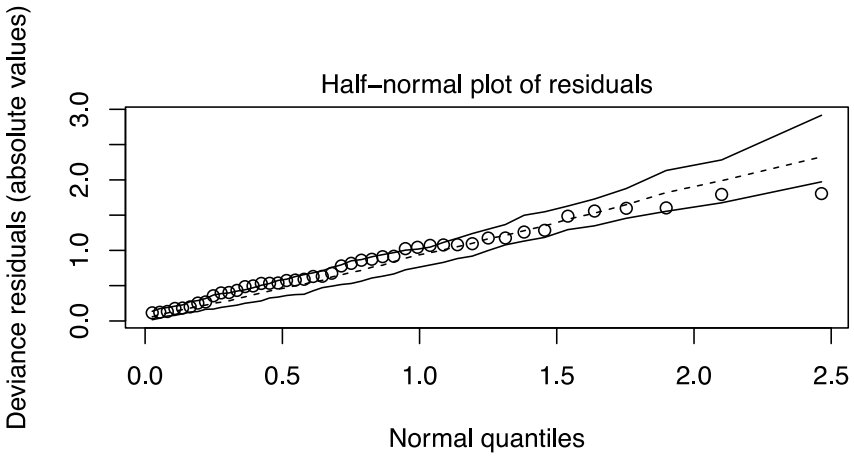


Figure G4. Diagnostic plot of deviance residuals vs. normal quantiles.

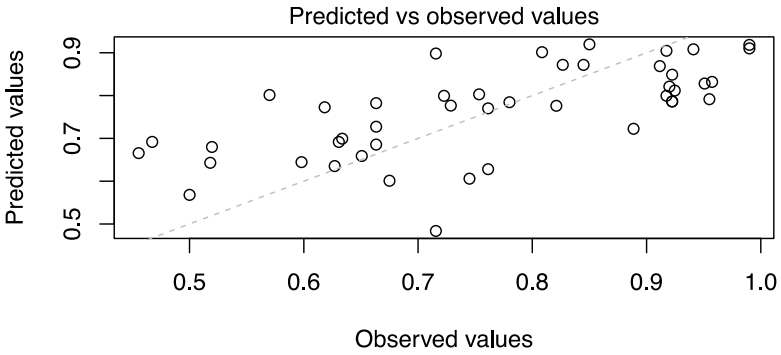


Figure G6. Diagnostic plot of predicted vs. observed values.

Appendix I

Touch Study Protocol
May 2016

Procedure Overview

(1) Study participants are taken in pairs to the experiment area, where they are introduced to the experimenter and the study.
(2) Then, the experimenter (E) administers the warm up task and training with the liking scale
(3) Following the warm up task, E introduces the shape game and flips a coin to see who gathers shapes first.
(4) Upon completion of the shape game, the experimenter will remove and count the shapes.
(5) The experimenter administers the fish feeding game.
(6) The experimenter administers the liking scale.

Detailed Procedure

(1)
M: "Hello, my name is Megan. I'm a researcher at Oxford University and I'm looking at how kids like different games. Today, we will play some games together."

(2)
M: "The first game is the Animal Game. We will pretend to be 2 different animals. When I say the animal's name, you will move around and make noises just as that animal would.

So, first let's try it together – show me your best FROG!
Ok, now let's see your best BIRD!

Ok, now that you know how to be frogs and birds, you're ready for the game.
When I say "Frog", you will act like a frog – jumping around like you just were. You will keep doing this until I shout to "find the shape!" – that's when you will both run over there [*point to the specific area of the space*] and find a frog shape - but not until I shout! Then, you will come back over here and stick it to one of the matching area on this board. Then you will do they same thing for birds.

Ok? So, when I say Frog, what will you do? (wait for answer) And when are you suppose to go find the frog shape?

Ok, Are you ready? Ok – Frog! – jump around like frogs"

[*Give participants a few seconds to decide how they will imitate birds, then encourage them to 'fly around'. When about 15 seconds have passed, shout 'Ok, Find a frog!". Then, make sure they place them in the right spots on the board. Then move on to the birds*].

M: “Ok, now be birds!”

[*Give them time to be birds. If they don’t move around enough, encourage them to ‘fly around’ like birds. Then shout ‘Ok, find a bird!” Then make sure they place the birds correctly onto the bird spaces on the board*.]

M: “Ok, Now I want to know how much you liked playing the Animal Game. I’m going to give you each a sheet of paper with two rows of faces on it [*show them the sheet*]. In the first row, circle the face that best matches how much you liked being a bird. Then, in the second row, select the face that best matches how you like liked being a frog. Do you understand?”

Ok, now you will both sit here and face opposite directions, so you don’t see each other’s paper.

[*Give them the paper and allow a few seconds to answer the face scales. Ask if they need help or have questions. Then, collect the papers and introduce the shape game*.]

(3)
M: “Now, we’re going to play a different game. This game is called the Shape Game and we have shapes of birds and frogs spread around the room. In this game, one person will fetch the shapes while the one stays frozen just like this *[demonstrating how to stand when ‘frozen’]*. If you are the fetcher, you will go around, look for the shapes and whenever you find a shape, you will bring it here and place it *really carefully* onto where you see the shape printed *[demonstrating]*. If you are frozen, you will wear this vest and try to stay still, not moving or speaking, until I call ‘Time”. Ok? You will both have a turn at being the fetcher and staying frozen. At the end, I'll count up all the shapes that you both collect together. Ok, let’s see who gathers shapes first by flipping a coin.

[*Assign heads and tails and flip the coin, determining who gathers shapes first*].

[In the experimental condition:]
M: “So, Child A, you’ll be the fetcher and look out for these shapes *[showing again]* around the room. They may be hidden *[give examples…]*. It’s really important you place it carefully and within the lines, Ok? And Child B, you will stay frozen. Here is your vest, now, put it on. And let’s see your frozen stance. Nice! We’ll play the game like this for 1 minute and then swap roles. OK? Is everybody ready? Ready, steady, go!”

[*Make sure the arms of the ‘frozen’ child are out to the side, enough to wrap around a strip of material*]

[In the control condition:]

[*Time one minute and stop the turn if he/she gets the vest half full before one minute is up*].

M: “Time! Time is up! Now let’s change turns – now it’s [name] turn to be frozen and [name] turn to be the fetcher.”

[*Assist them getting out of the vest and into the vest. Make sure that the 'frozen' child doesn't shake off their arms/legs before taking off the vest in the experimental condition. Repeat the instructions for each role and make sure the children know what they are doing in their new roles*].

M: "Ok, now [name], you will stand frozen while [name] gathers shapes one at a time. And [name], you also have one minute to gather shapes, ok? Ready, steady, go!"

[*Let the other participant gather shapes to fill up the vest, so that both participants give and receive equal touching*].

(4)
M: "Time! Okay, time is up! Now let's take off the vest and I'll count the shapes"

[*Carefully remove the vest from the participant and then remove each shape and place it in a box. Once the final shape is counted, write it down on a pad and move on to the fish feeding game*]

**No-touch condition*

(3)
M: "Now, we're going to play a different game, this time with shapes. You are both going to have a turn at gathering these shapes, one by one, from around the room. The shapes are rectangles and stars, like these – see?"

[*Show them the shapes*]

M: "While one of you gathers shapes, the other one will wear this vest and be 'frozen' next to this board, so you can't move and you have to stand like this with your arms slightly out – see?"

[*Demonstrate how to stand when 'frozen'*].

M: "So, while one of you wears the vest, the other will go and get one shape at a time and then come back over here and place that shape *really carefully* onto the board, where you see the shape printed. It's really important you place it carefully and within the lines, Ok? Do you understand? Ok, let's see who gathers shapes first by flipping a coin."

[*Assign heads and tails and flip the coin, determining who gathers shapes first*].

M: "Ok, you will both get a turn at gathering shapes and being frozen and at the end I'll count up all the shapes that you both collect together, but first let's start with [name] gathering shapes first and [name] being frozen first. Here is the frozen vest, [name]. I'll help you put it on and fasten it up."

[*Get the vest on the first participant*].

M: "Ok, [name] you're frozen now, so let's see your frozen stance."

[*Make sure arms are out to the side*]

M: "Ok, [name], you have one minute to gather one shape at a time and place them onto the shapes on [name] board. Ready, steady, go!"

[*Time one minute and stop the turn if he/she gets the vest half full before one minute is up*].

M: "Ok, time! Time is up! Now let's change turns – now it's [name] turn to be frozen and [name] turn to gather shapes."

[*Assist them getting out of the vest and into the vest*].

M: "Ok, now [name], you will stand frozen while [name] gathers shapes one at a time. And [name], you also have one minute to gather shapes, ok? Ready, steady, go!"

[*Let the other participant gather shapes to fill up the board*].

(4)
M: "Okay, time is up! Now let's take off the vest and I'll count the shapes"

[*Carefully remove the vest from the participant and then remove each shape, counting out load, and place it in a box. Once the final shape is counted, write it down on a pad and move on to the fish feeding game*]

(5)
M: "OK. Now, we'll move on to our last game. It's called the Fish Feeding Game.

[*Walk over to the fish feeding set up, where there is a wooden table with four plastic tubes of different colors placed down with clamps and a basket full of colored balls (same as the tubes) on top of the table. Three meters away is a 'fish box' – an apparatus designed to fit with the plastic tubes and make a chime noise when the balls hit chimes hidden inside, signifying successful feeding of the fish*]

M: (*Pointing to the fish box:*) "Do you see the fish box over there? The fish in the box are hungry! So, we'll feed them now. (*Pointing to the fish food table:*) There is some fish food right over here. We will first get the fish food from the table, put it in the tubes and then carry it over to the fish box to feed the fish. Let me show you how to do it- come, let's go to the fish food table."

[M takes children near the tubes.]

M: "(Child A), you will have the green tube and (Child B) you will have the blue tube. Now, *[turning to Child A]*, collect the green food from the basket and put them in your green tube. And (name), you'll collect the blue food and put them in your blue tube. Good… And now, you will hold the bar from both ends and lift it so that you can take your tubes out."

(Both children take their tubes out. Then, they bring it to the fish box, stick it to the beaker and feed the fish.)

M: “Now, pour it down from the box. Yaay! You fed the fish! Now you’ll do the same with the red food and the yellow food. But I need pop out to see your teacher in the other room and I’ll be back in a minute, alright? Go ahead and lift the bar yourself and feed the fish, ok?”

(Note: one of the tubes is set to have a faulty base, causing the balls to fall out of the bottom of the tube. The video recording is used subsequently to analyze how much help is offered. M waits outside for two minutes and then comes back. In case the children are not finished with feeding the fish by the time she re-enters the room, M silently waits for them to finish playing.)

M: “Have you fed the fish? Hmm… let me see, yes, the fish are not hungry anymore! Well done! And how did it go? *(If children do not start recounting the ‘accident’ straight away:)* Was everything alright? *(If children still do not reveal anything, M tries once more:)* Could you both feed the fish easily? *(Hopefully the children will tell what happened after this prompt. If not, then we’ll leave it like that and not introduce the subsequent emotion scales)*

Importantly, as children tell M about the accident, M looks surprised, says she’s sorry but focuses more on the toy being broken than one of the children being “victimised”. Immediately after that, she moves on to the liking scale.

(6)
M: “Ok, Now remember that paper I gave you in the beginning with the faces on it? I’m going to give you another one now, before you go. Here’s the paper. Now [name], you sit over here facing this direction, and [name], you sit over here, facing that way.”

[Give them each the paper]

M: “Ok, There’s one question on the sheet of paper. Please read it to yourself and pick the face that best matches your answer. Let me know if you need help.”

[Give them 15 seconds to select a face]

M: “When you’ve answered the question, just fold your paper in half and give it to me.”

[Ask for the papers or if help is still needed]

M: “Ok, you both played really well today and I want to give you each a sticker for playing with me. Thank you very much!”

[Give stickers]

Appendix J

CODING SCHEME FOR THE FISH FEEDING GAME

1. Coding of Helping Behaviour

Aim of the analysis
To find out whether the child with the green tube helped the child with the red tube.

What to analyse
A total of 45 videos amounting to about 70 minutes.

In each video, two children will be playing a game called the Fish Feeding Game. They will be carrying coloured tubes from a small table to a box with fish pictures on it. Soon after one of the children lifts up the red tube, it will break and the red balls will spill onto the floor. Of interest is whether the child carrying the green tube, the *Helper*, will help the child with the broken red tube, the *Victim* (see below for details on how to code for helping behaviour).

How to do the analysis
For each trial, you will code "Y" for Yes, "N" for No, and "O" for other to indicate the presence of helping behaviour. Each category has a sub-category also (e.g., 1,2 or 3). You will record both Category and sub-category.

1. Helping Category:

Assign the Helper's behaviour to Yes: Y1, Y2, Y3; No: N1, N2, N3; , or Other: O1, as listed below. On the spread sheet, write the category code (e.g., N2) under the column "Helping Category".

Helping Category	Description
Y	1. Helper sees the toy break and helps immediately 2. Helper sees toy break, empties own tube first, then helps Victim with their tube or balls 3. Helper doesn't see the toy break, empties own tube, then notices the accident and helps Victim with either the tube or balls.
N	1. Helper sees the toy break, but doesn't help at any point 2. Helper doesn't see the toy break, empties own tube and then notices the accident, but doesn't help at any point. 3. Helper doesn't see the toy break, empties own tube and then notices the accident, but only helps at Victim's request (i.e. not voluntarily)
O	1. Helper doesn't see the toy break and Victim resolves the problem, eliminating any opportunity for help (i.e. Victim fixes the

	broken tube and places the balls into the box before Helper became aware of the problem)

Appendix K

As we analysed the data, we realised that 3 participants behaviour were coded as "Helper doesn't see toy break, empties own tube and then notices the accident, but doesn't help at any point." In the coding of previous studies (Kirschner & Tomasello, 2010; Tunçgenç & Cohen, 2016), this particular response would have resulted in the data being dropped from analysis. We decided to run additional analysis with these 3 cases removed in order to compare the results. Below are the results of those tests.

Is touch related to helping behaviour?

A chi square test using only participants who meet criteria from previous studies suggests the relationship is not significant (X^2 (1, N = 78) = 2.21, p = .14).

Is gender related to helping bahaviour?

Unlike the main analysis, a chi square test using only participants who meet criteria from previous studies suggests the relationship is not significant (X^2 (1, N = 78) = 3.40, p = .07).

Does touch predict helping, controlling for gender?

A binomial regression using only participants who meet criteria from previous studies was run to test the effect of touch on helping, controlling for gender. Results suggest that there is a slight positive effect (1.06) of touch on helping, when controlling for gender, but this is not statistically significant (p = .13).

What is the effect of Touch, Gender, and Age on level of helping?

Ordinal logistic regression was used to examine whether touch, gender, and age influence level of helping. Helping was divided into 3 levels: 0 (no help), 1 (low-medium help), 2 (high help). Help was specified as ordered and age was specified as numeric, while gender and touch were specified as factors, with gender and touch as the (dichotomous) predictor variables, age as a continuous predictor variable, and level of helping as the ordered outcome variable.

The Proportional Odds Assumption was met and Proportional Odds Ratios indicate that age does not influence the model (OR = .98) and should be removed.

What is the effect of Touch and Gender on level of helping?
Ordinal logistic regression was used to examine how much touch and gender influence level of helping. Helping was divided into 3levels: 0 (no help), 1 (low-medium help), 2 (high help). Help was specified as ordered, while gender and touch were specified as factors with gender and touch as the (dichotomous) predictor variables and level of helping as the outcome variable.

The Proportional Odds Assumption was met and Proportional Odds Ratios indicate that for a one unit increase in condition (i.e. going from the no touch to the touch condition), the odds of high help (level 2) versus no help (0) or low-medium help (1) combined (and of high and low-medium help, versus no help) are 2.39 times greater, given that gender is held constant (95% CI [.67, 9.17]). For a one unit increase in gender (i.e. going from female (0) to male (1)), the odds of high help verses no help and low-medium help combined are .30 times less when controlling for condition (95% CI [.07, 1.07]). In both cases the CI crosses one, indicating that the effect is not reliable.

Is there an interaction effect between touch and gender?

Ordinal logistic regression was used in R to test for an interaction effect between touch and gender. Results indicate that there is no interaction effect (p = .54)

Do touch condition non-victims report liking their partner more than no-touch non-victims?

An independent samples t-test was conducted to compare non-victim liking in touch and no-touch conditions. Victims were not included in the analysis, due to potential confounds from either receiving or not receiving help. There was not a significant difference in the scores for touch non-victims (M = 1.05, SD = .51) and no-touch non-victims (M = 1.39, SD = .55); t(19.85)= 1.99, p = .06. Therefore, there was no significant effect of touch on non-victim liking.

Do children paired in the touch condition like each other more than those paired in the no-touch condition?

An independent samples t-test was used to compare liking between touch partners and no-touch partners. There was not a significant difference in the scores for touch (M = 2.71, SD = 1.67) and no-touch pairs (M = 3.11, SD = 1.80); t(35.97) = .94, p = .35. Therefore, there was no significant effect of touch on liking.

Do pairs in the touch condition have more similar liking scores than pairs in the no-touch condition?

An independent samples t-test was used to compare the similarity of partner liking scores for touch and no-touch pairs. There was not a significant difference in the scores for touch (M = .71, SD = 1.20) and no-touch pairs (M = .67, SD =1.32); t(33.00) = -.14, p = .89. Therefore, there was no effect of touch on liking similarity.

Appendix L

Study 3 Run Protocol

"My name is Megan. I'm a researcher. Do you know what a researcher is? […]
A researcher is someone who has a question and they try to figure out the answer. I have a question about how kids play and the types of games kids like to play, so I've got some fun activities for us to play."

"First, there are 2 really important rules:

#1 Listen very carefully to me
#2 You must follow the instructions

The activity has two parts: first, you learn the instructions and have a chance to practice, and then you do the whole activity. So to begin, listen carefully to the instructions."

1. Activity

"This activity uses 3 moves…"

Explain the actions involved in the game (the different touches):
"The moves are called – Wrist-Rock, Shoulder-Duster, and High-Claps. Each move has two different ways that you can do it. Are you ready to learn the moves?"

For Wrist-Rock, you can rock your own wrists like this (*demonstrate*) rocking them back and forth three times (count to three) OR each of you can take each others wrists and rock them back and forth three times like this (*demonstrate*).

For Shoulder-Duster, you can dust your shoulder three times like this (*demonstrate*) or dust the other person's shoulder three times.

For High-Clap, you can clap your hands three times above your head like this (*demonstrate*) or you can clap the other person's hands above your heads three times (*demonstrate*).

Ok? Let's try it out…

First, do the Wrist-Rock with *your* wrists (*check they do it gently and three times*)
Now, do the Wrist-Rock to the *other person's* wrists (see that they do it correctly)

Now, do the Shoulder-Duster to *your* shoulder.
Now, do the Shoulder-Duster to the *other person's* shoulder.

Now, do the High-Claps with *your* hands.
Now, do the High-Claps with the *other person's* hands.

[Repeat]

Now you're going to each have a role to play in this game – there's going to be a Colour-Matcher and a Place-Maker. I'll explain those roles more in a minute. For now, we're going to roll a dice to decide who will have which roll. If I roll a red, XX will be the 'Colour-Matcher' and YY will be the 'Place-Maker'. If I roll a yellow, YY will be the 'Colour-Matcher' and XX will be the 'Place-Maker'.

Roles are allocated and confirmed –

*"*Who is the Colour-Matcher? *and* Who is the Place-Maker?"

"Ok, now we're going to do a little training before we play the game":

Instructions for MVPA condition:

1a) **Both run along their lines**

"Both of you will start here, at the 'Start Cone', the Colour-Matcher here, facing in this direction, and the Place-Maker here, facing in this direction"

"I'm going to count down from 3 – I'll say '3-2-1-go!' Do you see these yellow circles around the mats? When I say 'go', Colour-Matcher, you will RUN along the inside circle (point to inside line), in this direction, staying as close as you can to the yellow cones, but don't touch them or go over them – just run right along beside them.

Place-Maker, when I say 'go' you will RUN along the outside circle (point out the outside circle) in the other direction, staying as close as you can to these yellow cones, but don't touch them or go over them – just run right beside them.

Remember you are not racing with each other, you can run like when you run around in the park, and keep going until I say 'stop' OK?

Let's try it out. Colour-Matcher, you start here Place-maker, you start here. When I say 'go', start running around the circle until I say 'stop'. Ready, 3-2-1-Go!

[Make sure they run along their respective lines. After 1 lap, tell them to stop and return to their start marks.]

1b) **Run along their lines with a wave:**

"Ok, come back to your start marks. This time you will do the same thing, but as you run past each other, give each other a wave. Ok? Let's try that… Ready? 3-2-1 Go!"

2) Color-Matcher runs to mat while Place-Maker continues running

"OK, get to your start cones"

"This time, you will RUN along your lines as before, but there is something extra that each of you will do. Who is the Colour-Matcher again?" [wait for child to respond correctly].

"Ok, Color-Matcher, I will give you your instruction first."

"You will run around your circle, just like we practiced, but at some point I will shout a colour to you– for example, "Colour-Matcher, Orange!" When you hear that, you will stop running in a circle and pick one of the Orange mats to run to and stand with your feet inside the footprints."

"Can you see that there are two mats for every colour? Ok, so you can choose which one you run to, so long as it's the colour that I say. It can be the closest one or the one further away. So, if I shout, "Color-Matcher Green!", what will you do?" [run to either green mat].
"Yes, you will RUN to one of the green mats and stand on the mat, with your feet inside the footprints. Ok"

"Now, who is the Place-Maker? Ok, when you hear my instruction to the Colour-Matcher, you just keep on running in your circle ok? Let's try it out."

"When I say 'go' start RUNNING along your circle. Ready? 3-2-1 go!"

[*Call instruction to Colour-Matcher. Make sure the Colour-Matcher goes to the right colour mat and is in the right position on the mat and that the Place-Maker continues to run, by calling "Place-Maker Keep Running!" In case of mistakes, correct and perform the training again.*]

3) <u>Place-Maker goes to different mat (Counter-balance with 4)</u>

"Ok, get back to your start cones"

"This time when the Colour-Matcher goes to a mat, you the Place-Maker will keep running until I give you your own instruction. "

"So, let's say the Colour-Matcher is on an Orange mat, and you are still running. I will then shout "Place-Maker, Orange high-clap". Place-Maker, when you hear this instruction, you will RUN to the *other* Orange mat, stand on the footprints, and do the Wrist-Rock with your wrist like this" * demonstrate*.

"Colour-matcher, you will already be on a mat, and will also do the Wrist-Rock with your wrists. Ready to try it out?…Ok, get to your start cones… Ready? 3-2-1 Go!"

Colour-Matcher Orange
Place-Maker, Orange high clap

[Repeat if necessary]

4) <u>Place-Maker goes to same mat as Colour-Matcher (Counter-balance with 3)</u>

"Ok, get back to your start cones"

"Now, we will play the same game, again, but this time, Place-Maker, if I shout "High-clap", you go to the *same* mat as the Colour-Matcher and do the action with the other person, just like we practiced earlier."

"So if the Colour-Matcher is standing on a Green mat and I tell you "Place-Maker, Green Shoulder-Duster", you will go to the Colour-Matcher's green mat, stand in the other pair of footprints, and you will both dust the other person's right shoulder 3 times, Ok?"

Let's try it out. Get to your start cones. Ready? 3-2-1 Go!

Colour-Matcher Orange
Place-Maker, Orange high clap

5 <u>Place-Maker decides what to do</u>

"Ok, get back to your start marks"

"The final instruction is for the Place-Maker."

"In the activity, the Place-Maker will have a choice of which mat to go to, so long as it's the colour that I say."

"So, Place-Maker, if I shout "Orange High-Clap", you can EITHER go to the Orange mat where nobody is standing OR you can go to the mat where the Colour-Matcher is standing. It is your choice – you can do either one."

"But, listen carefully, if you go to the mat where the Colour-Matcher is standing, you will each clap the other person's hands. If you go to the mat where nobody is standing, you will each clap your own hands.

"Ok, are we ready to play the activity? Any questions?".

Let's try it out. Get to your start cones, when I shout Go start running along your circle. Ready? 3-2-1 Go!

Colour-Matcher Orange
Place-Maker Orange High-Clap

[*Allow the Colour-Matcher to complete one lap, then shout the first Colour-Matcher order and remind the place-maker to keep running. From the point the Colour-Matcher has chosen a mat, allow the Place maker to run for 5 seconds. Then, when Place-Maker is*

approaching the mid-way point between the Colour-Matcher and the other similarly coloured mat, I shout the Place-Maker command, so that the Place-Maker is equidistant to both possible mat choices.]

"OK, now come back to the start. We are going to do that a 4 more times. Place Maker, remember you have a choice which mat you choose, as long as it's the colour that I say, OK? So, you can either go to the mat where no one is standing or you can go to the mat where the colour-matcher is standing. If you choose the mat where no body is standing, you will do the moves with your own hands and so will the colour-matcher. But if you go to the mat where the colour-matcher is standing, you do the move with the colour-matcher. It's up to you."

"Ready? 3-2-1 Go!"
[*Repeat the game a total of 4 times with the following order of colour and move combinations in a consistent order (I will have this as a checklist):*

1. Purple - Wrist-Rock
2. Green - Shoulder-Duster
3. Purple - Shoulder-Duster
4. Green – Wrist-Rock

PHASE 2 – DRAWING

"Ok, nice job. Now let's go over here. We're going to take a little breather and do something different."
[Walk over to the drawing area]

"Now it's time to make a picture. Place-Maker, you sit over here and Colour-Matcher, you sit here. Both of you sit cross-legged and facing outwards". [make sure they are seated correctly]

"Now, I'm going to give you each a piece of paper and two stickers. You are going to make a picture of you and your partner by placing the stickers anywhere in the grass on the picture."

"Just to be clear, don't place the stickers climbing up the tree, laying down, or upside down. Make sure their feet are somewhere on this green grass [demonstrate by sliding the sticker all along the green grass line].

So, what are you going to do with the stickers? [make sure they answer correctly]

Right. Now, here are the stickers and paper [give them the items].

"Go ahead and make your picture."

[Allow a few seconds. If they don't do it (or one doesn't do it) prompt with the instruction to 'make a picture of you and your partner' up to 2 more times.]

Once they are done (allow up to 2 min. Make sure they have the stickers on the page and move on):

"Ok, now we have one final game to play."

PHASE 3 – INHIBITION TASK

"Both of you stand on the orange line" [point out where to stand]

"This is my mystery box – there's something inside. It could be something sticky, something slimy, something hot or cold…it could be an animal. One of you will put your hand inside that box. You can't tell the other person what is inside, but you will describe it, so the other person can try to guess what it is."

"So, we will draw names from this bag to decide who will put their hand into the box."

"Ok, so the Place-Maker will stand here on this purple line and Colour-Matcher will wait to hear the description while the Place-Maker puts his/her hand into the box and describes what is inside. Ok?"

"So, place-maker, what are you going to do?... (wait for correct answer) Ok, and Colour-Matcher, what are you going to do?....(wait for correct answer). Right."

Ok, now stand still and don't move untill I say. [uncover the mystery box]

"Place-Maker, when you're ready, put your hand inside the box."

[Video recorded for post-hoc analysis of time taken to walk to box and put hand inside]

***Once I see they have felt the item, tell them to remove their hand and ask Place-Maker to describe it to the Colour-Matcher**

"Ok, that's right – it's a teddy bear. Good job! Now, you both get to pick a sticker from this bag."

[thank them and take them back to class]

Study 3
Protocol for Walk Condition

"My name is Megan. I'm a researcher. Do you know what a researcher is? […]
A researcher is someone who has a question and they try to figure out the answer. I have a question about how kids play and the types of games kids like to play, so I've got some fun activities for us to play."

"First, there are 2 really important rules:

#1 Listen very carefully to me
#2 You must follow the instructions

The activity has two parts: first, you learn the instructions and have a chance to practice, and then you do the whole activity. So to begin, listen carefully to the instructions."

1. Activity

"This activity uses 3 moves…"

Explain the actions involved in the game (the different touches):
"The moves are called – Wrist-Rock, Shoulder-Duster, and High-Claps. Each move has two different ways that you can do it. Are you ready to learn the moves?"

For Wrist-Rock, you can rock your own wrists like this (*demonstrate*) rocking them back and forth three times (count to three) OR each of you can take each others wrists and rock them back and forth three times like this (*demonstrate*).

For Shoulder-Duster, you can dust your shoulder three times like this (*demonstrate*) or dust the other person's shoulder three times.

For High-Clap, you can clap your hands three times above your head like this (*demonstrate*) or you can clap the other person's hands above your heads three times (*demonstrate*).

Ok? Let's try it out…

First, do the Wrist-Rock with *your* wrists (*check they do it gently and three times*)
Now, do the Wrist-Rock to the *other person's* wrists (see that they do it correctly)

Now, do the Shoulder-Duster to *your* shoulder.
Now, do the Shoulder-Duster to the *other person's* shoulder.

Now, do the High-Claps with *your* hands.
Now, do the High-Claps with the *other person's* hands.

[Repeat]

Now you're going to each have a role to play in this game – there's going to be a Colour-Matcher and a Place-Maker. I'll explain those roles more in a minute. For now, we're going to roll a dice to decide who will have which roll. If I roll a red, XX will be the 'Colour-Matcher' and YY will be the 'Place-Maker'. If I roll a yellow, YY will be the 'Colour-Matcher' and XX will be the 'Place-Maker'.

Roles are allocated and confirmed –

*"*Who is the Colour-Matcher? *and* Who is the Place-Maker?"

"Ok, now we're going to do a little training before we play the game":

Instructions for Walk condition:

1a) **Both walk along their lines**

"Both of you will start here, at the 'Start Cone', the Colour-Matcher here, facing in this direction, and the Place-Maker here, facing in this direction"

"I'm going to count down from 3 – I'll say '3-2-1-off you go!' Do you see these yellow circles around the mats? When I say 'off you go', Colour-Matcher, you will WALK along the inside circle (point to inside line), in this direction, staying as close as you can to the yellow cones, but don't touch them or go over them – just walk right along beside them.

Place-Maker, when I say 'off you go' you will WALK along the outside circle (point out the outside circle) in the other direction, staying as close as you can to these yellow cones, but don't touch them or go over them – just walk right beside them.

Remember you are not racing with each other, you can walk like when you walk around in the park, and keep going until I say 'stop' OK?

Let's try it out. Colour-Matcher, you start here Place-maker, you start here. When I say 'off you go', start walking around the circle until I say 'stop'. Ready, 3-2-1-off you go!

[Make sure they walk along their respective lines. After 1 lap, tell them to stop and return to their start marks.]

1b) **Walk along their lines with a wave:**

"Ok, come back to your start marks. This time you will do the same thing, but as you walk past each other, give each other a wave. Ok? Let's try that… Ready? 3-2-1 off you go!"

5) Color-Matcher walks to mat while Place-Maker continues walking

"OK, get to your start cones"

"This time, you will WALK along your lines as before, but there is something extra that each of you will do. Who is the Colour-Matcher again?" [wait for child to respond correctly].

"Ok, Color-Matcher, I will give you your instruction first."

"You will walk around your circle, just like we practiced, but at some point I will shout a colour to you– for example, "Colour-Matcher, Orange!" When you hear that, you will stop walking in a circle and pick one of the Orange mats to walk to and stand with your feet inside the footprints."

"Can you see that there are two mats for every colour? Ok, so you can choose which one you walk to, so long as it's the colour that I say. It can be the closest one or the one further away. So, if I shout, "Color-Matcher Green!", what will you do?" [walk to either green mat].
"Yes, you will WALK to one of the green mats and stand on the mat, with your feet inside the footprints. Ok"

"Now, who is the Place-Maker? Ok, when you hear my instruction to the Colour-Matcher, you just keep on walking in your circle ok? Let's try it out."

"When I say 'off you go' start WALKING along your circle. Ready? 3-2-1 off you go!"

[*Call instruction to Colour-Matcher. Make sure the Colour-Matcher goes to the right colour mat and is in the right position on the mat and that the Place-Maker continues to walk, by calling "Place-Maker Keep walking!" In case of mistakes, correct and perform the training again.*]

6) <u>Place-Maker goes to different mat (Counter-balance with 4)</u>

"Ok, get back to your start cones"

"This time when the Colour-Matcher goes to a mat, you the Place-Maker will keep walking until I give you your own instruction. "

"So, let's say the Colour-Matcher is on an Orange mat, and you are still walking. I will then shout "Place-Maker, Orange high-clap". Place-Maker, when you hear this instruction, you will WALK to the *other* Orange mat, stand on the footprints, and do the Wrist-Rock with your wrist like this" * demonstrate*.

"Colour-matcher, you will already be on a mat, and will also do the Wrist-Rock with your wrists. Ready to try it out?…Ok, get to your start cones… Ready? 3-2-1 off you go!"

Colour-Matcher Orange
Place-Maker, Orange high clap

[Repeat if necessary]

7) Place-Maker goes to same mat as Colour-Matcher (Counter-balance with 3)

"Ok, get back to your start cones"

"Now, we will play the same game, again, but this time, Place-Maker, if I shout "High-clap", you go to the *same* mat as the Colour-Matcher and do the action with the other person, just like we practiced earlier."

"So if the Colour-Matcher is standing on a Green mat and I tell you "Place-Maker, Green Shoulder-Duster", you will go to the Colour-Matcher's green mat, stand in the other pair of footprints, and you will both dust the other person's right shoulder 3 times, Ok?"

Let's try it out. Get to your start cones. Ready? 3-2-1 off you go!

Colour-Matcher Orange
Place-Maker, Orange high clap

6 Place-Maker decides what to do

"Ok, get back to your start marks"

"The final instruction is for the Place-Maker."

"In the activity, the Place-Maker will have a choice of which mat to go to, so long as it's the colour that I say."

"So, Place-Maker, if I shout "Orange High-Clap", you can EITHER go to the Orange mat where nobody is standing OR you can go to the mat where the Colour-Matcher is standing. It is your choice – you can do either one."

"But, listen carefully, if you go to the mat where the Colour-Matcher is standing, you will each clap the other person's hands. If you go to the mat where nobody is standing, you will each clap your own hands.

"Ok, are we ready to play the activity? Any questions?".

Let's try it out. Get to your start cones, when I shout 'off you go' start walking along your circle. Ready? 3-2-1 off you go!

Colour-Matcher Orange
Place-Maker Orange High-Clap

[*Allow the Colour-Matcher to complete one lap, then shout the first Colour-Matcher order and remind the place-maker to keep walking. From the point the Colour-Matcher has chosen a mat, allow the Place maker to walk for 5 seconds. Then, when Place-Maker is approaching the mid-way point between the Colour-Matcher and the other similarly*

coloured mat, I shout the Place-Maker command, so that the Place-Maker is equidistant to both possible mat choices.]

"OK, now come back to the start. We are going to do that a 4 more times. Place Maker, remember you have a choice which mat you choose, as long as it's the colour that I say, OK? So, you can either go to the mat where no one is standing or you can go to the mat where the colour-matcher is standing. If you choose the mat where no body is standing, you will do the moves with your own hands and so will the colour-matcher. But if you go to the mat where the colour-matcher is standing, you do the move with the colour-matcher. It's up to you."

"Ready? 3-2-1 off you go!"
[*Repeat the game a total of 4 times with the following order of colour and move combinations in a consistent order (I will have this as a checklist):*

1. Purple - Wrist-Rock
2. Green - Shoulder-Duster
3. Purple - Shoulder-Duster
4. Green – Wrist-Rock

PHASE 2 – DRAWING

"Ok, nice job. Now let's go over here. We're going to take a little breather and do something different."
[Walk over to the drawing area]

"Now it's time to make a picture. Place-Maker, you sit over here and Colour-Matcher, you sit here. Both of you sit cross-legged and facing outwards". [make sure they are seated correctly]

"Now, I'm going to give you each a piece of paper and two stickers. You are going to make a picture of you and your partner by placing the stickers anywhere in the grass on the picture."

"Just to be clear, don't place the stickers climbing up the tree, laying down, or upside down. Make sure their feet are somewhere on this green grass [demonstrate by sliding the sticker all along the green grass line].

So, what are you going to do with the stickers? [make sure they answer correctly]

Right. Now, here are the stickers and paper [give them the items].

"Go ahead and make your picture."

[Allow a few seconds. If they don't do it (or one doesn't do it) prompt with the instruction to 'make a picture of you and your partner' up to 2 more times.]

Once they are done (allow up to 2 min. Make sure they have the stickers on the page and move on):

"Ok, now we have one final game to play."

PHASE 3 – INHIBITION TASK

"Both of you stand on the orange line" [point out where to stand]

"This is my mystery box – there's something inside. It could be something sticky, something slimy, something hot or cold…it could be an animal. One of you will put your hand inside that box. You can't tell the other person what is inside, but you will describe it, so the other person can try to guess what it is."

"So, we will draw names from this bag to decide who will put their hand into the box."

"Ok, so the Place-Maker will stand here on this purple line and Colour-Matcher will wait to hear the description while the Place-Maker puts his/her hand into the box and describes what is inside. Ok?"

"So, place-maker, what are you going to do?... (wait for correct answer) Ok, and Colour-Matcher, what are you going to do?....(wait for correct answer). Right."

Ok, now stand still and don't move untill I say. [uncover the mystery box]

"Place-Maker, when you're ready, put your hand inside the box."

[Video recorded for post-hoc analysis of time taken to walk to box and put hand inside]

***Once I see they have felt the item, tell them to remove their hand and ask Place-Maker to describe it to the Colour-Matcher**

"Ok, that's right – it's a teddy bear. Good job! Now, you both get to pick a sticker from this bag."

[thank them and take them back to class]

Appendix M

CODING SCHEME FOR THE MAT GAME

1. Coding Aims

A) To determine whether the 'place-maker' chooses either the same mat as the 'colour-matcher', or a different mat of either the same or different colour ("PM Mat Choice")

B) To identify other behaviours (e.g. talking, singing, laughing, gesturing, running, walking) seen in the videos.

2. What to analyse

A total of 124 videos amounting to about 250 minutes (4.2 hours).

In each video, two children will be playing a game called the Mat Game. They will be walking or running in opposite directions around coloured mats arranged in a circle.

The 'colour-matcher' (CM) will be moving along the inside cones, closer to the mats.

The 'place-maker' (PM) will be moving along the outside of the cones.

Each pair of children will complete 4 trials. The behaviour demonstrated by the children should be coded for each trial, as per the instructions below.

3. How to do the analysis

A) Coding "**PM Mat Choice**"

In the column, "**PM Mat Choice**" you will code the PM's mat choice as either "T" for Together (i.e. when the PM chooses to stand on the **same** mat as the other child (the CM), "AS" for Apart Same (i.e. when the PM chooses a **different** mat of the same colour) or "AO" for Apart Other (i.e. when the PM chooses a different mat of a different colour).

For each trial, you will write the code (T, AS, AO) under each trial's column (e.g., "Trial1 PM Mat Choice", "Trial2 PM Mat Choice", etc.).

B) Coding other behaviours ("**Behaviour**" and "**CM Behaviour**")

For each trial, you will also code the behaviour of the CM and PM as they make their way around the cones. Use the numbers for each corresponding behaviour, as shown below, in the columns, "**Trial1 Behaviour**", "**Trial2 Behaviour**", etc. Record any of the behaviours observed from either the CM or PM. More than one behaviour may be entered for each trial, but each behaviour should only be recorded once per trial (e.g. if the children were laughing at different times during Trial 1, you would record a "3" only once for the trial). If more than one different behaviour is observed for a single trial, use commas to separate numbers (e.g. 1,2).

1 – Talking (to oneself, the other child, each other, or the experimenter)

2 – Singing (either alone or with each other)

3 – Laughing (either alone or with the other child)

4 – Gesturing (e.g. making motions with hands and/or arms to signal to the other person)

5 – Silent (i.e. not talking, singing, or laughing)

6 – Touching (the other child e.g. high-5, pushing, kicking)

In the columns for CM Behaviour (e.g. "**Trial1 CM Behaviour**"), mark the corresponding number below to indicate the behaviours specific to the CM, as he/she waits for the PM to chose a mat:

1 – CM gives gestural or vocal encouragement for PM to join the mat

2 – CM gives gestural or vocal encouragement for PM to choose the other mat

3 – No gestural or vocal encouragement from the CM to choose either mat

In the column marked, "**Walking or Running**", please indicate if the children were walking or running in each video. Use a "W" to indicate walking or an "R to indicate running.

Lastly, in the "**Comments**" column, you may note any other behaviours that are not specified, such as 'PM changes mat' or 'CM ties shoe at decision moment'.

4. Example Coding

In the example below, the PM chooses to go to the CM's mat on the first trial, but chooses a different mat of the same colour on the next three trials. The children were silent in trials 1 and 4 and talking during trials 2 and 3. The CM did not encourage the PM to go to either mat in all 4 trials. The children were running throughout the videos.

Video ID	Trial 1 PM Mat Choice	Trial1 Behaviour	Trial1 CM Behaviour	Trial 2 PM Mat Choice	Trail2 Behaviour	Trial2 CM Behaviour	Trial 3 PM Mat Choice	Trial3 Behaviour	Trial3 CM Behaviour	Trail 4 PM Mat Choice	Trail4 Behaviour	Trail4 CM Behaviour	Walking or Running	Comments
2-2-1	T	5	3	AS	1	3	AS	1	3	AS	5	3	R	

5. After Analysis

After two coders have completed coding for all the videos, the responses will be reviewed by the researcher. If any trials are not matched between the two coders, those trials will be re-examined together (coders and researcher) to determine why a discrepancy occurred.

CODING SCHEME FOR THE MYSTERY BOX

1. Aims of the analysis

1) To measure how long it takes the child to put their hand – up to the wrist – into the box.
2) To identify reactions from the child after being instructed to place hand inside the box.

2. What to analyse

A total of 124 videos amounting to about 124 minutes (2.06 hours).

In each video, the children will play a game called the 'Mystery Box', in which one child will be prompted to approach the box and put his/her hand inside to feel and describe the contents. The other child will try to guess what is inside. Of interest is how long it takes the child to put his/her hand inside the box and any reactions from the child (details of coding the time taken can be found below).

3. How to do the analysis

For each video you will record the moment when the experimenter finishes giving the instruction and the moment the child puts his/her hand inside the box. You will also record any reactions you see or hear from the child and whether or not the child places the hand into the box.

A) Hand in box – '**Start**' and '**Stop**'

You will hear the experimenter say 'when you're ready, put your hand inside the box'. Immediately after the experimenter says the word 'box', you will record the frame number in the column labelled, '**Start**'. Then, you will play the video until the child's hand is inside the box (see *Figure 1*), at which point you will pause the video and record the frame number in the column labelled, '**Stop**'. <u>If the child never places the hand inside the box, simply mark 'NA' in the column labelled, 'Stop'</u> (see end of document for examples). If you are unable to code the start and stop moments for any reason, please make a brief note in the '**Comments**' cell explaining why (e.g. 'child blocked view').

a) 

b) 

Figure 1. Still frame images of child's arm (a) before hand is fully inside the box (wrist indicated by red arrow) and (b) with hand – up to the wrist - inside the box. The 'Stop' frame should be recorded when the child's arm appears as in image (b).

B) Child's Reactions

You will code any reactions from the child following the experimenter's instruction and before they decide whether to put their hand in the box in the column labelled, '**Reaction**'. Specific reactions will have the following corresponding numbers:

1 – Child verbally expresses fear (e.g. "I'm scared")

2 – Child questions or comments to experimenter (e.g. "Is there an animal inside?", "In the yellow hole?", "I'm ready")

3 – Child tries to look inside

4 – Child initially places hand in box but retracts before the wrist (eventually either placing the whole hand up to the wrist inside or not).

5 – Child laughs

6 – Child goes directly to box and places hand inside

*It is possible to have more than one reaction in a video. If you observe more than one reaction, please separate numbers by a comma (e.g. 1,5)

C) Hand in box – '**Hand in**'

You will code whether or not the child places the hand, up to the wrist (see *Figure 1*), in the box by marking 'Y' for yes or 'N' for no in the column labelled '**Hand in**'.

Examples:

3_28_1_TB: Time starts at frame 101. The child is heard telling experimenter, "I'm ready right now." The hand is inside the box at frame 295.

5_2_3_TB: Time starts at frame 92. Child approaches box quickly and hand is in at frame 157.

4_4_1_TB: Time starts at frame 127. Child approaches very slowly and whispers, "I can't" as other child tells her to do it. She bends down to look inside and asks experimenter, "do you know what's inside?". Experimenter eventually asks if child is too scared and child opts out.

ID	Start	Stop	Reaction	Hand in	Comments
3_28_1_TB	101	295	2	Y	Child on knees (not standing)
5_2_3_TB	92	157	6	Y	
4_4_1_TB	127	NA	1,2,3	N	

4. After Analysis

After two coders have completed coding for all the videos, the responses will be reviewed by the researcher. If any trials are not matched between the two coders, those trials will be re-examined together (coders and researcher) to determine why a discrepancy occurred.

Appendix N

Assumption checks for the mixed effects logistic regression model:

*Independence of observations – the inclusion of participant as a random effect in the model satisfies this assumption

* If it is a binary logistic regression, the dependent variable must be binary – ours is binary and therefore meets the assumption.

* A large sample is required – ours is a large sample

* There must be linearity between the continuous independent variables and the log odds – this assumption check does not apply to our data, as we have categorical independent variables and only one continuous independent variable.

* There should be little to no multicollinearity among the independent variables.

Check for multicollinearity in R:

```
PAgame8.check<-glm(Choice ~ Trial + Condf + Gender + scale(Age), data = PAgameF, family=binomial())
vif(PAgame8.check)
#Trial     Condf     Gender   scale(Age)
#1.001172   1.000982   1.004777   1.006874
```

A vif over 10 is problematic; these are fine and pass the assumption check

Appendix O

Assumption checks for Mystery Box linear regression model

First, check for normality of the dependent variable (time) and the model residuals:

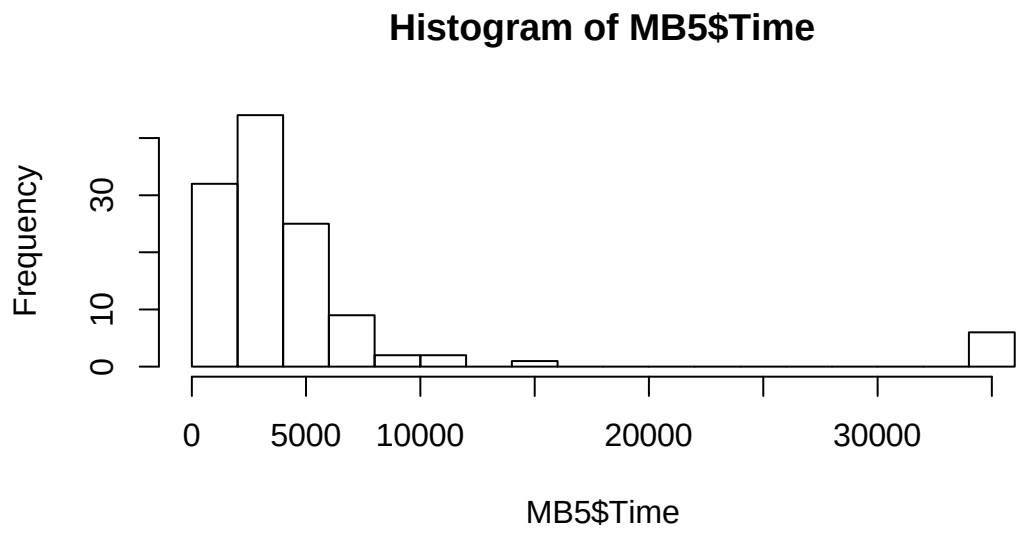


Figure L1. Histogram of Time

Not normal; Transform time using Box-Cox power transformation:

R Script:

Time2<-(MB5$Time^(-0.25))

Histogram of transformed time data (now normally distributed):

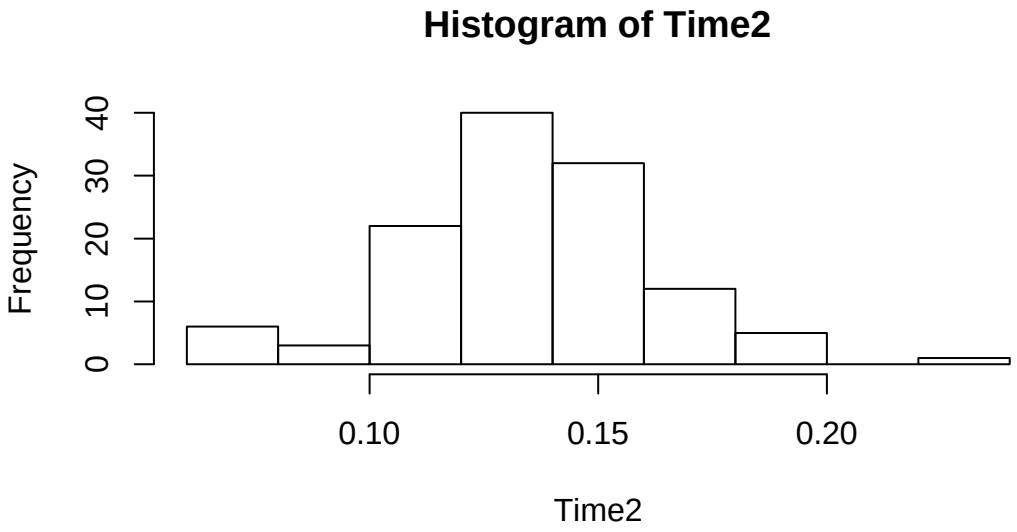


Figure L2. Histogram of transformed Time (Time2)

Now test for normality of model residuals using transformed time:

```
mod1 <- lm(Time ^ (-0.25) ~ Condition*Age*Sex, data = MB5)

qqnorm(resid(mod1))
```

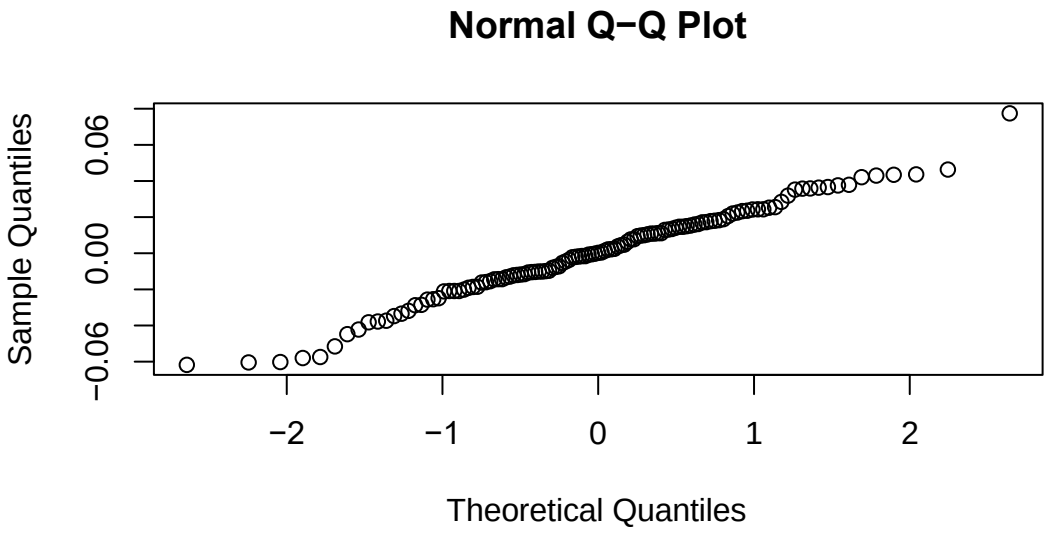


Figure L3. Q-Q plot for mod1 (linear model with condition, age, and gender as predictors of transformed time).

The values should fall along a diagonal line, indicating model fit. These values fall along a diagonal, though not perfectly. The fit is considered good, but we should do a further test to be sure.

Test for normality using Shapiro-Wilk:

```
shapiro.test(resid(mod1))

Shapiro-Wilk normality test

data:  resid(mod1)

W = 0.98683, p-value = 0.2921
```

* p-value should be above .05; this model passes the test.