Towards an understanding the perceptual foundations of prejudice

By

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A dissertation submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the University of Oxford

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Short abstract

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In-group identification is a central aspect of human social behaviour. There is evidence of the effects of in-group identification on different aspects of cognition but it is still unclear how in-group identification might affect basic perceptual mechanisms. Relying on an interdisciplinary perspective, this work investigates the extent to which in-group identification affects perception. This thesis explores the issue under three main themes.

The first theme deals with the effect of in-group identification on perception using behavioural paradigms and relies on the measures of accuracy and reaction time as well as questionnaire measures of the strength of in-group identification. In this case, individuals show enhanced perceptual matching performance for stimuli associated with an in-group as opposed to the stimuli associated to rival and neutral groups. Moreover, the enhanced performance for in-group associated stimuli correlated with the satisfaction subcomponent of an in-group identification measure.

The second theme aimed to gain a better understanding of the effects of in-group identification on both automatic (prosaccade) and inhibitory (antisaccade) aspects of explicit attentional orienting. In this case, the results provide evidence on the effect of in-group identification on the inhibitory control of overt attention, as well as on pupillary responses.

The third theme examined the neural underpinnings of in-group identification effects on perception. Neural correlates of in-group biases were found in brain networks previously associated with social saliency, emotion and attention, notably the posterior superior temporal sulcus, the dorsolateral prefrontal cortex and anterior insula. Moreover, carrying out a perceptual matching task changed the functional connectivity between the anterior insula and the inferior frontal gyrus, and this change in connectivity was related to the magnitude of behavioural biases to the in-group. This

suggests that such rapid changes in functional connectivity may provide a neural basis for the development of in-group favouritism.

The overall findings across the different chapters confirm that in-group biases affect perceptual matching in a variety of ways and through a specific neural network. In general, the results are in line with the hypothesis that our perception favours stimuli linked to our in-group. The limitations and future possible lines of study are discussed.

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Long abstract

Chapter 1 introduces basic concepts relating to in-group biases. In this chapter I try to overview the current literature in the field in an interdisciplinary manner. I briefly touch on the theoretical backgrounds based on classical social psychology studies. I further discuss the recent literature on the neural bases of in-group biases across different contexts and the effects of these biases on perception. Here, I mainly focus on major networks in the brain which have been shown to play a key role in in-group biases. These networks include the medial prefrontal region, the posterior temporal lobe as well as parts of the limbic system. In addition, I review the literature on the effects of in-group biases on inhibitory control in looking behaviour. I also briefly discuss eye tracking and fMRI techniques.

Chapter 2 focuses on a series of experiments including a field study with football fans and laboratory studies with fans and control participants. I present the results from the main paradigm used in the thesis in which participants had to learn to associate three different arbitrary shapes with the badge of their favourite team, a local rival team and a neutral team. Subsequently participants viewed the different badge/shape pairs which were either as originally shown or re-paired, to create match and mismatch trials. I tested whether participants' performance on the task (measured by reaction times and accuracy) was affected by their team identification. I further tested the effect of familiarity using a similar paradigm with different sets of targets. Here, I selected stimuli not linked to group membership but which varied more widely in their rated familiarity than the team badges used in the other experiments. The results showed enhanced perceptual matching for the in-group stimuli. The advantage for in-

group relevant stimuli was not found in the control participants who had knowledge about the teams but did not support them. Moreover, the effect was unlikely to be due to the familiarity of the items as no effects of familiarity were shown in a control study. The results indicate that the enhanced performance for the in-group team does not merely rely on the higher familiarity of the 'own team' badge.

Chapter 3 extends the scope of the studies in chapter 2 by generalising the perceptual in- group bias effects from shapes to colours. Here, I further asked how prior knowledge about the group-relevant colours affects in-group bias. Across three experiments I replicate the results that I depicted in chapter 2. Moreover, I show that the motivational relevance of the in-group stimulus, but not prior knowledge, drives the enhanced performance. Using a multicomponent in-group identification questionnaire (Leach et al., 2008), I further investigated the role of the different subcomponents of in-group identification in driving perceptual in-group biases and show that the satisfaction subcomponent of the in-group identification score correlates with the behavioural advantage for in-group stimuli.

Chapter 4 made use of mathematical modelling to examine processes affected by in-group association In a modification of the task used in chapters 2 and 3, participants made associations between a shape, a colour and either in- (own university) or out-group (rival university) labels. They then had to discriminate whether in- or out-group stimuli appeared, and single or redundant colours or shapes were presented. Responses to in- but not to out-group stimuli violated the predictions of models in which the associated features are processed independently. These redundancy gains were consistent with in-group stimuli (but not out-group) being processed with '*super-*

capacity'. These results provide the first evidence that there is enhanced perceptual integration for information associated with an in-group.

Chapter 5 presents the data from two eye tracking studies exploring the effects of in-group identification on both excitatory (prosaccade) and inhibitory (antisaccades) aspects of explicit attentional orienting. Using a central coloured cue, football fans were instructed to look at targets on prosaccade trials or the mirrored position on antisaccade trials (there were mixed random pro- and antisaccade trials). As before, the targets were badges of either the favourite team of the fans (the in-group), its closest rival (the out-group) or a non-local (neutral) team. The results showed that, on antisaccade trials, participants made more directional errors for the in-group badge compared to the badges of neutral and rival teams. Moreover, participants took longer to correct their directional errors for in-group stimuli compared to similar corrections for neutral and rival teams. A control study with individuals who were not football fans did not yield any significant differences between the contrasting badges, ruling out effects of low-level, stimulus-related differences.

Chapter 6 takes a slightly different paradigm with rowers performing eye movements in pure blocks of pro and antisaccade trials. The results were similar to those present in chapter 5.

Chapters 7 and 8 explore the neural basis of the effects. Chapter 7 tests whether resting state activity in the brain was related to in-group biases in perception. Furthermore, by comparing resting state activity before and after the in- and out-group matching task, I evaluated changes in underlying functional activity controlling for between-individual differences at baseline. The changes in resting state activity were then correlated against the strength of in-group biases in perceptual matching, proving a

link between neural activity and enhanced in-group perception. The results showed that changes in the strength of the resting state intrinsic connectivity between the left anterior insula and the left inferior frontal gyrus predicted the in-group biases.

Chapter 8 explores the neural correlates of the effect of in-group identification on perception. Using the same task as that used in chapter 2, I show that the in-group advantage is linked to increased activity in the left posterior superior temporal sulcus. In contrast, there was greater activity for rival over in-group associations within the dorsal attentional control network (the left dorsal prefrontal, superior medial and inferior dorsal parietal cortex) and also the anterior insula. Notably, poor performance to stimuli associated with the rival team was correlated with the size of signal change in the left anterior insula providing evidence for a role of emotional reaction to the rival in in-group bias.

Chapter 9 puts together the overall findings presented in the experimental chapters and draws a comprehensive conclusion based on these findings. Both the limitations and future lines of research are discussed in detail.

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Chapter 1

General introduction

In-group biases: Background and general framework

Belonging to a group is an essential need for human beings (Turner, 1987). Group membership provides greater access to resources and yields protection against out-groups and therefore guarantees survival under competition.

In-group identification refers to "the perception of oneness with or belongingness to some human aggregate" (Ashforth & Mael, 1989, p. 21) and has been shown to contribute to shaping beliefs and social behaviour (for example see, Fiske, 2002). A common characteristic of a sense of belonging to a group is in-group favouritism (for example see, Brewer, 1979). Biases in favour of in-group members and associated stimuli have been revealed across many studies and contexts over the last fifty years (Allport, 1954; Hewstone, Rubin, & Willis, 2002; Molenberghs, 2013; Tajfel, 1978). In-group biases can take a variety of forms ranging from mild forms of biases to prejudice and discrimination (Hewstone & Cairns 2001). These biases might not always be expressed explicitly. In fact, recent studies in the field of prejudice and in-group biases have mostly focused on implicit forms of bias, which could be counted as mild forms of prejudice. These implicit in-group biases are thought to be unintentional and sometimes hidden even to the individuals themselves (for a review see, Hewstone et al., 2002).

Social psychological studies have shown that, upon encountering a person, we automatically classify them as an in- or an out-group member, based on whether or not an individual is similar to self (for example see, Macrae & Bodenhausen, 2000). In-group identification can influence judgements, attitudes, empathy, memory and even perception (Howard & Rothbart, 1980; Islam & Hewstone, 1993; Molenberghs, Hala´ sz, Mattingley, Vanman, & Cunnington, 2012; Van Bavel, Packer, & Cunningham, 2008; Xu, Zuo, Wang, & Han, 2009). For example, it has been shown that when people

are arbitrarily assigned to be members of mutually exclusive groups, they tend to allocate more rewards to their in-group than to out-group members (for example, see Tajfel, 1970). It has also been shown that individuals have enhanced memory for the events and stimuli related to their in-group compared to those of out-groups (for review see, Meissner & Brigham, 2001). In-group identification has additionally been shown to affect whether or not we trust people. People usually perceive their in-group members to be more trustworthy compared to out-group members (Dovidio, Gaertner, Kawakami, & Hodson, 2002; Hewstone et al., 2004). More importantly, studies reveal that empathic responses to others' suffering are modulated by group membership (Cikara, Bruneau, & Saxe, 2011), with stronger empathic responses to in-group members compared to individuals from out-groups.

In line with this, there are also effects of group identification on perceptual tasks (Rule, Ambady, Adams, & Macrae, 2007). For example, previous studies suggest that group identification can modulate face processing. In the well-known 'own race bias' (ORB), individuals show enhanced memory and identification for faces belonging to their own racial group relative to faces belonging to other races (e.g., Brigham, Bennett, Meissner, & Mitchell, 2007).

These studies suggest that there is a value in learning about individuals with whom we have some similarities and share common interests (the in-group) as opposed to those outside this boundary (out-groups). It has been proposed that biases that favour the in-group can be learned in infancy through emotional contagion (Hirschfeld, 1996). In line with this, there is evidence that humans tend to imitate the actions of in-group members more often compared to those of out-group members (Lyons et al., 2011; McGuigan et al., 2011). In-group favouritism appears to be the case for real world groupings based on religiosity, ethnicity, race, political parties and sports teams (for a

review see Amodio, 2014). However, it has been shown that even the mere categorization as members of different groups is enough to produce in-group biases (see for example, Brewer, 1979, using a so-called 'minimal group paradigm'; see above).

Different theories have been developed in social psychology to explain in-group biases including those that relate to the concepts of social identity and social comparison (see for example, Tajfel & Turner, 1979; for an extensive review of theories of in-group biases see Hewstone et al., 2002). One important mechanism that can explain in-group biases roots it in our sensitivity to threats in competitive contexts. Being a part of a group, especially when there is competition over scarce resources, increases the chance of access to the resources, and promotes safety from the threatening out-groups (Dunbar, 1993).

In line with this, previous studies have highlighted the important role of competition in driving in-group biases (for example see, Harvey, White, Hood, & Sherif, 1961). In a highly influential social psychology study, Sherif and colleges (1961) showed that putting groups into competition results in intergroup conflict, even when the members of the competing groups have no prior experience and familiarity with one another.

However, referring back to the minimal group paradigm in which participants are randomly placed in different groups, it has been suggested that the mere categorization into one group vs. another is salient enough to produce in-group biases (see for example, Tajfel & Turner, 1979). Nevertheless, the concepts of social identity theory suggest that real groups in rivalry generate stronger in-group biases (see for example, Mullen, Brown, & Smith, 1992).

Despite the evidence for in-group biases across different domains, their effects on perception are still not clear. Many accounts propose that perception is a bottom-up

process, driven by the properties of stimuli computed in primary visual cortices and fed-forward to subsequent recognition processes (e.g., Marr, 1982). However there is recent evidence for perceptual processes being affected by social relevance (Sui, He, & Humphreys, 2012). Notably, perception in the real world does not occur in isolation but in particular social contexts. The effects of social factors on perception might extend beyond cognitive factors to include factors such as group identification – for example, generating enhanced perception of stimuli associated with an in-group. With regard to the current literature pointing to the effect of intergroup competition on in-group biases, it would be particularly interesting to investigate how in-group biases formed based on real world rivalry permeate perceptual mechanisms. This thesis takes a social cognitive approach using different methodologies including behavioural, mathematical modelling, eye tracking and functional magnetic resonance imaging to study the perceptual foundations of prejudice in a multidisciplinary manner. The basic promise of this approach is that it provides a comprehensive understanding of the perceptual foundation of prejudice based on the information reflecting the effect at different levels. Conducting studies on social aspects of human behaviour and cognition including in-group biases is extremely complex. Therefore, in the field of social cognitive neuroscience it would be good practice to employ a multi-method, multidisciplinary approach. In line with this notion, in the following section, I will provide evidence on more recent approaches such as those employed in social neuroscience to study in-group biases.

What can neuroscience teach us about in-group biases?

It has been suggested that changes in the human brain's structures and functions throughout evolution equipped human beings with an ability to form and maintain complex groups (Dunbar, 2011).

Despite long-lasting attention to the issue of in-group biases and prejudice in the history of social psychology (Tajfel, 1978), social neuroscience has only recently started to focus on studying in-group biases (for a review see, Molenberghs, 2013). Although neuroscientific techniques have their distinct shortcomings they are still useful in that they help to foster a better understating of the question of interest at the neural level. For the neuroscientist, the domain of in-group biases provides a unique context for examining the neural underpinning of complex social issues. Neuroscientific techniques, and in particular functional magnetic resonance imaging (fMRI), has revolutionised research into in-group biases by providing the unique opportunity to study the human brain *in vivo*. Despite its imperfections (e.g., its long time course), fMRI offers neuroscientists the opportunity to start connecting current knowledge on human brain function to important social issues, such as intergroup conflict, racism and stereotyping.

Indeed, recent studies in social neuroscience on in-group biases have provided a remarkably rich body of information. Recent work traces the physiological roots of in-group favouritism using twin studies (Lewis & Bates, 2010) and neuroimaging (Mathur Harada, Lipke, & Chiao, 2010). Neuroimaging studies have shown that the brain perceives and responds differently to in-group and out-group members (Gilbert, Swencionis, & Amodio, 2012; Golby, Gabrieli, Chiao, & Eberhardt, 2001; Van Bavel et al., 2008). For example, Van Bavel and colleagues (2008) found greater BOLD response in the amygdala, fusiform gyri, orbitofrontal cortex, and dorsal striatum when

participants viewed novel in-group faces compare to those of out-groups. More importantly, the neural activity in orbitofrontal cortex was correlated with the self-reported liking for the faces. Moreover, studies reveal that certain brain areas might be involved in the in-group modulation of attention and perception. Here it appears that in-group bias affects different aspects of perception as a result of modulation of coordinated neural networks rather than single brain regions. Rich networks, such as those involved in different aspects of perception (Molenberghs et al., 2012; Van Bavel, Packer, & Cunningham, 2008; Van Bavel, Packer, & Cunningham, 2011), reasoning and theory of mind (Carrington & Bailey, 2008; Saxe, 2006), and empathy (Mathur et al., 2010) appear to be affected by group membership. Notably, previous studies have highlighted the role of the brain's midline structures including medial prefrontal cortex in in-group biases (Mitchell, Macrae & Banaji, 2006). The brain's midline structures have also been shown to mediate self-referential processes, which are shown to be prioritized over the information associated with others (Mitchell, Banaji & Macrae, 2005; Northoff & Bermpohl, 2004; Northoff et al., 2006). For example, studies found that participants better remembered self-associated objects than those associated with others (Gronau, Cohen, & Ben-Shakhar, 2003).

Attentional prioritization for self-relevant stimuli has been shown to occur automatically. For example, Bargh (1982) showed that in a task where participants were instructed to shadow words presented to one ear while ignoring words presented to the other ear some of the words were relevant to the participants' personal schema as being independent or not, and the rest were neutral words with no personal relevance. Bargh (1982) found that self-relevant words demanded fewer processing resources when they were attended (shorter shadowing RTs) and also that, when presented as distractors (to the to-be-ignored ear) the self-related words were more likely to distract

attention from a probe target.

In line with these findings, Sui, Rotshtein, & Humphreys (2013) have recently shown that self-prioritization occurs for neutral stimuli with which participants had no previous experience. Participants were asked to associate three geometric shapes with three personal labels (e.g., circle- stranger, square- friend, triangle - you). Participants then had to judge whether shape-label pairs were as originally instructed or new pairings (circle-friend, square-you, triangle-stranger). Participants were substantially faster and more accurate to respond to stimuli associated with themselves (e.g., triangle-you) compared with stimuli associated with other people (circle-stranger, square-friend). Sui et al. (2013) further demonstrated the neural basis of this effect. They found that self-related stimuli showed enhanced activation in the ventro-medial prefrontal cortex (vmPFC) and in the posterior superior temporal sulcus in the left hemisphere (LpSTS). Sui et al. (2013) argued that vmPFC activity was linked to the activation of self representations (see also Northoff et al., 2006), while the LpSTS activity reflected an increased attentional response to self-related items. In contrast, responses to stranger-related items was associated with increased activity in the dorso-lateral frontal cortex and dorsal posterior parietal cortex – brain areas associated with attentional control (Corbetta & Shulman, 2002). This perceptual matching task has recently been used in the context of in-group relations by Moradi, Sui, Hewstone and Humphreys (2015) (see Chapter 2 here). They had football supporters form associations between geometric shapes and the badge of either their favourite football team, the badge of a neutral football club, or the badge of their rival football team. The task was then to decide whether a badge and shape was as originally paired or whether the stimuli had been re-paired. They found that matches were more efficient to in-group stimuli than to out-group pairings, and that matches correlated with the amount of satisfaction

participants expressed with their in-group.

The link between enhanced attention for both self and in-group relevant information and their shared neural correlates fits well with influential social psychology theories on the mechanisms of in-group identification, including social identity theory and self categorization theory (for example see, Tajfel & Turner 1979; Turner, 1987), which propose some overlap between the self and in-group membership. According to these theories, overlap between the self and the in-group results in individuals showing enhanced perception and attention toward in-group relevant information. The cognitive neuroscientific evidence indicates that this overlap extends to common brain structures.

Recent fMRI studies have further confirmed the role of the medial prefrontal cortex in in-group referential processes. For example, activity in ventromedial prefrontal cortex has been observed when individuals categorize in-group as opposed to out-group words (Molenberghs & Morrison, 2012). However, there is evidence too that in-group referential processes might result in neural activity in different regions of medial prefrontal cortex depending on the context of the study, the nature of the task and the amount of experience and perhaps emotional bond with the members of in-groups (Mitchell et al., 2006; Molenberghs et al., 2012; Volz, Kessler, & Von Cramon, 2009). In addition to the medial prefrontal networks of the brain, there is evidence on the role of two other major networks playing a role in modulating the effects of in-group biases on attention and perception. These networks include the temporoparietal and limbic networks. Reliable effects of in-group driven differential neural activity have been associated with the temporoparietal junction (TPJ), the posterior cingulate cortex and the precuneus (Bruneau & Saxe, 2010; Cavanna & Trimble, 2006; Denny, Kober, Wager, & Ochsner, 2012; Ochsner et al., 2004; Samson, Apperly, Chiavarino, &

Humphreys, 2004; Saxe, 2006). For example, Bruneau and Saxe (2010) presented Arab, Israeli and control participants with statements about the Middle East from the perspective of in or the out-group members. Participants rated how 'reasonable' each statement was, while their brain activity was recorded. The results of fMRI revealed increased activation in the precuneus while reading pro-out-group vs. pro-in-group statements. More importantly, Bruneau and Saxe (2010) used both an implicit association test (IAT), as well as explicit measure of in-group biases. An online questionnaire, consisting of personality measures as well as the Balanced Emotional Empathy Scale (Mehrabian, 1997) and series of statements about Israeli and Arabs were used as explicit measures. In this study a difference score was calculated by subtracting the rating for 'Arab Muslims' from the rating for 'Jewish Israelis', resulting in a range from − 10 ('pro-Arab') to + 10 ('pro-Israeli'). They showed that these neural activities were strongly correlated with both explicit and implicit measures of negative attitudes towards the out-group.

In another fMRI study, Adams and colleagues (2009) instructed Caucasian and Asian participants to judge the mental state of in and out-group members depicted in photos of White and Asian people. In this study participants were instructed to choose the word that best explained the emotions depicted in the eyes ("Reading the mind in the eyes task"; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). Participants showed a behavioural advantage (better accuracy and faster response) judging the mental state of in-group over out-group members. At the neuronal level, such in-group bias was associated with increased activity in the posterior STS/TPJ area. As mentioned earlier, similar studies have also demonstrated the key role of the mPFC in in-group bias especially in higher-level social cognitive functions such as empathy and Theory of Mind (ToM). For example, Mathur and colleagues (2010) showed that watching in-

group members in pain resulted in increased activity in mPFC, relative to when similar images were shown of out-group members, and this pattern of neural activity predicted greater empathy and altruistic motivation for one's in-group (see also Denny et al., 2012; Ochsner et al., 2004).

There is also evidence on the role of the brain's limbic structure in processing in- and out-group relevant stimuli. In particular, there is reliable evidence on the role of the amygdala in in-group biases and prejudice (for a different argument see Chekroud, Everett, Bridge, & Hewstone, 2014). For example, Hart et al. (2000) showed that viewing racial out-groups resulted in increased activity in the amygdala.

Much of the research on the role of amygdala in in-group perception suggests that amygdala activation might reflect an implicit threat response to racial out-group members. For example, Phelps and colleagues (2000) showed that presenting participants with out-group faces resulted in neural activity in the amygdala, and the strength of this activity was correlated with both performance in the IAT and with startle responses. Interestingly, experience with the out-group can modulate the amygdala's response to out-group faces (Phelps et al., 2000). Recent studies have also suggested that perceptual load might decrease the amygdala's response to out-group faces. For example, in one study participants were instructed to detect the small dot on an image of faces of individuals who were either in- or out-group members. Attention to a stimulus property unrelated to racial grouping (detecting a small dot on the face) resulted in decreased amygdala responses to out-group faces (Wheeler & Fiske, 2005). More recent studies in the field of in-group biases highlight too the role of the insula in a range of tasks directly or indirectly related to group categorization. In particular, co-activation of anterior insula together with sub-regions of the frontal cortex including the anterior cingulate cortex and medial and lateral prefrontal cortices broadly function to

represent emotional and social related processes (see for example, Craig, 2009). Remarkably, the anterior insula is frequently associated with aspects of social cognition and social emotion including in-group modulation of social emotions. Although there have been few studies on the role of the anterior insula on in-group biases, its activity is frequently associated with responses to out-group versus in-group members in the context of racial grouping (see for example, Lieberman, Hariri, Jarcho, Eisenberger, & Bookheimer, 2005). This finding has been interpreted as evidence for negative emotional reactions such as disgust towards racial out-groups. More importantly, such activity in the anterior insula has been shown to predict participants' implicit negative attitudes towards members of the out-group (Knutson, Mah, Manly, & Grafman, 2007). Therefore, the anterior insula seems to contribute to the subjective negative affect against out-group members, which might in turn modulate perception and attention to both in- and out-group members.

Taken together recent neuroimaging studies in the field of in-group biases suggest the contribution of a rich neural network including but not limited to the amygdala, the MPFC, the insula, TPJ and pSTS in in-group modulation of perception.

Multidisciplinary approach in the current studies

In-group biases are multifaceted and can influence behaviour and cognition across different levels. Therefore, a multidisciplinary approach in studying in-group biases is necessary. The primary goal of the current thesis was to present a thorough assessment on the perceptual foundations of in-group bias at both behavioural and neural levels. To do this, across seven chapters I recruited various methods including behavioural, eye tracking and fMRI techniques to investigate the issue of in-group biases in perception. The chapters are divided into three major themes. These themes

include: Behavioural measurements of in-group biases in perception, eye tracking approaches and fMRI approaches. I will provide a brief summary of the aims and questions of interest in each theme and how I approached the different facets of perceptual effects of in-group identification using the different methodologies.

Methodological considerations

This thesis is based on three main forms of measurement: behavioural (RTs and accuracy of performance), eye-movement and neuronal (fMRI). In the following sections I discuss the feasibility of the different approaches that I took within each theme and how each approach helped me unravel a different aspect of the influence of group identification on visual attention and perception. Here, the methodological considerations regarding each approach are discussed.

Behavioural approach: Aims and hypotheses

This theme mainly focuses on reaction times and accuracy measures taken in a perceptual matching task where participants learn to associate an arbitrary feature (colour and/ or shape) with in-group or out-group stimuli target (e.g., badge or label of a team that the participant supported).

Chapter 2, as a starting experimental chapter, includes a field study with football fans, as well as laboratory studies with fans and control participants. I further tested the effect of familiarity using a similar paradigm with different sets of targets. Here, I selected stimuli not linked to group membership but which varied more widely in their rated familiarity than the team badges used in the other experiments (I used images of animals which were rated outside the experiment as being familiar or unfamiliar by an independent group of participants). If the in-group bias occurred because the own team

badge was simply more familiar, an advantage should emerge for associative shape matching for familiar relative to unfamiliar animals. However, if group identification is critical, then participants should not show any preference for matching the familiar compared to the unfamiliar animals here.

In chapter 3, I extended the scope of the studies in Chapter 2 by generalising the perceptual in-group bias effects from shapes to colours. In this chapter I explored how in-group identification affects performance based on whether a certain colour was associated with an in or out-group label. I further asked how prior knowledge about the group relevant colours affects the in-group bias. I hypothesized that there should be enhanced processing and more efficient matching for in-group compared to out-group associated stimuli (Loersch & Bartholow, 2011). I manipulated group-relevant colours related to university rowing teams, since colours are an important part of the identity of these groups (Elliot & Maier, 2014; Georgeson & Lampard, 2005). In addition to assessing performance with learned colour-team relations I also assessed how performance varied when the learned colours were associated with other teams. In a 'swap' condition, I paired the in-group label (Oxford) with the colour of the rival team (Cambridge) or the neutral team (Newcastle). If the motivational relevance of the in-group association is sufficient to produce in-group bias, participants should still perform better on in-group pairs compared to the pairing that has not been changed. For example, responses to the pairing of Oxford with the Newcastle colour should be faster than response to the pairing of Cambridge with its learned light blue. Furthermore, I asked whether in-group bias would exist in the absence of any learned relations between the colour-team associations. I also explored whether motivational relevance of in-group identification was necessary for enhanced performance. I predicted that the same associations should not yield any significant biases for the participants who did

not identify with either of the university teams, even though they had knowledge of the colour associations. Using a multicomponent in-group identification questionnaire (Leach et al., 2008), I further explored the role of different subcomponents of in-group identification in driving perceptual in-group biases. One line of research assumes that in-group favouritism can be explained by self-investment as in-group can be accounted as a part of the self. Using the multicomponent in-group identification questionnaire I explored the self-investment account of in-group identification (Leach et al., 2008). Self-investment is directly linked to the amount of commitment that one shows for group activity. For instance, individuals who identify strongly with their in-group are more likely to feel psychological and emotional bonds with their in-group (Lewin, 1948), and they may experience greater reward by acting in relation to the in-group. Based on this, I predicted that satisfaction with an in-group (as a subcomponent of the questionnaire) might play an important role in perceptual in-group biases for both learned and novel in-group associations.

In Chapter 4, I took a mathematical approach based on independent race models and asked whether perceptual integration is modulated by in-group affiliation. Previous studies have shown that decision times are faster when detecting two targets for which the same response is required, compared to when only one of the targets is present - resulting in a redundancy gain (see for example, Gondan, Niederhaus, Rösler, & Röder, 2005). In line with these findings, Sui, Yankouskaya and Humphreys (2015) recently examined whether self-relevance has any impact on perceptual integration measured through redundancy gains. They showed enhanced redundancy for self-associated stimuli as opposed to stimuli associated with others, which could not be accounted for by the independent processing of single targets – consistent with self-relevance enhancing perceptual integration of stimuli. In Chapter 4 I evaluated whether the same

held for in-group associated stimuli. Participants made associations between a shape, a colour and either in-group (own university) or out-group (rival university) labels. They then had to discriminate whether in- or out-group stimuli appeared, and single or redundant features were presented. I hypothesized that group identification would result in larger redundancy gain for in- as opposed to out-group targets (see Sui et al., 2015). Such results might suggest enhanced perceptual integration for information associated with an in-group. Taken together the behavioural studies presented in Chapters 2, 3 and 4 compare and contrast the effect of familiarity as well as in-group motivation on perceptual learning. The experiments demonstrate that in-group association enhances perceptual processing, including facilitating the perceptual integration of stimuli.

Eye tracking approach: Aims and hypotheses

Eye tracking has been used in numerous social neuroscience studies to acquire a better understanding of different aspects of human social cognition in both healthy participants and patients with various neurological conditions. Modern eye trackers (including the Tobii eye-tracker that I employed in my studies) use infrared illuminators and video cameras to record the position of the eyes as well as pupil responses and eye movements. The information gained includes pupil responses (dilation and constriction), fixation durations (the time that eyes hold on at the same location), gaze direction and saccade latencies, and these additional measures have helped enhance our understanding of human social attention. Over the past 25 years of social neuroscience (Ochsner & Lieberman, 2001), eye tracking studies have generated a wealth of data, including demonstrating in-group bias effects. Across different contexts, previous studies have shown that group identification can affect eye-movements depending on whether participants were looking at in- or out-group targets. For example, Liuzza et al.

(2011) had participants make an eye movement to a peripheral target presented on the face of a politician who either had or did not have the same political persuasion as the participant and who made an eye movement congruent or incongruent with the position of the target. For individuals who shared the views of the politician, eye movements were disrupted when the politician made a saccade incongruent with the position of the target. For individuals who did not share the political views of the politician, there was no effect of whether the politician made an eye movement congruent or incongruent with the location of the target. Since there is normally some effect of the congruency of the eye movement of a central face, this last result suggests some suppression of responses to a politician whose views do not match one's own.

The congruency effect on eye movements (above) suggests that attention can be modulated by the social relevance of stimuli in a manner that may be relatively automatic. Other results support this proposal. For example, in a visual search task, participants were instructed to detect a target in a display containing three distractors (Alexopoulos, Muller, Ric, & Marendaz, 2012). Before the onset of visual display, a spatial cue was presented (Muller & Butera, 2007) for a very short time (235 ms.) which was either the participant's own name, the name of a familiar person or the name of a stranger. Across three different experiments, Alexopoulos and colleagues (2012) showed that participants were faster at looking at a target proceeded by their own name as a valid (spatially relevant) cue compared to targets spatially cued by another person's name. Since the cueing time was short they suggest that this effect was automatic and beyond the reach of intentional control (see Briand, 1998).

Such studies suggest that the social relevance of stimuli (e.g., whether the stimuli are related to the self or to an in-group) results in the capture of eye-movements. In most studies, experimenters have studied how social association affects the

orientation of attention toward the social stimuli – for example by measuring pro-saccades to stimuli (for example, see Alexopoulos et al., 2012). However, the contrast between pro- and antisaccades can also be informative about the attention-capturing properties of social and emotional stimuli. For example, previous studies have shown that the emotional properties of stimuli can differentially modulate pro and antisaccades (for example, see Kissler & Keil, 2008). In particular, pictures with high emotional content (both pleasant and unpleasant) not only facilitate prosaccades but disrupt antisaccades (generating more directional errors in antisaccade trials). However, it is not clear whether more abstract stimuli connected to an in- or out-group would modulate pro and antisaccades in a similar way to emotional stimuli. Moreover, there is a lack of knowledge on whether the social modulation of eye-movements extends to more abstract stimuli (rather than one's own or in-group's name and face as mentioned earlier). Here, using eye tracking I aimed to address whether these effects extend beyond own name and face stimuli to include effects of stimuli associated with in- and out-groups. By contrasting pro- and anti-saccades I will assess how well participants can control their orienting to in-group associated stimuli – poor control would be shown by participants making frequent pro-saccades to in-group associated stimuli on an anti-saccade trial.

Across Chapters 5 and 6, I present data from a series of eye tracking studies aiming to gain a better understanding of the effects of in-group identification on both automatic (prosaccades) and inhibitory (antisaccades) aspects of explicit attentional orienting. I hypothesized that the individuals with strong in-group affiliation (fans) would make faster prosaccades toward the badge of their favourite football team but also slower antisaccades away from it. I also hypothesized that the urge to look at an in-group badge would result in more directional errors on antisaccade trials for these

stimuli compared with rival and neutral badges. Moreover, I hypothesized that those individuals without in-group identification would not exhibit any difference in their looking behaviour towards or away from different badges.

In Chapter 6, I used a slightly different paradigm with rowers performing eye movements in pure blocks of pro and antisaccade trials. I hypothesized that similar results to those of Chapter 5, would emerge. Taken together the studies presented through Chapters 5 and 6 provide evidence about the effect of in-group identification on inhibitory control in looking behaviour.

Functional MRI approach: Aims and hypotheses

As previously noted, functional magnetic resonance imaging has recently been widely used in social neuroscience studies including those examining in-group biases (Vul, Harris, Winkielman, & Pashler, 2009). This method is based on the indirect measurement of the neuronal activity in the brain using blood oxygen level dependent changes (BOLD). Unfortunately, the scope of this thesis is too limited to focus on the fMRI acquisition and analysis in details. Instead, I briefly touch on some important aspects of this method and the pros and cons of how this methodology can contribute to our understanding of perceptual in-group biases.

fMRI methods are based on the changes in BOLD response in the brain when participants are placed in a strong magnetic field. The functional images acquired throughout the fMRI experiments (both using task and resting state conditions) are composed of thousands of *voxels* containing the information about the BOLD signal as images are acquired. These images are normally poor in spatial resolution. During the pre-processing stage these images get co-registered on the anatomical image, which has

a better spatial resolution and this enables the researchers to conduct the group level analyses in order to find out the common areas activated in the task.

The pre-processing stage also reduces the noise in the data and enables scientists to compare both the structural and functional variability in different brains. Different factors contribute to the noise and variability in fMRI data. Moreover, the correlation between the neural activity and BOLD response is complicated and is still not fully understood (Logothetis, 2008). Nonetheless, as a rule of thumb in fMRI studies, it is assumed that enhanced neural activity results in an increase in the demand for oxygen in brain tissue and therefore an increase in BOLD signal. The de-noised fMRI data can be modelled to investigate both increase and decrease of activity in different brain regions. The most common approach in analysing fMRI data is to look for the activation (or deactivation) throughout the whole brain using *univariate* general linear model analyses. This approach however is susceptible to *type I* error. In addition, to control for the family wise error (*FWE*), scientists commonly conduct region of interest (ROI) analyses to answer more specific questions and to confine the comparisons within limited regions of interest.

The main critiques of fMRI are concerned with the poor temporal resolution of the technique, and the lack of differentiation between excitatory and inhibitory activation. Despite these critiques especially in the domain of social neuroscience (for example see, Amodio & Ratner, 2013), fMRI continues to enable social neuroscientists to develop a better understanding of the complex aspects of human social behaviour and social cognition. Therefore, as an interdisciplinary attempt to understand the perceptual foundations of prejudice, this thesis employed fMRI. Using this technique in Chapters 7 and 8, I specifically asked how the brain's response differs to stimuli associated with an in-group as opposed to a rival team. The aim of this research was to identify a neural

marker for group driven biases in the context of football rivalry that permeates basic perceptual mechanisms.

I asked two different questions in Chapters 7 and 8. In Chapter 7, I investigated whether resting state activity in the brain was related to in-group biases in perception. Resting state activity can reflect the functional connections between brain regions, which operate in coordination as a part of an underlying neural network (Damoiseaux et al., 2006; Taylor, Seminowicz, & Davis, 2009). In line with this notion, in Chapter 7 I focus on whether changes in resting state activity after participants performed perceptual matching with in- and out-group stimuli were correlated with in-group bias in behavioral performance. Here, I assessed whether behavioral performance was reflected in changes in resting state activity in brain regions associated with processing emotions. Furthermore, by comparing resting state activity before and after the in- and out-group matching task, I evaluated changes in underlying functional activity controlling for between-individual differences at baseline. The changes in resting state activity were then correlated against the strength of in-group biases in perceptual matching, showing a link between neural activity and enhanced in-group perception.

In Chapter 8 I used data from a task-based fMRI study based on the same procedure that I presented in Chapter 2, and I explored the neural correlates of in-group biases in perceptual matching. I further investigated whether performance in the matching task is mediated by the magnitude of neural activity in brain areas such as mPFC, pSTS and insula that have previously been associated with aspects of emotional and social relevance (Aichhorn et al., 2009; Gill, Sarter, & Givens, 2000; Molenberghs & Morrison, 2012).Taken together these two chapters provide a better understanding of the neural underpinnings of in-group biases in perception.

Overall, this thesis provides a multi-method approach to studying in-group biases using different techniques across seven experimental chapters. Taking different approaches, throughout seven experimental chapters, I aimed to gain a better understanding of the perceptual foundations of in-group biases. In the final chapter, I discuss the overall findings of the thesis and integrate the results of my studies with the current literature, after which I draw some main conclusions and discuss some limitations.

Chapter 2

In-group modulation of perceptual matching

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Abstract

I report a novel effect of in-group bias on a task requiring simple perceptual matching of stimuli. Football fans were instructed to associate the badges of their favourite football team (in-group), a rival team (out-group) and neutral teams with simple geometric shapes. Responses to matching in-group stimuli were more efficient and discriminability was enhanced compared to out-group stimuli (rival and neutral) - a result occurring even when participants responded only to the (equally familiar) geometric shapes. Across individuals the in-group bias on shape matching was correlated with measures of group satisfaction and similar results were found both when football fans performed the task in the context of the football ground and in a laboratory setting. There were also effects of in-group bias on the response criteria in some but not all experiments. In control studies the advantage for in-group stimuli was not found in an independent sample of participants who were not football fans. This indicates that there was not an intrinsic advantage for the stimuli that were 'in-group' for football fans. Also performance did not differ for familiar versus unfamiliar stimuli without in-group associations. These findings indicate that group identification can affect simple shape matching.

Keywords: cognitive bias, in-group, out-group, football fans

Introduction

Imagine standing in the front row of a stadium watching a match between your favourite and a rival football team. Suddenly the referee whistles to stop play, indicating that a player from your favourite team handled the ball. You, on the other hand, are convinced that the ball struck the player's shoulder. Could this difference of opinion simply reflect a cognitive bias to favour your team, or could it reflect a difference in how you 'see' the action, perhaps because you have 'biased' perception of your player's actions? Does in-group identification affect basic perception?

Many accounts stress that perception is a bottom-up process, driven by the properties of stimuli computed in primary visual cortices and fed-forward to subsequent recognition processes (e.g., Marr, 1982). However there is considerable evidence for perceptual processes, and their associated neural substrates, being affected by top-down knowledge and expectations about stimuli (Chelazzi et al., 1993; Kastner & Ungerleider, 2000), consistent with the view of perception as a predictive process (Spratling, 2008). Furthermore, perception in the real world does not occur in isolation but in particular social contexts. The effects of stored knowledge on perception then may extend beyond cognitive factors to include effects of social context and even factors such as group identification – for example generating enhanced perception to stimuli associated with an in-group. This was investigated here in the context of a simple perceptual matching task with neutral stimuli associated with 'in' or 'out' groups based on associations to rival football teams.

There is much research indicating that being a member of a group is commonly accompanied by categorizing the 'self' and the 'others' into in- and out-groups (Amodio, 2008; Tajfel, 1982). This group identification affects how strongly people empathize with others when they watch simple actions (Molenberghs et al., 2012;

Mathur et al., 2010) and it can modulate implicit association judgments (e.g., in the Implicit Associative Test (IAT); Amodio, 2008; Greenwald, McGhee, & Schwartz, 1998). There are also effects on putatively perceptual tasks. For example, previous studies suggest that group identification can modulate face processing. In the well-known 'own race effect', individuals show enhanced memory and identification for faces belonging to their own racial group relative to faces belonging to other races (e.g., Brigham et al., 2007). The enhanced performance can be linked to the greater processing of the configural properties of own race faces (e.g., based on the spatial relations between different facial features) (Michel, Corneille, & Rossion, 2007, 2010). The magnitude of this effect can vary with our experience with faces from other races with the own-race bias reducing as experience increases with other race faces (Brigham & Malpass, 1985). However there is also evidence that biases can be set-up 'on the fly', based on in- and out-group coding. For example, there is greater configural coding if other race faces are categorized as belonging to the observer's own university group (Cassidy, Quinn & Humphreys, 2011; Hugenberg, & Sacco, 2008). These data suggest that perception can undergo rapid modulation depending on whether participants are motivated to classify individuals as in- or out-group members.

Although there is evidence that group identification can affect perception we still have little knowledge about the extent of such effects. Can such effects be found with stimuli that are much simpler than faces and can they be established even for previously neutral stimuli which have newly-formed associations to in- or out-group categories? Effects of social context on simple shape matching have recently been explored using novel associative learning procedures. Sui, He and Humphreys (2012) had participants associate neutral geometric shapes with a label relating either to themselves (e.g., 'you' - circle), a friend ('friend'-square) or a stranger ('stranger'-

triangle). Participants were then presented with shape-label pairs with the task being to decide whether the pairs match (you-circle, friend-square) or mismatch (you-square, friend-circle). Responses to matching self-related stimuli were faster and showed higher perceptual sensitivity than responses to other people. The data suggest that social categorization can moderate the perceptual processing of simple shapes.

Our research used the associative learning procedure of Sui et al. (2012) to evaluate whether in-group identification affects matching performance for previously neutral shapes. Group identification was manipulated in a real-world context by testing football supporters. Rather than associating a geometric shape with a label (Sui et al., 2012) I had supporters associate a shape with the badge of the football club they supported or a rival team or a neutral team without strong linkage to the favourite team. I asked whether there was enhanced matching of the shape linked to the badge of the favourite team measured in terms of response time, perceptual sensitivity (d prime) and the response criterion. In addition, I went beyond prior studies on the self (Sui et al., 2012) by examining associative matching to a rival team. In this case I asked whether there might be poorer matching for such stimuli, when compared with neutral 'baseline' associations, perhaps due to suppression of any association to a competing group.

I report 5 experiments. Experiment 1 used simultaneous shape-badge matching. Experiment 2 employed sequential matching, where participants responded to the shape alone, after it had been preceded by the badge. As participants respond directly to the shape in the sequential condition, advantages for in-group stimuli are then unlikely to be due to differences in the familiarity of the stimuli to which the response is initiated. These experiments were conducted in the field just before the football matches took place at a venue close to the home ground that was frequented by football supporters (a local hotel). Experiments 3a and 3b replicated the results but in this case the football

supporters were brought into the laboratory to assess if the biases observed in Experiments 1 and 2 were stable and did not depend on the heightened context of a match that was about to be played.

For all the experiments involving football fans (Experiments 1-3) I also measured in-group identification based on a multicomponent social identity questionnaire (Leach et al., 2008). I hypothesized that in-group bias would be related to the degree of in-group identification of individual participants, based on their satisfaction on being a member of the group. Experiments 4 and 5 were control studies. In Experiment 4 I recruited participants who were not football fans and who expressed no preferences for the badge of one football team over another. If the in-group advantage reflects intrinsic attributes of the in-group badge (e.g., its colour and shape) which facilitate its bottom-up processing across all participants, then the in-group bias should occur here too. On the other hand, if an in-group advantage reflects group identification on the part of participants then the advantage should only be found with supporters and not with non-supporters. Experiment 5 tested whether variations in stimulus familiarity affect perceptual matching. Here I selected stimuli not linked to group membership but which varied more widely in their rated familiarity than the team badges used in the other experiments (I used images of animals which were rated outside the experiment as being familiar or unfamiliar by an independent group of participants). If the in-group bias was related to the own team badge simply being more familiar, an advantage should emerge for associative shape matching for familiar relative to unfamiliar animals. However, if group identification is critical, then participants should not show any preference for matching the familiar compared to the unfamiliar animals here.

Experiment 1: Simultaneous badge-shape matching

Method

Participants

Twenty-two football fans took part. Five participants were excluded due to having low levels of accuracy (accuracy rate < .30 in more than one condition). The participants were all male (mean (SD) age = 33 years ± 10) and had been fans of the local professional football club (Oxford United) for at least 5 years. All were right handed with normal or corrected-to-normal vision. The participants were recruited in the lounge of a hotel adjacent to the Oxford United football stadium two hours before a match. Before running the experiment, a written consent form approved by the University of Oxford research ethics committee was completed by all participants.

Stimuli

Four geometric shapes (circle, hexagon, square, and triangle) were presented with each shape paired with a badge for four different football teams. The teams were the participant's favourite football team (the in-group: Oxford United), the closest rival team (the out-group: Swindon Town), and two neutral teams (which participants neither liked nor disliked, Everton and Birmingham City). Participants were asked to associate each shape with one of the badges of the different clubs. The associations between the shapes and the badges were counterbalanced across participants. Each shape and badge (160×160 pixels, corresponding to 4.5 × 6.5 degree of visual angle) was presented randomly at approximately 4˚ above or below the fixation cross (1˚ x 1˚) at the center of the screen on a white background and the stimuli were viewed from approximately 50 cm. from the screen. The stimuli were displayed on a 14-inch monitor (1324 × 768), and the experiment was run on a Laptop using E-prime software (Version 2.0).

Procedure

In an initial block of 40 trials (10 for each badge-shape pair) participants were trained to associate the four shapes to (respectively) the badges of their own favourite team (Oxford United; yellow and blue badge), the local rival team (Swindon Town; red and white badge), and two neutral teams (Everton, Birmingham City; both blue and white badges). After this, there was a short practice block (20 trials) and then 240 experimental trials, half of which were 'correct matches' (the badge and shape as originally paired) and half were mismatches (the badge and shape re-paired). Each trial began with a fixation cross for 500 ms. followed by the simultaneous presentation of a badge and shape, one above and one below the fixation cross (randomly chosen) for 600 ms. Participants judged whether the badge and shape were a pair as originally shown or whether they had been re-paired. The pair appeared on the screen at various intervals between 1000 and 2000 ms. after fixation and there was a response time limit of 1500 ms. Participants responded by pressing the N and M keys using their preferred hand. Key assignment for matching and mismatching trials was counterbalanced across participants. Feedback for each trial was given during the practice but not on the actual test; however, the performance in the practice block was not included in the final analyses. Figure 1 shows a schematic representation of the task in Experiment 1.

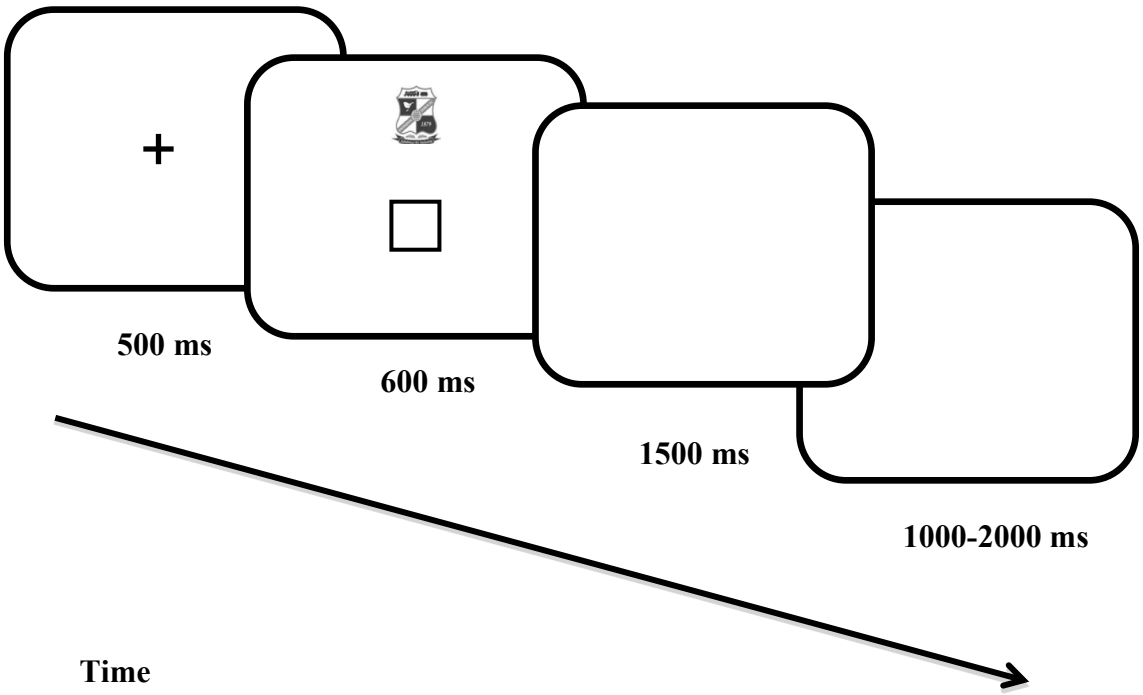


Figure 1. Example task in Experiment 1(simultaneous presentation). The original background was fifty percent grey, and the badge was red and white (representing Swindon Town football club).

Before the experiment participants were asked to complete a 'badge familiarity' survey. In this survey participants rated the level of familiarity of the badge of 16 different football clubs including their favourite team and the traditional rival team from 1 (*not familiar*) to 7 (*perfectly familiar*). Moreover to measure explicit prejudice, participants also marked on a visual analogue scale how they felt about each of 16 clubs from 1 (*Like*) to 7 (*Dislike*) (for more details on the badges please refer to the appendices). To understand the extent of each fan's experienced link to their team, I adapted a multicomponent social identity questionnaire, which measures relatively stable levels of 'belongingness' to relevant social categories (Leach et al., 2008). I also asked participants how many games per season they typically attended games and

which team they thought was the main rival to their own. For all experiments, the adequate sample size to produce the power of .80 was estimated in a pilot study. Based on the differences between the mean of the conditions, the minimum sample size of sixteen participants yielded power of .80 (see for example, Murphy, Myors & Wolach, 2009).

Results

All the participants classed Swindon Town as their rival team (to their team, Oxford United) and all classed Everton and Birmingham City as neutral teams. The mean (SD) familiarity ratings were: in-group = 6.88 (±.33), rival = 6.64 (±.42), neutral 1= 5.82 (±.39), neutral 2=5.64 (±.49) .These ratings differed across the teams, $F(3,48)= 42.86$, $p < .001$, $\eta 2 = .728$; this was due to the neutral teams being rated as less familiar compared to the rival, $t(16) = 6.42$, $d= 1.55$, $t(16) = 6.73$, $d = 1.63$ (respectively for neutral 1 and neutral 2) and the in-group, $t(16) = 10.18$, $d = 2.46$, $t(16) = 9.05$, $d= 2.19$, $ps < .001$. However, there were no differences between the two neutral teams, $t(16) = 1.37$, $p < .188$, or between the rival and the in-group teams, $t(16) = 1.72$, $p < .188$. The mean (SD) disliking ratings were: rival = 5.90 (±1.30), neutral 1= 4.50 (±1.50), neutral 2 = 4.45 (±1.50). These ratings differed across the teams, $F(2,32) = 49.70$, $p < .001$, $\eta 2 = .756$, with the rival team being rated as more disliked than the neutral teams, $t(16) = 7.10$, $p < .001$, $d = .98$, $t(16) = 7.32$, $p < .001$, $d = 1.02$ *(respectively for neutral 1 and neutral 2)* which did not differ from one another, $t(16) = 1$, $p < .332$ (see Lakens, 2013 for calculation of effect size for correlated samples). On average participants attended 30 matches per year. The mean (SD) score for the subcomponents of the in-group identification questionnaire were solidarity = 18.50 (±2.10, max 21), satisfaction = 25

(±2.60, max 28), centrality = 17.50 (±2.60, max 21), in-group homogeneity = 10 (±2.70, max 14) and self-stereotyping =10 (±2.30, max 14).

For each participant correct responses shorter than 150 ms. or longer than 1000 ms. (corresponding to approximately ± 3 SD from the mean) were excluded. This resulted in rejecting 5% of the whole data. The analysis was performed on the remaining trials.

For each participant d prime was calculated as a measure of sensitivity for discriminating match and mismatch trials across the different association categories. d prime was derived using the Green and Swets (1966) formula, taking the data for mismatch trials based on the badge that was presented.

$$d' = z(H) - z(F)$$

In addition, the response criterion (C) was calculated using the formula (Macmillan, 1993):

$$C = -\tfrac{1}{2}\,[z\,(H) + z\,(F)]$$

RTs

I used 2 × 3 ANOVAs on the RTs with two within subject variables, match condition (match, mismatch) and team (in-group, rival, neutral1, and neutral2). Since the two neutral teams did not differ on measures of RT (means = 627 and 624 ms.), $t(16) = 1.74$, $p > .05$, the data were averaged across the two neutral teams[1].

The analysis for the RT data showed a significant main effect of match, $F(1, 16) = 59.74$, $p < .001$, $\eta 2 = .789$. Pairwise comparisons revealed that participants were in general faster on match trials compare to mismatch trials, $p < .001$. There was no

[1] This procedure allowed us to maintain consistent analyses across the experiments and subsequently to combine the data in an across-experimental analysis.

significant main effect of team on RT, $F(2, 32) = 2.43$, $p > .05$, $\eta 2 = .132$. However, the interaction between the match condition and the team was significant, $F(2, 32) = 12.02$, $p < .001$, $\eta 2 = .429$.

To decompose the interaction post hoc comparisons were conducted separately on match and mismatch trials. On match trials participants were quicker to respond to in-group stimuli compared to stimuli linked to the rival team, $t(16) = 2.74$, $p < .02$, $d = .54$, and the neutral team, $t(16) = 3.83$, $p < .001$, $d = .89$. The rival and neutral teams did not differ, $t(16) = 1.63$, $p < .12$. On mismatch trials, participants were significantly slower to stimuli with both in-group and rival badges compared to stimuli when the neutral team badge was present, $t(16) = 3.29$, $p < .005$, $d = .38$.

D prime and response criterion

The d prime scores did not differ between the two neutral teams (mean = .66, .63), $t(16) = 1.77$, $p > .05$, and therefore the data were averaged across two neutral teams for the subsequent analyses. Analysis of the d prime data revealed that there was a significant main effect of team, $F(2, 32) = 24.05$, $p < .001$, $\eta 2 = .600$. Pairwise comparisons showed that d prime was larger for the in-group team compared to other teams, $ps < .001$.

Analyses of the response criterion also revealed a significant main effect of the team, $F(2, 32) = 34.18$, $p < .001$, $\eta 2 = .681$. Pairwise comparisons showed that the criterion for the in-group was significantly lower than that for the other teams, $ps < .001$, which did not significantly differ ($ps > 0.05$).

The mean RTs on match and mismatch trials, along with the mean d prime values for each team, are shown in Figures 2a & 2b.

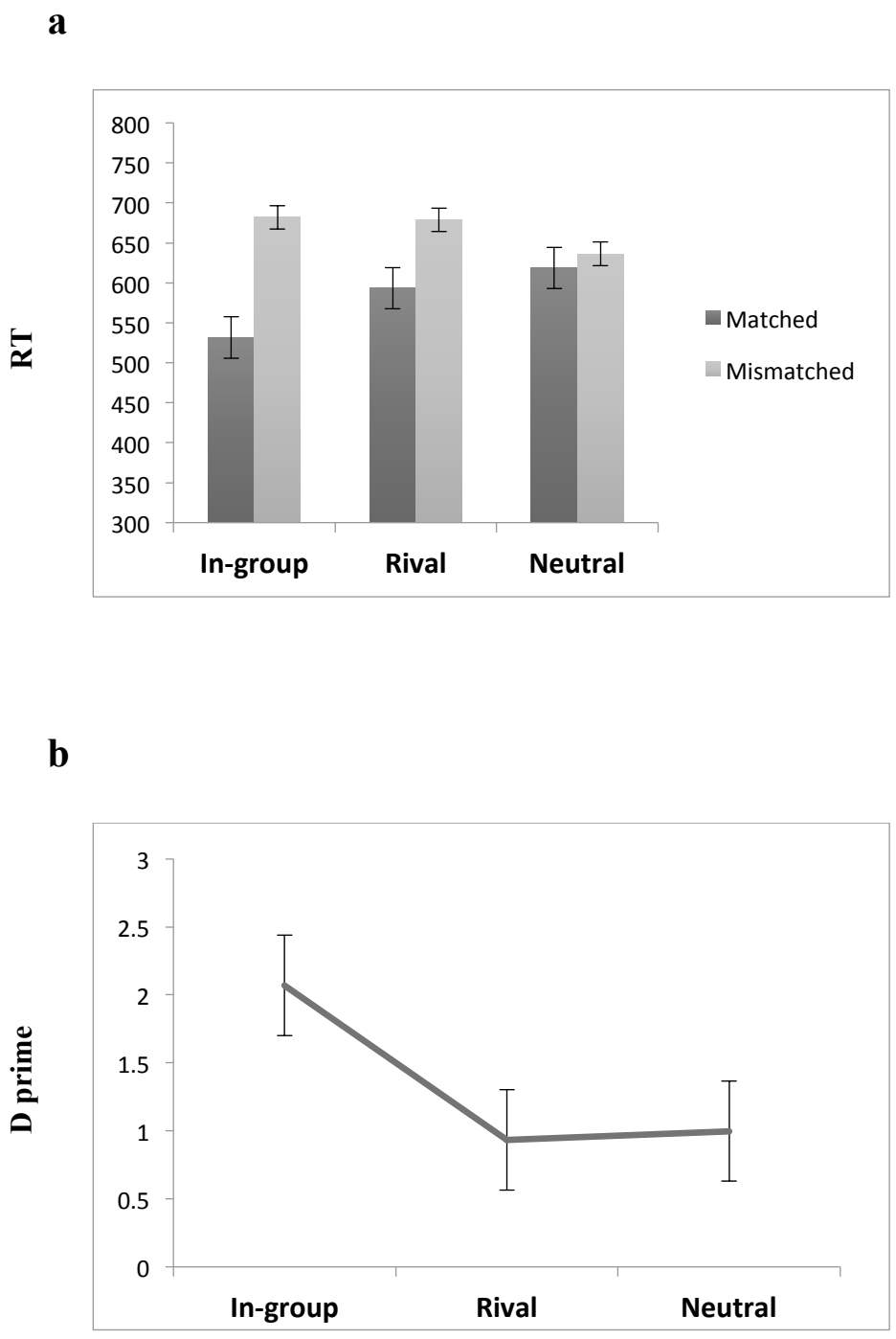


Figure 2. Behavioural performance in Experiment 1. (a) Mean correct RTs (in milliseconds) for match and mismatch trials (in milliseconds). **(b)** All d prime values for each team in Experiment 1. Error bars represent standard error.

The mean accuracy and RTs for the match and mismatch trials in Experiment 1 are presented in Table 1. The mean d prime and criterion values are presented in Table 2.

Table 1

Mean correct RTs (SD in brackets) and proportion correct responses (SD in brackets) in Experiment 1.

Matching condition	Group	RT	Accuracy
Match	In-group	531(104)	.91(.09)
	Rival	593(120)	.61(.15)
	Neutral 1	627(110)	.61(.14)
	Neutral 2	624(111)	.60(.12)
Mismatch	In-group	682(119)	.67(.13)
	Rival	678(139)	.71(.13)
	Neutral 1	636(121)	.73(.16)
	Neutral 2	635(120)	.72 (.15)

Table 2

Mean d prime and response criterion results for each experiment.

Experiment	Condition	d prime	Criterion
Exp.1 (simultaneous)	In-group	2.07	-.54
	Rival	.93	.15
	Neutral	.99	.20
Exp.2 (sequential)	In-group	2.23	-.67
	Rival	1.17	-.27
	Neutral	1.28	-.56
Exp.3a (simultaneous)	In-group	2.78	-.4
	Rival	1.74	.00
	Neutral	1.85	-.13
Exp.3b (sequential)	In-group	3.03	-.27
	Rival	1.80	.00
	Neutral	2.13	.03
Exp.4 (control 1)	In-group	3.00	-.04
	Rival	2.80	.01
	Neutral	3.13	.06
Exp.5 (control 2)	Familiar (Cow)	2.54	-.04
	Unfamiliar 1 (Donkey)	2.27	-.11
	Unfamiliar 2(Camel)	2.27	.09
	Unfamiliar 3 (Zebra)	2.39	-.01

Discussion

The data indicate that there was a benefit on RTs and sensitivity (d prime) for matching the in-group badge with a shape, compared to conditions where the rival team badge was match to a shape and where the badge was for a neutral team. This extends prior results where shapes had to be matched with self or 'other' labels (Sui et al., 2012), showing effects above the level of individual association. In addition to this, the rival team did not differ from the neutral teams. This last result suggests that the in-group advantage was not tied to suppression of the rival group.In addition, there was evidence that a lower response criterion was adopted for the in-group compared with the other teams. Given that d prime and the response criterion are independent (Macmillan, 1993), the data suggest that in-group association may affect more than one stage of processing – on the one hand , modulating perceptual processing (perceptual sensitivity) but on the other also affecting the response threshold so that it is set lower to accept a match between the badge and a shape for the in-group compared with the other teams. I will return to discuss this after presenting the data from the other studies.

Experiment 2: Sequential badge-shape matches

Experiment 2 replicated Experiment 1 with two changes. The main change was that the badge preceded the shape to which participants responded, so that differences based on the familiarity of the stimulus that participants respond to should not modulate performance (participants never respond to the badge but only to the associated shape). Secondly, I used one rather than two neutral stimuli. In Experiment 1 there were few differences between responses to the neutral teams; reducing the number of neutral teams made the association task easier to learn and reduced the numbers of trials to make field testing easier.

Method

Unless otherwise mentioned, the Method was the same as that in Experiment 1.

Participants

Seventeen fans of the local professional football team (mean age (SD) = 35 ±9.50 years) participated, all male. All other selection criteria were identical to those in Experiment 1.

Stimuli and Procedure

The stimulus and procedure were identical to Experiment 1, except that here I only included one neutral team (Everton) and the procedure on each trial involved first presenting the badge for 300 ms. and then at the offset of the badge, the shape (which match or mismatch the badge) for 300 ms. No participants had any difficulty identifying the badges at the presentation duration used. Responses were timed from the onset of the shape. Figure 3 shows a schematic representation of the task.

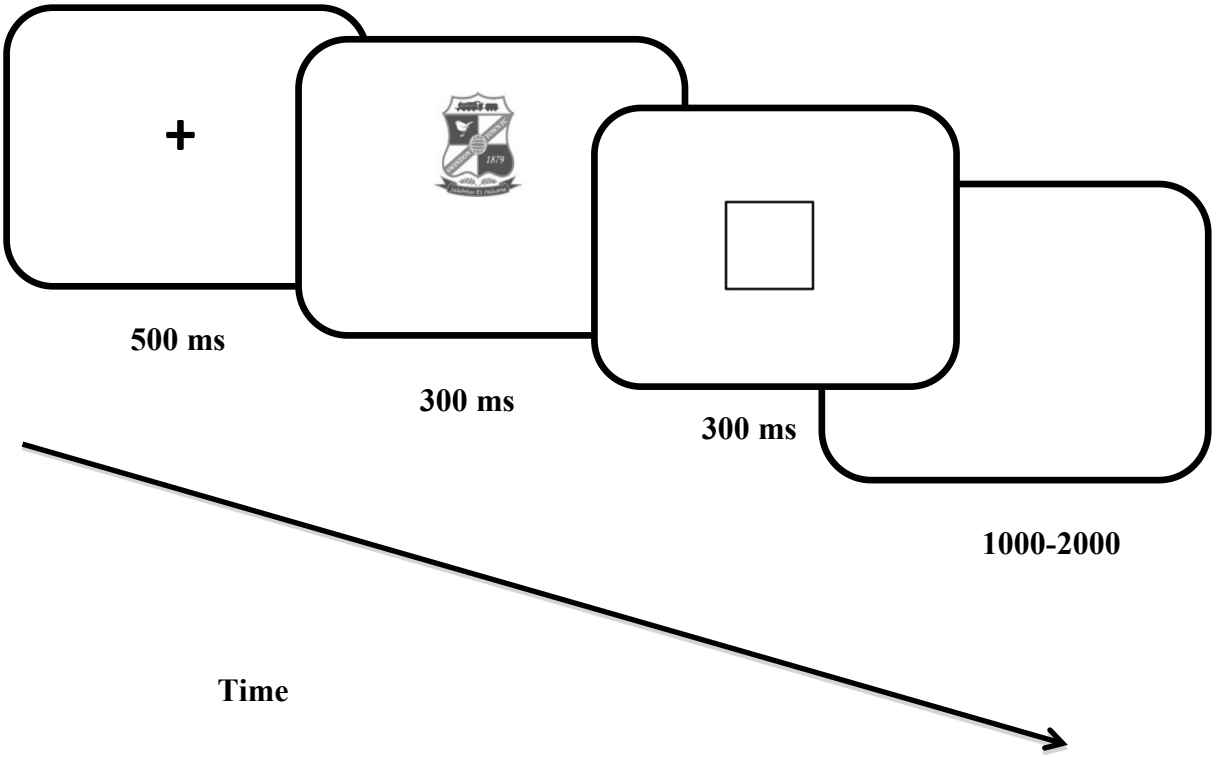


Figure 3. Example trial in Experiment 2 (sequential presentation). The original background colour was grey and the badge was red and white (Swindon Town).

Results

The mean (SD) familiarity ratings were: in-group = 6.9 (±.36), rival = 6.60 (±.40), neutral = 5.80 (±.42). These ratings differed across the teams, F (2,32) = 37.02, $p < .001$, $\eta 2 = .698$; this was due to the neutral team being rated as less familiar compared to the in-group, $t(16) = 8.24$, $d = 1.99$, and rival teams, $t(16) = 5.89$, $ps < .001$, $d = 1.42$. However the familiarity ratings did not differ for in-group and rival stimuli, $t(16) = .56$, $p < .58$.

The mean (SD) disliking ratings were: rival = 5.20 (±1.20) and neutral = 4.10(±1.30). These ratings differed, $t(16) = 3.95$, $p < .001$, $d = .95$, with the rival team being rated as more disliked than the neutral team. On average participants attended 32 matches per year. The mean (SD) score for the subcomponents of the in-group identification were: solidarity = 19 (±2.00, max. 21), satisfaction = 25 (±2.10, max. 28), centrality = 17.5 (±1.80, max. 21), in-group homogeneity = 11 (±1.90, max. 14), self-stereotyping =11 (±2.10, max. 14).

RTs

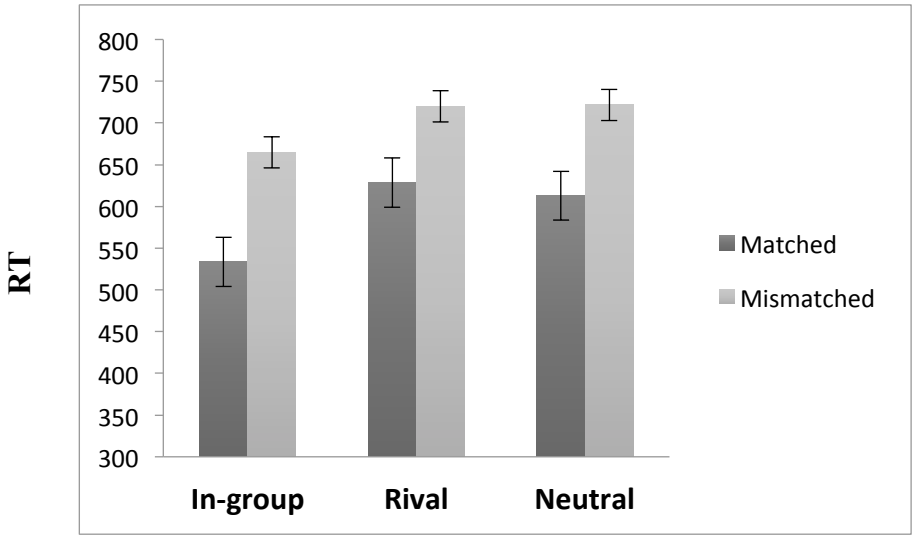
For each participant correct responses shorter than 150 ms. or longer than 1000 ms. (corresponding to approximately ± 3 SD from the mean) were excluded. This resulted in rejecting 2% of the whole data. The analysis was performed on the remaining trials.

A 2 × 3 ANOVA was conducted on the RTs with two within subject variables, match condition (match, mismatch) and team (in-group, rival and neutral). There was a significant main effect of the match condition, $F(1, 16) = 19.71$, $p < .001$, $\eta 2 = .552$. Participants were significantly faster on match trials compared to mismatch trials, $p < .001$. There was also a significant main effect of team, $F(2, 32) = 24.27$, $p < .001$, $\eta 2 = .603$. Pairwise comparisons showed that participants were significantly faster for their in-group team compared to both the rival and neutral teams, $ps < .001$. RTs to the rival and neutral teams did not differ. The interaction between match condition and team was not significant, $p > .05$.

D prime and response criterion

The analysis of the d prime data showed a reliable main effect of team, $F(2, 32) = 15.44$, $p < .001$, $\eta 2 = .491$. Pairwise comparisons showed that d prime was significantly larger for the in-group team compared to both the neutral and rival teams *(ps* < .001*),* which did not differ. Analyses of the response criteria also showed that there was a significant main effect of team, $F(2, 32) = 11.69$, $p < .001$, $\eta 2 = .42$. Pairwise comparisons showed that the response criterion for both the in-group ($p <$ .001) and the neutral team ($p < .006$) differed significantly from that of rival team. The in-group and neutral teams did not differ ($p > .05$). The mean RTs on match and mismatch trials and d prime values for each team in Experiment 2 are shown in Figures 4a & 4b. The mean accuracy and RTs for the match and mismatch trials in Experiment 2 are presented in Table 3.

a



b

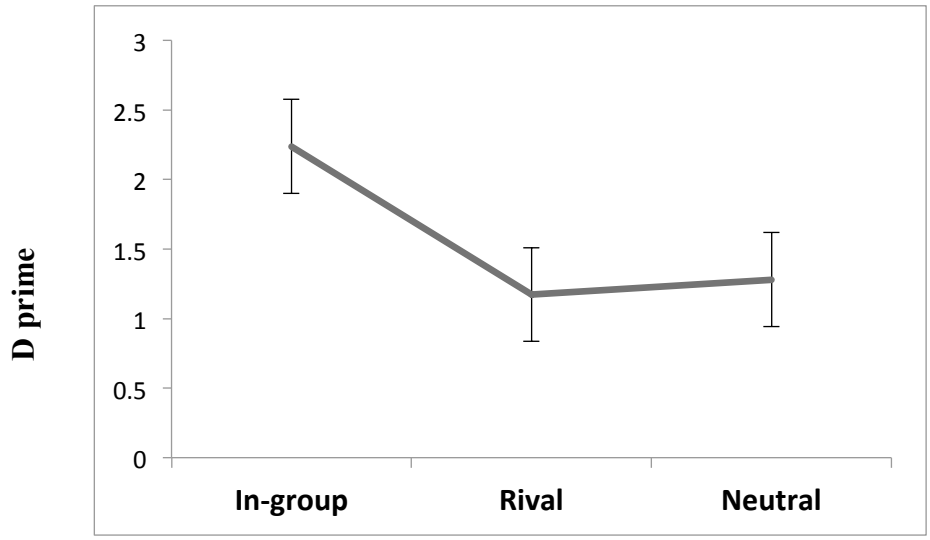


Figure 4. Behavioural performance in Experiment 2. (a) Mean correct RTs (in milliseconds) for match and mismatch trials (in milliseconds). **(b)** All d prime values for each team in Experiment 2. Error bars represent standard error.

Table 3

Mean correct RTs (SD in brackets) and proportion correct responses (SD in brackets) in Experiment 2.

Matching condition	Group	RT	Accuracy
Match	In-group	533(118)	.95(.04)
	Rival	628(117)	.80(.06)
	Neutral	612(124)	.85(.10)
Mismatch	In-group	664(99)	.64(.16)
	Rival	719(85)	.60(.15)
	Neutral	721(105)	.52(.22)

Discussion

Experiment 2 replicated Experiment 1 and confirmed that there is a benefit for matching in-group stimuli compared with stimuli associated to neutral and rival teams. This result occurred on both RTs and perceptual sensitivity, consistent with in-group identification enhancing perception. As in Experiment 1, there was no evidence for suppression of the rival team. The response criterion for accepting in-group matches was again set lower for in-group compared with the rival team but in this case the in-group did not differ from the neutral team. This confirms that the d prime effects are not linked to the response criteria and that the in-group advantage (relative to the neutral team) does not necessarily stem from a shift in response bias, though there may be some bias when the in-group badge and shape are presented simultaneously (Experiment 1). On the other hand, the data do indicate that the response criterion can be conservative for the rival team. Interestingly, this had little impact on match RTs (which did not differ for the neutral and rival teams).

One other change, under sequential compared with simultaneous presentation conditions (in Experiment 2 vs. Experiment 1) was that the benefit for the in-group here was found on mismatching as well as on matching trials. When there is a positive response bias to the in-group stimuli (in Experiment 1, compared with the neutral team), there may be a disruptive effect on mismatching responses involving the in-group badge. Here, there was no differential response bias for the in-group relative to the neutral stimuli and responses to mismatching stimuli paired with the in-group badge were speeded rather than slowed. After Experiment 3 I review how strongly these conclusions hold.

The results with sequential presentation are interesting in that differences due to the familiarity of the badge should not modulate performance, since participants never

responded to the badge here. This is also suggested by the pattern of the results. In both Experiments 1 and 2 the in-group and rival badges were rated as more familiar than the neutral badges, though the in-group and rival ratings did not differ. In contrast, RT for the in-group condition differed from the rival and neutral conditions. The data indicate that the results are unlikely to reflect some linear relation between stimulus familiarity and RT. In addition, the familiarity of the association between the badge and these shapes cannot be critical, since all the associations were novel (between a badge and a neutral shape) and the shapes were counter-balanced across participants; any association would not be differentially familiar for the in-group compared to the other teams. It is not the familiarity of the association itself that is critical but more that the association to the in-group, newly established, exerting a strong effect on matching performance. I examined this again in Experiment 5 where rather than trying to eliminate the effects of familiarity (as here by using sequential presentations), I manipulated effects of familiarity to test if this factor alone can generate the bias effects I observe.

Experiments 3a and 3b: Tests in a laboratory setting

Experiments 3a (simultaneous presentations) and 3b (sequential presentations) set out to replicate Experiments 1 and 2 but data here were collected with football supporters in a laboratory setting rather than in the field. Can similar effects be established outside of the social context of the football ground and match, which might be expected to heighten in-group biases? The experiments were run within-subjects to enable direct comparisons to be made between the different presentation modes (simultaneous vs. sequential).

Method

Participants

Sixteen male fans of Oxford United (mean (SD) age =35 years ± 7 years) took part.

Stimuli and Procedure

For Experiment 3a, the stimuli and the procedure were identical to Experiment 1 except that I used only one neutral team. Similarly to Experiment 1 the badge and the shape were presented simultaneously. For Experiment 3b, the stimuli and the procedure were identical to Experiment 2 and as before the badge and the shape were presented sequentially. The same participants took part in Experiments 3a and 3b and the order of presentation was counterbalanced between the participants with a one-hour gap between two experiments. The same shape-badge assignments were used in both experiments.

Results

The mean (SD) familiarity ratings were: in-group = 6.60 (±.50), rival = 6.30 (±.34), neutral= 5.90 (±.33). These ratings differed across the teams, $F(2,30) = 11.12$, $p < .001$, $\eta 2 = .426$, with the neutral team being rated as less familiar than the in-group, $t(15) = 5.19$, $p < .001$, $d = 1.29$. However the familiarity rating did not differ for the in-group and rival teams, $t(15) = 2.07$, $p > .05$.

The mean (SD) disliking ratings were: rival = 5.70 (±1.30), neutral =3.80 (±1.20). These ratings differed across the teams, $t(15) = 5.00$, $p < .001$, $d = 1.25$, with the rival team being rated as more disliked than the neutral team. On average participants attended 21 matches per year. The mean (SD) score for the subcomponents of the in-group identification questionnaire were: solidarity = 17.50 (±1.90, max. 21),

satisfaction = 24 (±2.10, max 28), centrality = 16.70 (±2.20, max. 21), in-group homogeneity = 10 (±1.70, max 14), self-stereotyping =10 (±1.50, max. 14).

RTs

For each participant correct responses shorter than 150 ms. or longer than 1000 ms. (corresponding to approximately ± 3 SD from the mean) were excluded. This resulted in rejecting 2% of the whole data. The analysis was performed on the remaining trials.

A 2 × 3× 2 ANOVA was conducted on the RTs with three within-subject variables: match condition (match vs. mismatch), team (in-group, rival and neutral) and viewing mode (simultaneous vs. sequential – Experiment 3a vs. Experiment 3b). There was a significant effect of match condition, $F(1,15) = 37.92$, $p < .001$, $\eta 2 = .717$. Across the two experiments participants were significantly faster to respond to the match compared to the mismatch trials ($p < .001$). The effect of viewing mode was also significant, $F(1,15) = 7.98$, $p < .013$, $\eta 2 = .347$. In general, participants were faster in the sequential viewing mode than the simultaneous mode ($p < .05$). This effect was not dependent on the order of the experiments and did not interact with order when this was included as a factor. There was a significant main effect of team, $F(2, 30) = 36.62$, $p < .001$, $\eta 2 = .709$, and a reliable interaction between team and viewing mode, $F(2, 30) = 3.87$, $p < .032$, $\eta 2 = .205$. The interaction was decomposed using post hoc comparisons for the sequential and simultaneous experiments. RTs to the in-group were faster than to the neutral and rival groups both when the stimuli were presented simultaneously ($t(15) = 4.60$, $p < .001$, $d = 1.15$, $t(15) = 6.34$, $p < .001$, $d = 1.58$ respectively) and when they were presented sequentially ($t(15) = 3.80$, $p < .002$, $d = .95$, $t(15) = 4.9$, $p < .001$, $d = 1.22$, respectively). The neutral and rival team did not differ significantly, for either

presentation mode. The interaction arose because the differences between the teams were larger when the stimuli were presented simultaneously, though the effects remained reliable under sequential presentation conditions.

D prime and response criteria

I also tested whether there were effects of viewing mode and team on d prime. There was a main effect of viewing mode, $F(1,15) = 5.18$, $p <. 038$, $\eta 2 =. 257$. Perceptual sensitivity was greater for sequential presentations (Experiment 3b) than for simultaneous presentations (Experiment 3a). There was main effect of the team, $F(2,30) = 110.62$, $p < .001$, $\eta 2 = .871$. Pairwise comparisons showed that d prime was larger for in-group stimuli compared to both rival and neutral stimuli ($ps < .001$). D prime scores for the rival and neutral teams did not differ significantly ($p >.09$). The interaction between viewing mode and team was not significant. Thus there was enhanced sensitivity for in-group over the neutral and rival teams and this was the same magnitude for simultaneous and sequential presentations.

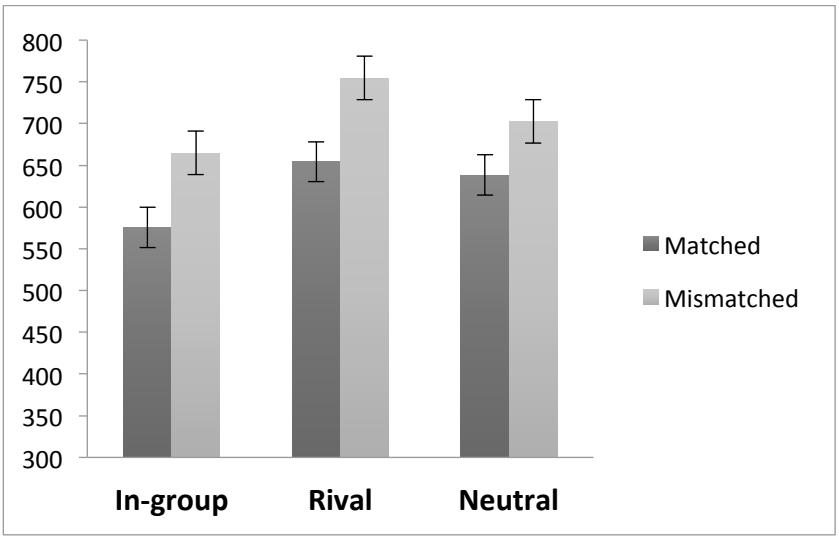
For the criterion data the results showed a significant main effect of viewing mode, $F(1,15) = 5.50$, $p < .033$, $\eta 2 = .269$. The criterion was lower (participants adopted a less conservative criterion) in Experiment 3a (simultaneous presentations) compared with Experiment 3b (sequential presentations). There was also a significant main effect of the team, $F(2,30) = 25.15$, $p < .001$, $\eta 2 = .626$. Pairwise comparisons showed that the response criterion for in-group stimuli was lower compared to the rival and neutral teams, $ps < .001$, which did not differ overall. However, the interaction between viewing mode and team was also significant, $F(2,30) = 3.96$, $p < .03$, $\eta 2 = .209$. The criterion for in-group stimuli was lower than for both the rival and neutral teams, both for simultaneous presentations, $t(15) = 7.60$, $p < .001$, $d = 1.90$, and $t(15)$

=4.47, $p < .001$, $d = 1.11$, vs. the rival and neutral teams; and sequential presentations, $t(15) = 7.28$, $p < .001$, $d = 1.82$, *and,* $t(15) = 3.92$, $p < .001$, $d = .98$, vs. the rival and neutral teams. However, the criterion for neutral and rival teams did not differ in either the sequential or the simultaneous presentation conditions (see Table 6).

To examine the relations between effects of team on the criterion and d prime I correlated the two measures across the experiments. There were no significant correlations for the in-group ($r = .074$, $n = 66$, $p < .57$), rival ($r = .149$, $n = 66$, $p < .235$) or neutral ($r = .147$, $n = 66$, $p < .244$) teams [2]. I also conducted correlation analyses on RTs and accuracy to ensure that the data did not stem from any speed-accuracy trade-offs. There were no correlations: for the in-group ($r = .10$, $n = 66$, $p < .43$), the rival ($r = -.051$, $n = 66$, $p < .68$) or neutral teams ($r = .074$, $n = 66$, $p < .57$). [3]

The mean RTs on match and mismatch trials and the d prime values for each team in Experiment 3a (simultaneous presentation) are shown in Figures 5a & 5b. Figures 6a & 6b show similar data for Experiment 3b (sequential presentation).

a



[2] Note that the total number of 'participants' was 66, reflecting the separate sessions for Experiments 3a and 3b.

[3] This correlation analyses was conducted for match trials across Experiment 1, 2, 3a and b.

b

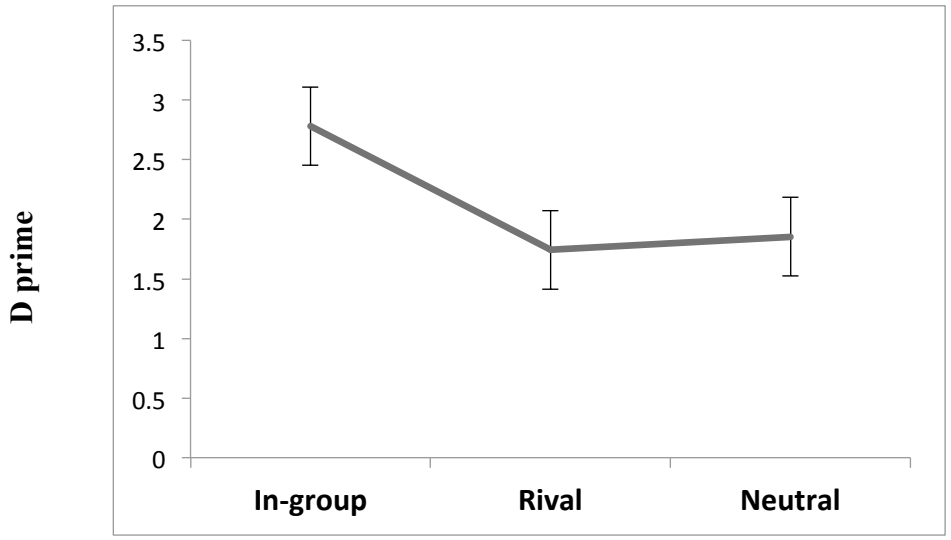
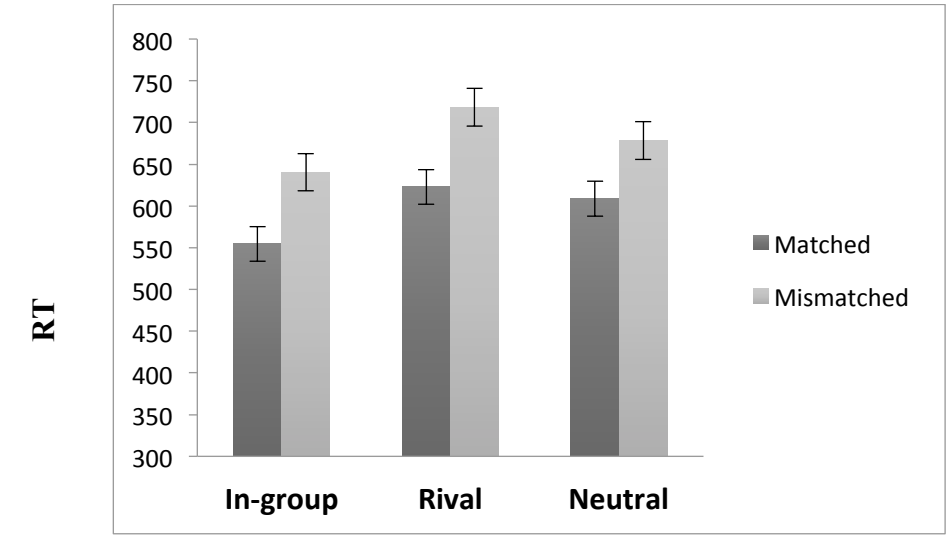


Figure 5. Behavioural performance in Experiment 3a. (a) Mean correct RTs (in milliseconds) for match and mismatch trials (in milliseconds). **(b)** All d prime values for each team in Experiment 3a. Error bars represent standard error.

a



b

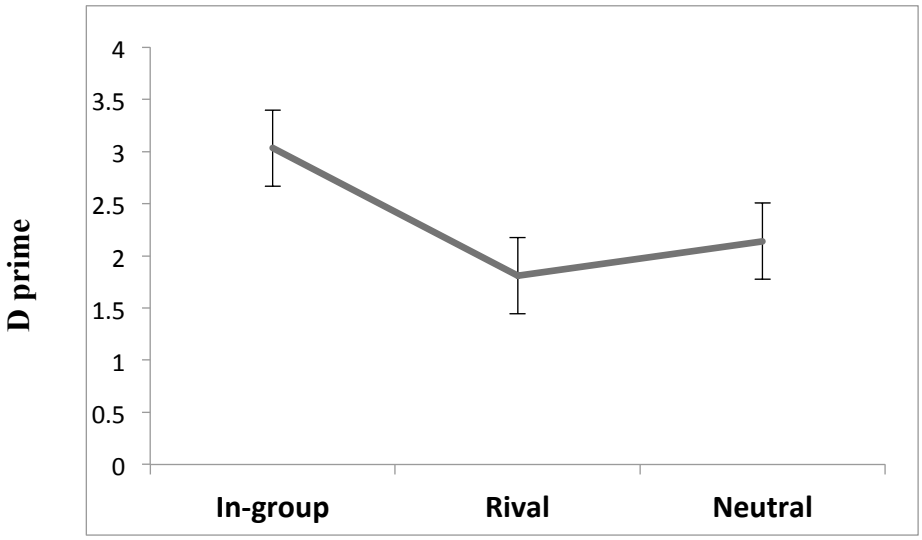


Figure 6. Behavioural performance in Experiment 3b. (a) Mean correct RTs (in milliseconds) for match and mismatch trials (in milliseconds). **(b)** All d prime values for each team in Experiment 3b. Error bars represent standard error.

The mean accuracy and RTs for the match and mismatch trials in Experiment 3a are presented in Table 4. Table 5 presents similar data for Experiment 3b.

Table 4

Mean correct RTs (SD in brackets) and proportion correct responses (SD in brackets) in Experiment 3a.

Matching condition	Group	RT	Accuracy
Match	In-group	575(100)	.95(.05)
	Rival	654(116)	.79(.10)
	Neutral	638(114)	.83(.09)
Mismatch	In-group	664(118)	.82(.07)
	Rival	754(123)	.78(.11)
	Neutral	702(123)	.76(.11)

Table 5
Mean correct RTs (SD in brackets) and proportion correct responses (SD in brackets) in Experiment 3b.

Matching condition	Group	RT	Accuracy
Match	In-group	554(108)	.95(.04)
	Rival	622(131)	.79(.12)
	Neutral	608(130)	.83(.10)
Mismatch	In-group	640(118)	.86(.06)
	Rival	718(133)	.78(.12)
	Neutral	678(137)	.82(.14)

Questionnaire analysis

Our results indicated that across four experiments, performance was enhanced for in-group matches relative to matches to a neutral stimulus. I next investigated how this enhanced performance for the in-group related to scores on the subcomponents of the in-group identification questionnaire. In order to utilize both RTs and accuracy within a single measure, I used Inverse Efficiency (IE) as a single score reflecting both accuracy and reaction time. IE is calculated by dividing response times by proportion correct response rates separately for each condition. IE specifically tries to deal with the issue of combining speed and error into one single score.

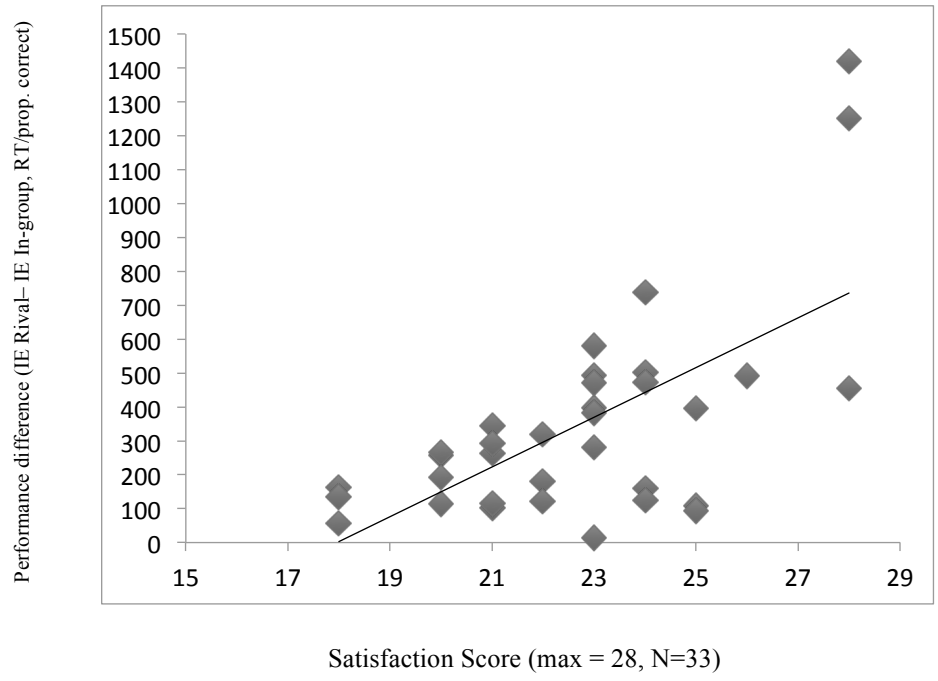
$$IE = \frac{\text{RT}}{\text{PC (Proportion Correct)}}$$

Therefore, IE higher value indicates worse performance (Roder, Kusmierek, Spence, & Schicke, 2007; Townsend & Ashby, 1983). Here, IE was calculated only for match trials. The difference between the IE scores for each participant's own team and the rival team was then used as a measure of "*in-group bias*"[4].

I tested whether indices of in-group bias in the matching task were associated with the Solidarity and Satisfaction and centrality subcomponents of the in-group identification questionnaire. I combined the data across Experiments 1 and 3a (simultaneous presentations) and Experiments 2 and 3b (sequential presentations) to maximize power. For both sets of experiments I found a positive correlation between ratings of satisfaction with the participant's in-group team and the matching advantage for the in-group team compared with the rival team, $r = .653$, $n = 33$, $p < .001$, for Experiments 1 and 3a and $r = .497$, $n = 33$, $p < .003$, for Experiments 2 and 3b. The scatterplots are presented in Figures 7a & 7b (for simultaneous and sequential presentations, respectively).

[4] The contrast was made between the in-group and the rival team here in order to maximise the in-group bias effect whilst equating the stimuli for familiarity (which was match for the in-group and rival teams).

a



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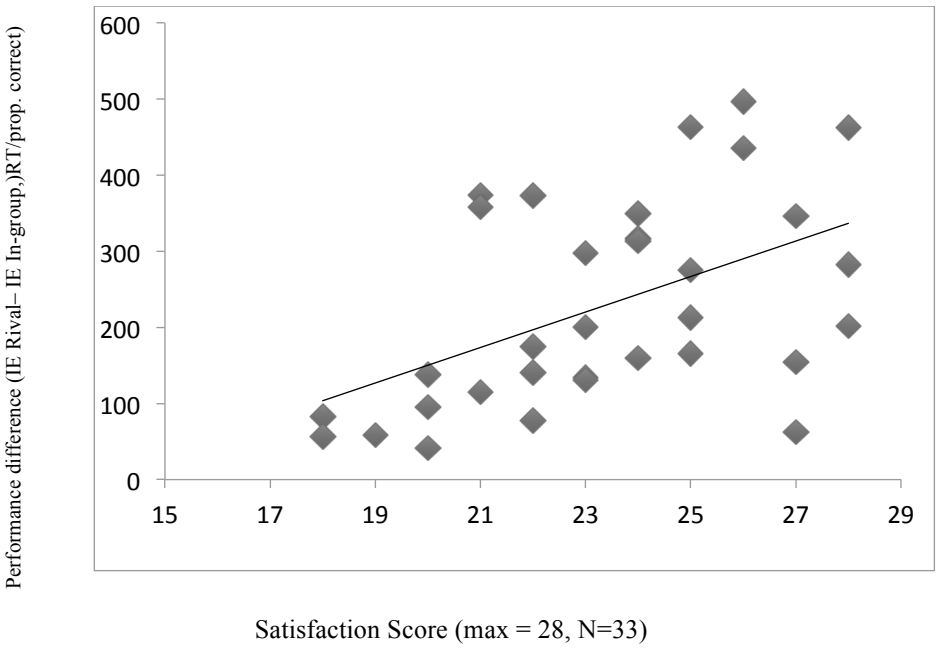


Figure 7. Correlations between in-group satisfaction ratings and the matching advantage for in-group over rival team. (a) Simultaneous presentations (Exps. 1 and 3a pooled) and (b) sequential presentations (Exps. 2 and 3b pooled).

There were no significant correlations between other subcomponents of the in-group identification questionnaire and in-group bias on the matching task. There were no correlations between the in-group bias and the rated familiarity, number of matches attended and the reported disliking rate for the local rival team.

Discussion

The laboratory data (Experiments 3a and 3b) replicated the results collected in the field (Experiments 1 and 2). The data indicate the stability of the results across different experimental contexts and that the in-group advantage is not dependent upon the heightened environment of participants being tested in close temporal proximity to an in-group football match.

As in the earlier experiments, there were some differences between effects with simultaneous and sequential presentations. The in-group advantage was larger for simultaneous over sequential presentations and the response criterion tended to be less conservative for simultaneous exposures. The reduced advantage for sequential presentations can be attributed to the visual complexity of the target displays being reduced (a shape was presented alone under sequential presentation conditions as opposed to the badge and shape appearing together) and to participants being able to use top-down prediction under sequential conditions. Nevertheless the in-group effects were robust across the conditions and present on d prime and not just the response criterion. Unlike Experiment 1 however, the in-group advantage was present on both match and mismatch trials (similarly to Experiment 2). The data suggest that under the conditions of heightened group awareness immediately prior to a football match (in Experiment 1 but not here), mismatch trials linked to both the in-group and rival team

badges were slowed, perhaps reflecting the involvement of some further factor such as arousal. This speculation needs to be tested in future experiments.

Combining the data across experiments, I found that the in-group bias correlated with measures of group satisfaction and this was replicated across both the simultaneous and sequential presentation conditions. This provides converging evidence that in-group identification is critical to producing the results. This was tested in Experiment 4 where I used the same stimuli as here but with individuals who were not football supporters to assess whether the effects do not depend on the stimuli themselves (e.g., the colour of the Oxford United rather than the Swindon Town badge) but rather the individual's association with the in-group team.

Experiment 4: Effects with non-football fans (control study 1)

Experiment 4 was a control study undertaken with participants who were not football fans in order to assess if the in-group bias in Experiments 1-3 was due to some intrinsic perceptual advantage for the local team badge over the other badges (e.g., the badge of Oxford United was the only badge with yellow). Experiment 4 tested whether or not the enhanced performance on the local team badge was related to the physical characteristics of the stimuli.

Method

Participants

Sixteen university students, eight male (mean age (SD) = 25 ± 4) took part.

Stimuli and procedure

Unless otherwise mentioned, the Method was the same as that in Experiment 2. For this experiment, I did not take the disliking ratings.

Results

The mean familiarity ratings were: in-group = 3, rival = 3, neutral = 4. These familiarity ratings were overall reduced for these participants compared with the football fans; the ratings also did not differ across the teams, $F(2,30) = 2.10$, $p < .135$.

RTs

For each participant correct responses shorter than 150 ms. or longer than 1000 ms. (corresponding to approximately ± 3 SD from the mean) were excluded. This resulted in rejecting 1% of the whole data. The analysis was performed on the remaining trials. A 2 × 3 ANOVA on the RTs showed a significant effect of match, $F(1, 15) = 34.80$, $p < .001$, $\eta 2 = .699$. Participants were significantly faster on match compared to mismatch trials *(p<001).* The main effect of team was not significant, $F(2, 30) = .15$, $p > .861$, and neither was the interaction between the match condition and the team, $F(2, 30) = 2.73$, $p > .10$ [5].

D prime and response criterion

The analysis of the d prime results did not yield any significant results, $F(2, 30) = 2.14$, $p > .14$. The same held for analyses of the response criterion, $F(2, 30) = 1.02$, $p > .37$.

[5] These data held for just the male participants in the study, indicating that any differences between these data and those for the football supporters (Experiments 1-3) was not due to the involvement of more female participants in Experiment 4. Note, however, that the experiment aimed to test for effects of the stimulus per se (e.g., its colour), even when it had no in-group association. It is highly unlikely that effects of the stimulus (its colour, shape) differ between male and female participants.

The mean RTs on match and mismatch trials, and the d prime values for each team in Experiment 4, are shown in Figures 8a & 8b.

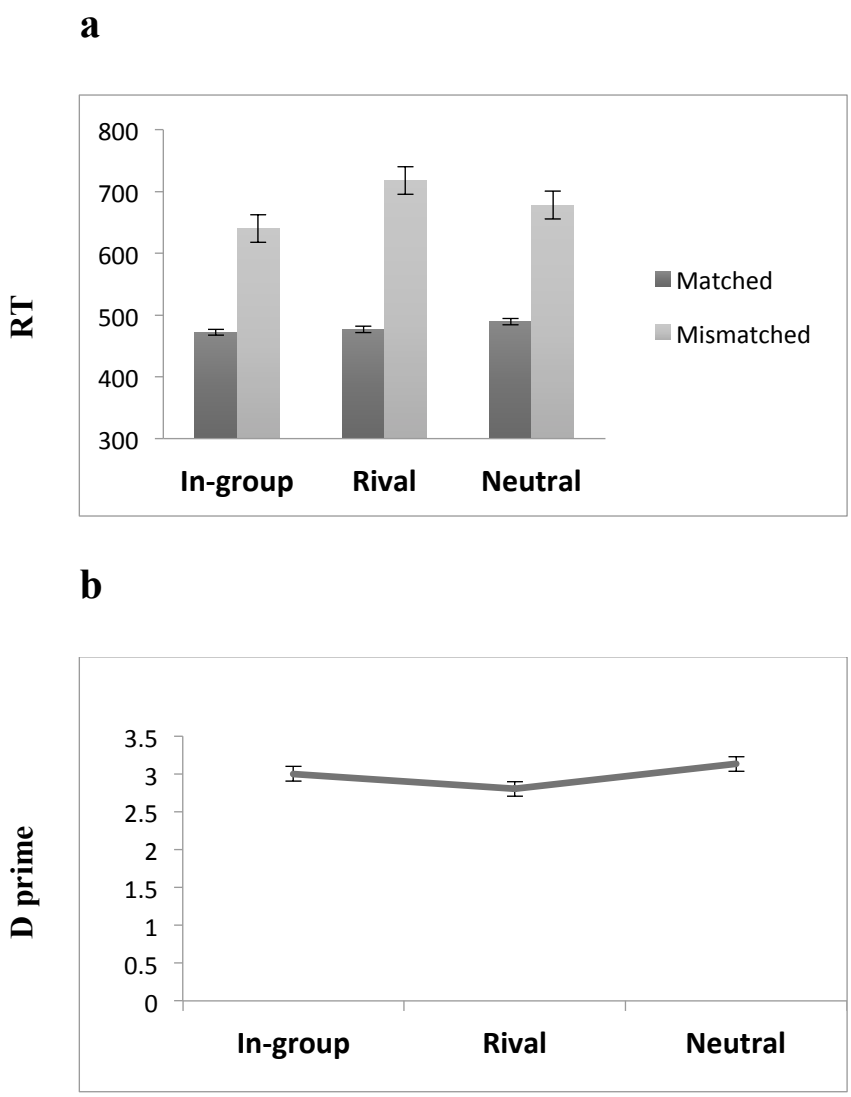


Figure 8. Behavioural performance in Experiment 4. (a) Mean correct RTs (in milliseconds) for match and mismatch trials in Experiment 4 (not football supporters). (b) All d prime values for each team. Error bars represent standard error.

The mean accuracy and RTs for the match and mismatch trials in Experiment 4 are presented in Table 6.

Table 6

Mean correct RTs (SD in brackets) and proportion correct responses (SD in brackets) in Experiment 4.

Matching condition	Group	RT	Accuracy
Match	In-group	472(62)	.92(.05)
	Rival	476(63)	.90(.08)
	Neutral	489(69)	.91(.07)
Mismatch	In-group	542(68)	.92(.03)
	Rival	545(68)	.90(.06)
	Neutral	524(83)	.94(.03)

Discussion

There was no evidence here that differences emerged in a perceptual matching task for individuals who were not football fans of the in-group team. I conclude that there were no intrinsic advantages for matching the Oxford United badge compared with the other badges.

Experiment 5: Testing effects of familiarity (control study 2)

Experiment 5 was designed as a test of stimulus familiarity on matching performance. Here instead of examining matches of football team badges to shapes, I examined performance when participants match images of animals to shapes and I chose animals that varied in their familiarity to participants. The animals selected varied more widely in familiarity than the football teams did for the football fans in

Experiments 1-3. Following Experiment 1, I assessed performance when there were 4 associations to be learned. One animal (the cow) received uniform familiarity ratings of 7 (maximum familiarity); the others (donkey =5.30, camel = 4.50 and zebra = 4.70) received lower scores from an independent set of thirty raters. There were overall differences in familiarity between the stimuli, $F(3, 87) = 252.87$, $p < .001$, $\eta 2 = .897$) and the cow was rated as more familiar than the other stimuli which did not differ ($ps <$ .001). If familiarity is critical, then there should be more efficient matching of the shapes to the cow compared with when the shapes were match to the other animals.

Method

Unless otherwise mentioned, the Method was the same as that in Experiment 1.

Participants

Thirty university students, seven male (mean age (SD) = 26 ± 5) took part.

Stimuli and Procedure

I used the same procedure as Experiment 1 except that I replaced the football badges with the same size drawn images of animals taken from a standard database (Snodgrass & Vanderwart, 1980). The animals were cow (the most familiar animal) donkey, zebra and camel (less familiar animals). The animals were all drawn in the same pose and viewed against white background.

Results

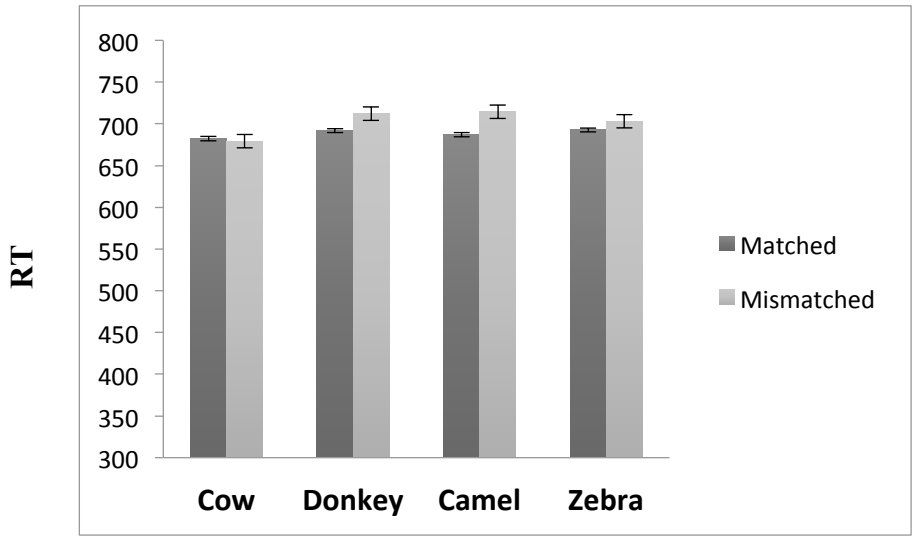
RTs

For each participant correct responses shorter than 150 ms. or longer than 1000 ms. were excluded. This resulted in rejecting 5% of the whole data. The analysis was performed on the remaining trials. A 2 × 4 ANOVA on the RTs showed that there was a significant effect of match condition, $F(1,29) = 192.59$, $p < .001$, $\eta 2 = .869$. Participants were significantly faster to respond to matching pairs compared to mismatching pairs. However neither the main effect of animal, $F(3, 87) = .076$, $p < .973$, $\eta 2 = .003$, nor the interaction approached significance, $F(3, 87) = .423$, $p < .737$.

D prime and response criterion

Analysis of d prime also revealed no significant effect of the animal, $F(3,87) = 1.26$, $p < .293$. Analysis of the response criterion did show a significant effect of the animal, $F(3,87) = 3.90$, $p < .012$, $\eta 2 = .119$. Pairwise comparisons revealed that the response criterion for the donkey was significantly different from that of the camel ($p < .003$). The response criterion was not significantly different for the other animals. The mean RTs on match and mismatch trials, and the d prime values for each team in Experiment 5 are shown in Figures 9a and 9b. The mean accuracy and RTs for the match and mismatch trials in Experiment 5 are presented in Table 7.

a



b

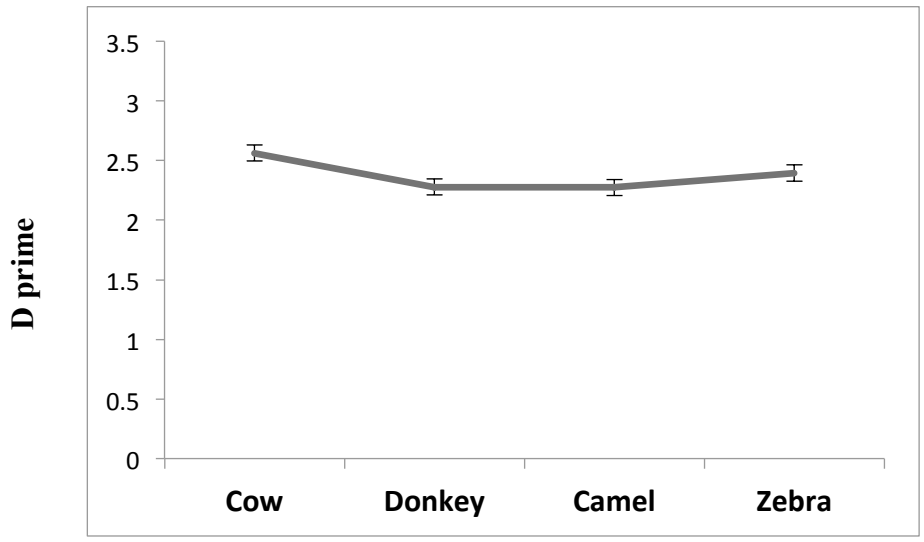


Figure 9. Behavioural performance in Experiment 5. (a) Mean correct RTs (in milliseconds) for match and mismatch trials in Experiment 5 (animal stimuli). (b) All d prime values for each stimulus. Error bars represent standard error.

Table 7

Mean correct RTs (SD in brackets) and proportion correct responses (SD in brackets) in Experiment 5.

Matching condition	Group	RT	Accuracy
Match	Familiar (Cow)	682(81)	.87(.09)
	Unfamiliar 1 (Donkey)	692(85)	.87(.08)
	Unfamiliar 2(Camel)	687(85)	.82(.14)
	Unfamiliar 3 (Zebra)	692(90)	.85(.11)
Mismatch	Familiar (Cow)	766(74)	.86(.09)
	Unfamiliar 1 (Donkey)	762(65)	.83(.09)
	Unfamiliar 2 (Camel)	761(70)	.86(.10)
	Unfamiliar 3 (Zebra)	761(86)	.86(.09)

Discussion

There was no evidence here that stimuli that were more familiar were matched more efficiently than stimuli judged less familiar, even though the stimuli employed here varied more widely in rated familiarity than the own and rival teams in Experiments 1-3. The result provides support for the argument that stimulus familiarity was unlikely to be critical in generating the in-group advantage in the earlier experiments, adding to the argument from the sequential stimulus manipulation (Experiments 2 and 3b) that differences in the familiarity of the stimuli did not drive the in-group benefit.

General Discussion

Across 5 sets of experiments I examined whether in-group associations, established to neutral shapes, could modulate perceptual matching with those shapes. After a short series of learning trials, where participants associated a geometric shape with the badge of different teams, football fans showed a clear advantage for matches to their favourite team (their in-group) relative to matches to other (rival and neutral) teams. This effect occurred on both RTs and on a measure of perceptual sensitivity (d prime). It also occurred both on simultaneous match trials (Experiments 1 and 3a) and with sequential badge-shape trials (Experiments 2 and 3b).

The robustness of the in-group advantage across the presentation conditions indicates that the bias cannot simply be attributed to the visual familiarity of the in-group badge. Since, under sequential conditions responses were made to the shapes rather to pairs of badges and shapes appearing together. In addition, while there was a clear performance advantage for stimuli linked with the in-group team over both the rival and neutral teams, familiarity ratings showed a different pattern and varied between the neutral team and the others (the in-group and rival teams, which did not differ). This last argument was also supported by the results from Experiment 5, which used stimuli that varied more widely in familiarity than did the football badges for our football supporters and yet I failed to establish any effect of familiarity on matching performance. A further control study, Experiment 4 demonstrated that the in-group advantage did not reflect the intrinsic properties of the particular badges I used (e.g., the colour of the Oxford United badge). Here I showed that individuals who were not football fans displayed no differences in matching the different badges used in Experiments 1-3. Rather than the familiarity and intrinsic properties of the stimuli being important I argue that the enhanced responses to the in-group badge reflect the

social value of the stimuli for the participants. This last argument is also supported by the correlations I performed examining the relations between in-group biases and ratings of in-group identification, with the in-group bias on matching being associated with ratings of in-group satisfaction.

Overall, these results indicate that in-group associations can be rapidly established and that they can affect the matching and even the identification of newly associated (and previously neutral) items (e.g., under the sequential presentation conditions). The in-group preference here is consistent with the effects previously found in relation to the self by Sui et al. (2012). Indeed, one possible reason for a preference for in-groups over out-groups could be that people are more likely to find self-related attributes in their in-group (Allport, 1954,1979), perhaps reflecting some overlap between the cognitive representations of the self and groups that I identify with strongly (Smith, Coats, & Walling, 1999; Smith & Henry, 1996). According to this account, people represent the in-group as a part of the self. Linkage between cognitive representations for the self and the in-group might facilitate perceptual matching for in-group stimuli.

An alternative proposal is that the better performance for in-group relative to out-group stimuli can be attributed to emotional and motivational factors (Amodio, 2008). The emotional significance of a stimulus has been shown to modulate early perceptual processing (Schupp et al., 2003) and it may be that in-group pairs inherit a positive emotional tag which in turn leads in better matching performance here. Moreover, I found some evidence of a negative bias against the rival team in Experiments 3a and 3b, which might occur if these items inherit a negative emotional tag. Responses to stimuli with a positive emotional tag may be faster than those which either have no or a negative tag.

In line with arguments about the emotional significance of the in-group, I found that the magnitude of the enhanced performance for the in-group varied as a function of the rated satisfaction component of the group identification questionnaire. The stronger the satisfaction with the in-group, the more efficient the performance on the in-group as opposed to rival stimuli. The correlation results fit with the self-investment account of in-group identification (Leach et al., 2008). Self-investment is directly linked to the amount of commitment that one shows for group activity. For instance, individuals who identify strongly with their in-group are more likely to feel psychological and emotional bonds with their in-group (Lewin, 1948), and they may experience greater reward by acting in relation to the in-group.

Our data on newly established associations fit with other results on face perception where social categorization has been shown to produce rapid changes on performance to stimuli that do not have long-term links to the experimentally manipulated social groups (Van Bavel et al., 2011). In studies of face recognition, such effects are associated with changes in the configural processing of faces (Cassidy et al., 2011; Hugenberg & Sacco, 2008). The data indicate that group identification can enhance processing of the perceptual properties of newly associated stimuli.

Relative to the robust evidence for enhanced performance for in-group associations, the evidence for suppression of the rival team was weak for both the RT and sensitivity measures. This may be because in naturally established groups (football teams, for football fans), all out-groups are perceived as homogenous (Ostrom & Sedikides, 1992). Notably, this was not due to the rival team being in some sense neutral. The football fans had strong negative opinions about the rival team reflected in their ratings of disliking; even so though, this did not lead to robust suppression of responses relative to stimuli associated to neutral teams. The data indicate that new

associations can easily be formed to out- as well as in-group stimuli, but the in-group associations uniquely produce enhancement of matching and identification performance to formerly neutral stimuli. This general effect of "in-group favouritism but not out-group derogation" is supported by several social psychology studies. For instance, in the minimal group paradigm participants often allocate reward to their in-group but without necessarily punishing out-group members (e.g., see Brewer, 1979, 1999; Goette, Huffman, & Meier, 2006 for a review).

One other finding was that performance was affected by the context of the experiment. In general participants performed better under sequential compared with simultaneous presentation conditions (in Experiments 2 and 3b vs. Experiments 1 and 3a) and the differences between the teams were smaller (though still highly reliable) with sequential presentations. This is not surprising given that under sequential presentation conditions participants can generate an expectancy of the upcoming stimulus and this then reduces the benefit for in-group items. Despite this however, the in-group effect remained.

Alongside the changes in perceptual sensitivity I found some changes in the response criterion adopted. In the main, participants adopted a less conservative criterion for responding to the in-group relative to the other teams, though this was not always the case (Experiment 2). In addition, participants tended to be more conservative when responding to the rival team compared with the neutral team (Experiments 1-3a). These shifts in the response criterion exert effects that are independent to the effects based on shifts in sensitivity (Macmillian, 1993), and indeed I failed to find any correlations between the response criterion and d prime measures. The effects on the response criterion may arise at a response rather than a perceptual stage of processing. Group biases may not only modulate our perceptual responses to stimuli but also the

threshold at which we are willing to respond to in-group and rival-associated items. Our results contrast to some previous studies where it has been found that the response criterion can be lower for other race faces compared to own race faces (Criss & McClelland, 2006; Meissner & Brigham, 2001). The contrasting results may be due to the level of familiarity of own race faces, which makes participants adopt a stricter response criterion (especially when recognition is assessed). In my paradigm however I reduced the overall influence of familiarity and here a stricter criterion for the in-group stimuli was not adopted.

The exact neural mechanisms responsible for the enhanced performance for in-group stimuli have not been fully understood yet. However, several lines of research including neuroimaging studies, suggest that some parts of the so called "social brain" including the amygdala (Anderson & Phelps, 2001) and the medial part of prefrontal cortex (Sui, Rotshtein, & Humphreys, 2013) might play role in the enhanced processing of stimuli that are emotionally salient and related to the self. It will be helpful for future studies to explore the neural correlates of in-group bias in visual perception to test the relations between the in-group effects and those of emotion and self-interest. In addition, it will be important to examine whether the in-group biases we have established can predict in- and out-group differences in attitude and other social behaviours. For example, if individuals perceive in-group related stimuli more accurately and faster than out-group related stimuli, then our sensitivity to variations and individuality within the out-group may be decreased. This line of research thus has important implications for broader areas of social behaviour including intergroup conflict and prejudice and might pave the way to better understanding how we might be able to help resolving or at least weakening prejudice.

Chapter 3

Motivational relevance but not stored knowledge drives in-group bias

This chapter is *under revision* in *European Journal of Social Psychology*.

Abstract

I investigated the effects of stored knowledge on in-group biases in simple perceptual matching. In Experiment 1, members of a university rowing team were instructed to respond to the original colours of their team (in-group); the rival team and the neutral team (out-groups) paired with the corresponding team labels. Participants performed more efficiently on in-group related trials compared to out-group trials (for rival and neutral teams). The in-group bias remained when the original (pre-learned) colours of the items were swapped, although there were then costs to the out-group stimuli if they were paired with the original in-group colour. In Experiment 2, I confirmed the in-group advantage when team labels were paired with three novel colours. In a further control study (Experiment 3), the bias for in-group stimuli was not found in an independent sample of participants who were not identified with the teams, but who had knowledge of the university-colour associations. This indicated that motivational relevance, rather than stored knowledge about the stimuli, enhanced performance for in-group related pairs. I discuss the consequences of these findings for understanding in-group effects on perceptual processing, and understanding social perception.

Keywords: Stored knowledge, Perceptual matching, Motivational relevance, In-group, Out-group

Introduction

It has been shown that, across different contexts, people are biased in their responses towards stimuli linked with their in-group compared with an out-group (Ostrom & Sedikides, 1992; Sporer, 2001; Wilson & Hugenberg, 2010). Most notably, studies of face recognition have long established an in-group bias, in which recognition is better for members of one's own race compared with members of a different race (e.g., Meissner & Brigham, 2001; Weise, 2012). This effect may be modulated both by long-term experience (Yankouskaya, Humphreys, & Rotshtein, 2014) and by mere in-group categorization. For example, when people are randomly assigned to different groups in lab. settings, they tend to better recognize faces categorized as members of their in-group (Van Bavel et al., 2011). In-group categorization can modulate how sensitive people are to configural properties in faces (Bernstein, Young, & Hugenberg, 2007; Cassidy et al., 2011) and it affects early face-specific event-related responses (Cassidy, Boutsen, Humphreys & Quinn, 2014). The categorization effect for in-group stimuli is not due to stored knowledge of the faces *per se* since the faces of in-group and out-group members were equally familiar in these categorization studies. Rather, the effect could be explained in terms of the motivational relevance of the faces of in-group members; there is enhanced processing of stimuli that are motivationally relevant. The findings are in line with recent studies on the effects of the motivational relevance of faces on the activation of face-specific networks of the brain. For example, Van Bavel and colleagues (2011) showed that activity in the well-known fusiform face area (*FFA*) was greater for the faces of in-group members compared to those of out-group members. The assignment of faces to in- and out-groups was arbitrary in this study and orthogonal to the race of the faces; thus the stronger activity for the in-group faces reflects the higher motivational relevance of these stimuli.

One question that emerges from this work is whether the in-group bias arises only for stimuli that we typically categorize as being related to an in- or out-group (faces), or whether the bias will occur with stimuli assigned, such an in- or out-group relation, even though they are not habitually associated with an in- or out-group. Can in- and out-group relations be set-up 'on the fly' through linkages to previously neutral stimuli? The effect of social relations on responses to newly associated stimuli has recently been studied by Sui and colleagues in the context of self-bias. Sui, He and Humphreys (2012) had participants carry out a simple matching task based on a newly established association between a word corresponding to a person (you, friend, and stranger) and a geometric shape (circle, square, triangle). Participants discriminated whether label-shape pairs were the same as initially established (you-circle, friend-square, stranger-triangle) or whether the items were re-paired (you-square, friend-triangle, and stranger-circle). Match times were substantially faster to self-related pairs than to pairs for other people (see also Frings & Wentura, 2014). Sui, Lui, Mevorach and Humphreys (2013) further showed that the self-associated shapes, when placed in hierarchical (local-global) forms with shapes associated with other people, acted as high-saliency stimuli – interfering with identification responses to the shape for the other person. This interference effect was similar to that found when the perceptual saliency of shapes is varied (Mevorach, Hodsoll, Allen, Shalev & Humphreys, 2010).

Based on this evidence, in the current study I first asked whether the effect that Sui and colleagues (2012) found for self- and other-associations could be extended to include in-group relevant stimuli. Therefore, I utilized the associative learning paradigm of Sui et al. (2012) to explore how in-group identification alters performance based on whether a certain colour was associated with an in- or out-group label. I hypothesized that there should be enhanced processing and more efficient matching for

in-group compared to out-group associated stimuli (Loersch & Bartholow, 2011). I manipulated group-relevant colours related to university rowing teams, since colours are an important part of the identity of these groups (Elliot & Maier, 2014; Georgeson & Lampard, 2005). In our context, different blue colours are respectively associated with Oxford (dark blue) and Cambridge (light blue) rowing teams, and these colours are strongly linked to the historical rivalry between the teams (indeed all sports teams of the two universities wear, respectively, dark and light blue colours).

To evaluate whether any in-group bias was linked to stored knowledge of the University-colour relationship, rowers from the University of Oxford rowing team were instructed to learn different sets of associations (original, swapped, novel) between colours and group-relevant labels. For example, in the original setting all colour/label associations were based on stored knowledge about the colours of the rowing teams. For example, participants learnt to associate the word "***Oxford***" with a dark blue circle, which is the real colour of the Oxford University rowing team. In the same set, another association was made between the word "***Cambridge***" and a light blue circle (the real colour of the Cambridge University rowing team) and the word "***Newcastle***" and a third shade of blue (intermediate between Cambridge and Oxford – corresponding to the real colour of the Newcastle team). These associations were already learnt based on real-world knowledge about the teams. Given that all the participants knew these colour-team relations, I predict few differences in performance in matching paired labels and colours for the different combinations of stimuli (Oxford-dark blue; Cambridge-light blue; Newcastle-intermediate blue: the in-group, rival and neutral team pairings). However, differences in motivational relevance, favouring the in-group, may lead to facilitated matching of in-group stimuli compared with both out-groups (rival and neutral pairings).

In addition to assessing performance with learned colour-team relations I also assessed how performance varied when the learned colours were associated with other teams. In this 'swap' condition, I paired the in-group label (Oxford) with the colour of the rival team (Cambridge) or the neutral team (Newcastle). Was there better matching of any colour associated with the in-group label, or was this benefit modulated by stored knowledge of the colour-team relation? Continuing the 'swap' condition, I re-paired the colour-team relations for two teams and left the relations the same (and so pre-learned) for the third association. If the motivational relevance of the in-group association is sufficient to produce in-group bias, participants should still perform better on in-group pairs compared to the pairing that has not been changed. For example, responses to the pairing of Oxford with the Newcastle colour should be faster than response to the pairing of Cambridge with its learned light blue.

I further asked whether in-group bias would exist in the absence of any learned relations between the colour-team associations. To investigate this question, in Experiment 2, rowers performed the same task with three novel colours, where there were no connections to the colours of the teams in the real world. In all of the experiments, after being instructed to learn the associations between colours and team labels, participants viewed different pairs and judged whether or not the pairings were correct according to the information just learned. I predicted that the mere connection of colours to the in-group label would be enough to drive in-group bias. Therefore, even if the assignment of colours to team labels was not meaningful, the in-group pair would still show enhanced matching.

Finally, I asked whether motivational relevance was necessary for enhanced performance. In Experiment 3, the original colours of the teams were paired with team labels for a group of participants who were students from another university for whom

none of the teams were motivationally relevant – although in all cases the students had learned knowledge of the colours normally associated with the teams. I hypothesized that even in the presence of existing knowledge about the colours of different teams, participants who did not identify with a team would perform similarly on all pairs. Therefore, stored knowledge alone could not drive the bias in the absence of motivational relevance.

To disentangle the underlying mechanisms of any in-group bias effect, in all experiments I measured explicit self-report ratings of liking and familiarity for each colour. I asked whether or not the enhanced performance for in-group stimuli was owing to the in-group colour being more familiar and likable, or whether the motivational relevance of any given colour connected to the in-group could result in enhanced perception of in-group pairs.

I report three experiments. If the in-group bias is stable, participants who identified with their in-group team (here Oxford) should show enhanced performance for their own team across different settings (original, swapped, novel, Experiments 1, 2). If the effect was solely owing to stored knowledge about the colours of the different teams, the in-group bias should only occur in the original setting and not in 'swap' or novel settings. Moreover, if the in-group bias is dependent on motivational relevance rather than stored knowledge, then participants who did not identify with the teams should not show any effect, regardless of their knowledge about the teams' colours (Experiment 3). Together, these three experiments provide us with a comprehensive picture of how stored knowledge and motivational relevance of in-group stimuli contributes to in-group bias even with stimuli that are not typically associated with motivational relevance.

Experiment 1

Method

Participants

Thirty-three participants (seven male) took part. Participants (mean age (SD) = 22.5± 5, range 19-40) were all right handed, with normal or corrected-to-normal vision. All the participants were members of the University of Oxford rowing team (all had at least two months' experience at the time of testing; mean (SD) length of membership= 8.8 ± 9.4, range 2-42 months). Participants were recruited via an internal advertisement. Prior to the experiment, a written consent form approved by the University of Oxford research ethics committee was completed by all participants.

Stimuli

The shape stimuli were selected by each participant from three different geometric shapes (square, triangle and circle) of 2 degrees of visual angle in size. At the start of the experiment, participants were asked which of these shapes they preferred and that shape was then used throughout (40% of the participants chose the square, 30% the circle and 30% the triangle). In the main experiment, the chosen shape was presented in three different colours. The colours corresponded to the Oxford University rowing team (dark blue RGB 0, 33, 71), the Cambridge University rowing team (light blue, RGB 163, 193, 173) and Newcastle University rowing team (mid blue RGB 11, 18, 238), and these colours were paired respectively with the team labels, Oxford, Cambridge and Newcastle, so resulting in a pre-learned colour assignment as all participants knew the colours for the selected rowing teams prior to commencing the study. Oxford, Cambridge and Newcastle were chosen because (i) Oxford was the in-group for all the participants; (ii) Cambridge is the traditional rival rowing team (e.g.,

as highlighted in the annual Oxford vs. Cambridge boat race), and (iii) Newcastle is a non-rival, neutral team. Each pair (coloured shape and label) was presented at a visual angle of 4 degrees above or below the fixation cross (0.5 degrees of visual angle in size) in a random order on a grey background (RGB 128, 128,128), with the label always appearing at the bottom and the shape at the top. The stimuli were viewed from approximately 57cm from the 17-INCH monitor display (1920 × 1080 with 60 Hz refresh rate). The experiment was implemented using E-prime software (Version 2.0).

Procedure

The experiment began with a block of 12 trials in which participants saw each label (Oxford, Cambridge, and Newcastle) with its paired coloured shape. For example a circle painted in "Oxford Blue" was associated with the label "***Oxford***", a mid blue circle was associated with the label "***Newcastle***" and a "Cambridge Blue" circle was associated with the label "***Cambridge***" [1]. Participants then performed a short practice block of 24 trials, where they saw either matching colours and labels or mismatching pairings (e.g., Oxford blue colour paired with the label Cambridge). Subsequently, the experimental trials were arranged over three blocks. Participants received feedback after each trial throughout the practice and the main experimental blocks. At the end of the experiment, participants received feedback showing their overall accuracy across the whole experiment.

Each participant completed two sessions of the experiment in a random order for a total of 720 trials. Both sessions were completed in one day with a 20-minute gap between the two sessions. In the first session, all the associations between colours and team labels were based on the real-world associations. In the second session (swap), the associations between the colours and team labels were manipulated to test whether any

differences between the original conditions reflected the participant's prior knowledge of the team-colour assignment, and if there was any residual effect of the first (pre-learned) assignment on subsequent learning and associative responding. There were two different swap conditions with half of the participants randomly assigned to each condition. For the *neutral swap*, participants learned to associate the shape in 'Newcastle blue' with the label "Oxford" and vice versa for the label "Newcastle". In this case the Cambridge stimulus remained the same. For the *rival swap* condition, participants in their second session associated the shape coloured 'Cambridge blue' with the label "Oxford" and vice versa for the label "Cambridge" ('Oxford blue'). Here the Newcastle stimulus remained the same. In both the original (session 1) and swap (session 2) experiments, half of the experimental trials were "match pairs" (the colour and the label were paired according to the experimental instructions) and the other half were "mismatch" (the pairing between the colour and the label was swapped). All thirty-three participants completed the experiment with the original associations. Seventeen participants were assigned to the *neutral swap* condition and sixteen participants completed the *rival swap* condition.

Each trial started with a white fixation cross (on the same grey background as used for the display trials) for 500 ms. followed by the simultaneous presentation of a shape, and the label at 4 degrees of visual angle above and below the fixation cross for 100 ms. with the label always appearing below the fixation cross. The stimulus conditions (in-group, out-group, neutral, match or mismatch) occurred randomly. Participants judged whether the colour and label were a pair as originally shown or whether they had been re-paired by pressing two different keys on the keyboard (n, m keys). The inter-trial interval varied randomly between 800 and 1200 ms. and the response time was limited to 1000 ms. Trials in which responses were longer than 1000

ms. were aborted. After each trial, participants received written feedback on the computer about whether their response was correct, incorrect or too slow. Response-key assignment to match and mismatch trials was counterbalanced across participants. Figure 10 shows a schematic representation of the task in Experiment1.

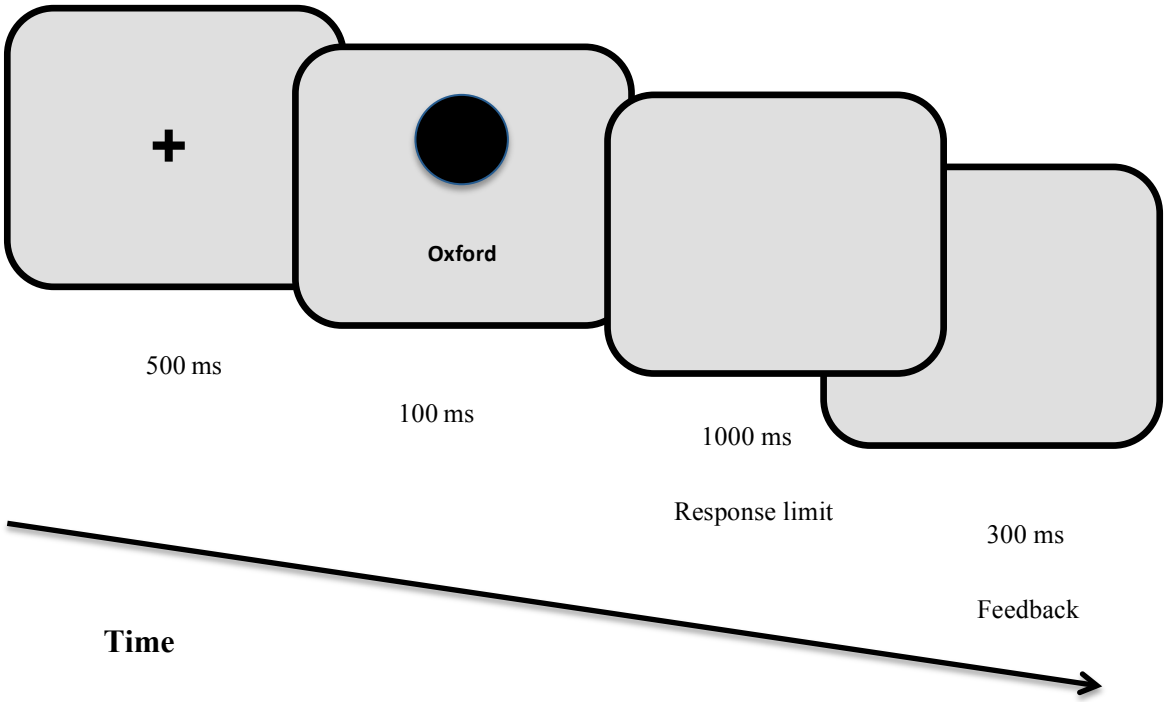


Figure 10. **Example task used in Experiment 1**. The original background was fifty percent grey and the shape was painted in dark blue (RGB 0, 33, 71).

Prior to the experiment, participants were asked to identify which colour went with which university rowing team and they also explicitly rated their level of familiarity with each rowing team, with ratings from 1 (*not familiar*) to 7 (*perfectly*

familiar). In the same survey, participants were asked to rate how much they liked each colour/shape combination from 1 (*not at all*) to 7 (*very much*) . There were three different shapes (a triangle, a square and a circle) and three different colours ('Oxford Blue', 'Cambridge Blue' and 'Newcastle Blue'), resulting in nine different combinations of shape and colour. Participants were also asked to fill in an adapted version of the multicomponent social identity questionnaire (Leach et al., 2008).The subcomponents of the in-group identification were solidarity, satisfaction, centrality, in-group homogeneity and self-stereotyping. Participants additionally rated in general how competitive each rowing team was in the annual university boat races on a scale from 1 (*not competitive at all*) to 7 (*very competitive*). They were also asked whether or not they had friends among the members of any team. Moreover, participants expressed explicitly from 1 (*not motivated*) to 7 (*very motivated*) how motivated they were to learn the task with regard to the different teams.

Results

All the participants classed the Cambridge University rowing team as being the rival (to the Oxford University rowing team) and all classed Newcastle University rowing team as being neutral (a non-rival team). The mean (SD) familiarity ratings were: in-group = 6.03 ± .91, rival = 5.90 ± .94, neutral = 4.60 ± .82. These ratings differed across the teams, $F(2, 64) = 129.33$, $p < .001$, $\eta 2 = .80$. This difference was owing to both the in-group and rival teams being rated as more familiar compared to the neutral team, $t(32)=12.34$, $p < .001$, $d = 2.14$, $t(32)=11.75$, $p < .001$, $d = 2.04$. The rival and the in-group teams did not differ in terms of familiarity. The mean (SD) liking ratings for the original colours were: in-group = 5.50 ± .90, rival = 3.60 ± 1.16, neutral = 4.50 ± 1.27) (with the data averaged across the different shapes). These

ratings differed across the teams, $F(2,64) = 19.37$, $p < .001$, $\eta 2 = .337$, with the in-group team being rated as more liked than the neutral team, $t(32) = 3.30$, $p < .002$, $d = .57$, and the rival team, $t(32) = 8.00$, $p < .001$, $d = 1.39$ which again differed, $t(32) = 2.47$, $p < .019$ (with the neutral team being rated as more liked). The mean (SD) ratings of competitiveness of each team were: in-group = 6 ± .86, rival = 6 ± .89 and neutral = 4.75 ± 1.17. These ratings also differed across the teams, $F(2,64) = 27.00$, $p < .001$, $\eta 2 = .458$. The neutral team was rated as less competitive compared to both the in-group team, $t(32) = 4.89$, $p < .001$, $d = .89$, and the rival team, $t(32) = 7.16$, $p < .001$, $d = 1.24$. The in-group and rival teams did not differ in terms of how competitive they were rated, $t(32) = .40$, $p < .69$. All participants correctly identified which colour went with which team.

For each participant the responses were filtered to eliminate both very fast (RTs <150 ms.) and very slow (RTs >950 ms.) reaction times. This led to the rejection of 2% of all trials. The analysis was performed on the remaining trials. Moreover, for each participant I calculated d prime as a measure of sensitivity for discriminating match and mismatch trials across the different conditions; d prime was derived using the Green and Swets (1966) formula, taking the data for mismatch trials based on the team label that was presented.

$$d' = z(H) - z(F)$$

In addition, the response criterion (C) was calculated using the following formula (Macmillan, 1993):

$$C = -½ [z(H) + z(F)]$$

RTs

I first tested whether there was any effect of group relevance on RT in Experiment 1 with the original association between colours and team labels. RTs were subjected to a two-way analysis of variance (ANOVA) with two levels of matching condition (match, mismatch) and three levels of group relevance (in-group, neutral, rival), all manipulated within subjects. All effects were statistically significant at the .05 significance level. For the multiple comparisons, the significance level was set at .01. There were significant main effects of matching condition, $F(1, 32) = 75.62$, $p < .001$, $\eta 2 = .75$, and group relevance, $F(2, 64) = 59.30$, $p < .001$, $\eta 2 = .65$, on RT. There was also a significant interaction between matching condition and group relevance, $F(2, 64) = 66.40$, $p < .001$, $\eta 2 = .67$, indicating that the difference between RTs on match and mismatch trials varied as a function of group relevance. I conducted *post hoc* comparisons to understand how the RTs for the pairs with different group relevance were affected by the matching condition. On match trials participants were quicker to respond to in-group stimuli compared to stimuli linked to the rival team, $t(32) = 12.33$, $p < .001$, $d = 2.14$ (Mean difference (SE) = 100 ± 46) , and the neutral team, $t(32) = 10.38$, $p < .001$, $d = 1.80$. (Mean difference (SE) = 72 ± 40), and RTs were also faster on rival team stimuli compared to that of the neutral, $t(32) = 3.61$, $p < .001$, $d = .62$ (Mean difference (SE) = 28 ± 44). However, on mismatch trials there was no significant effect of group relevance ($.18 < ps < .52$).

Next I tested whether there was an advantage on RTs for in-group stimuli in the swap experiment similar to the one I found in the original condition, and whether any in-group bias differed as a function of the colour-team relations being swapped. I used a 2 x 3 x 2 mixed model ANOVA on RTs with matching condition (match vs. mismatch) and group relevance (in-group, neutral, rival) as within-subject variables,

and swap condition (swap colour with the neutral team vs. swap colour with the rival) as a between-subject variable. Overall, seventeen participants were randomly assigned to the swap-neutral condition and the remaining sixteen assigned to the swap-rival condition.

The results showed that the main effect of swap on RTs was not significant, $F(1,31) = .82$, $p < .38$, $\eta 2 = .02$; nor was the interaction between swap and matching condition, $F(1, 31) = .12$, $p < .73$, $\eta 2 = .004$, or between swap and group relevance, $F(2, 62) = 2.43$, $p < .10$, $\eta 2 = .07$. The three-way interaction was also not reliable, $F(2, 62) = .37$, $p < .70$, $\eta 2 = .01$. However, there were significant main effects of matching condition, $F(1, 31) = 27.27$, $p < .001$, $\eta 2 = .47$, and group relevance on RT, $F(2, 62) = 14.29$, $p < .001$, $\eta 2 = .32$. The interaction between matching condition and group relevance was also significant, $F(2, 62) = 17.60$, $p < .001$, $\eta 2 = .36$. In order to decompose the interaction effect and to understand how the effect of group relevance on RTs varied across the matching conditions, I conducted *post hoc* comparisons on match and mismatch trials separately. The results showed that, for match trials, participants were significantly faster to respond to in-group compared to both neutral, $t(32) = 4.83$, $p < .001$, $d = .84$ (Mean difference (SE) = 37 ± 44), and rival stimuli, $t(32) = 8.36$, $p < .001$, $d = 1.45$ (Mean difference (SE) = 54 ± 37). The neutral and rival stimuli did not differ, $t(32) = 1.90$, $p < .07$. For the mismatch trials, none of the comparisons were significant ($.32 < ps < .97$).

D prime and response criterion

I tested whether there was any effect of group relevance on d prime as a measure of sensitivity of discriminating between match and mismatch pairs (Green &

Swets, 1966). As before, the analyses of variance were conducted separately on the original and swap experiments.

For the original experiment, there was a significant effect of group relevance on d prime, $F(2, 64) = 92.64$, $p < .001$, $\eta 2 = .74$. Pairwise comparisons showed that d prime for in-group stimuli was significantly larger compared to both neutral, $t(32) = 13.04$, $p < .001$, $d = 2.26$ (Mean difference (SE) = 1.10 ± .48), and rival items, $t(32) = 10.33$, $p < .001$, $d = 1.79$ (Mean difference (SE) = .95 ± .53); the latter did not differ, $t(32) = 1.63$, $p < .12$.

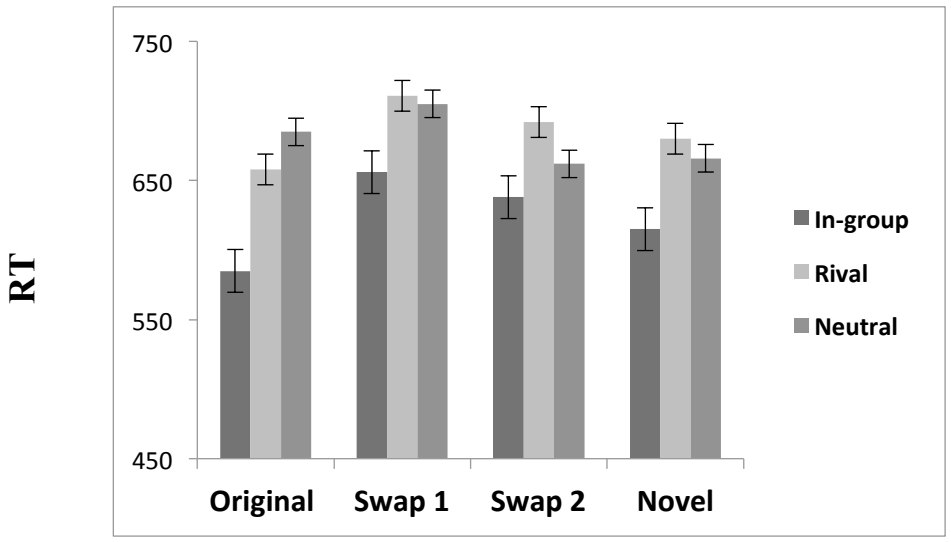
Analyses of the response criterion also revealed a significant main effect of group relevance, $F(2, 64) = 34.18$, $p < .001$, $\eta 2 = .681$. *Post hoc* comparisons showed that the criterion for the in-group was significantly lower than that for the neutral stimuli, $t(32) = 9.58$, $p < .001$, $d = 1.73$ (Mean difference (SE) = .6 ± .35) and rival stimuli, $t(32) = 6.48$, $p < .001$, $d = 1.12$ (Mean difference (SE) = .36 ± .32). The criterion for the rival team was also lower than that for neutral stimuli, $t(32) = 3.92$, $p < .001$, $d = .68$ (Mean difference (SE) = .22 ± .33) .

For the swap experiment, I computed a 2x3 ANOVA on both d prime and response criterion with group relevance as a within-subject and swap condition as a between-subject variable. The result showed that there was a significant main effect of group relevance on d prime $F(2, 62) = 23.44$, $p < .001$, $\eta 2 = .43$. *Post hoc* comparisons showed that d prime was significantly larger for in-group compared to both neutral stimuli, $t(32) = 3.85$, $p < .001$, $d = .67$ (Mean difference (SE) = .32 ± .48) and rival stimuli, $t(32) = 8.10$, $p < .001$, $d = 1.41$ (Mean difference (SE) = .55 ± .39). There was also a larger d prime for neutral compared to the rival stimuli, $t(32) = 2.57$, $p < .015$, $d = .45$ (Mean difference (SE) = .23 ± .51). However, there was no significant main

effect of swap condition on d prime, $F(1, 31) = .44$, $p < .51$, $\eta 2 = .01$. The interaction between group relevance and swap condition was not significant.

Analysis of the response criterion data showed that there was a significant main effect of group relevance on the response criterion, $F(2, 62) = 52.74$, $p < .001$, $\eta 2 = .63$. *Post hoc* comparisons showed that the response criterion was significantly lower for in-group compared to both neutral stimuli, $t(32) = 7.71$, $p < .001$, $d = 1.34$ (Mean difference (SE) = .37 ± .27) and rival stimuli, $t(32) = 8.29$, $p < .001$, $d = 1.44$ (Mean difference (SE) = .52 ± .36). The response criterion for neutral stimuli was also lower than for rival stimuli, $t(32) = 3.23$, $p < .003$, $d = .56$ (Mean difference (SE) = .15 ± .27). However, there was no significant main effect of the swap condition on the response criterion, $F(1, 31) = .30$, $p < .58$, $\eta 2 = .01$, and no interactions involved this factor. The summary of the results for the RT and accuracy data are shown in Figures 11a & 11b. The mean RTs and accuracy data for Experiment 1 are shown in Table 8.

a



b

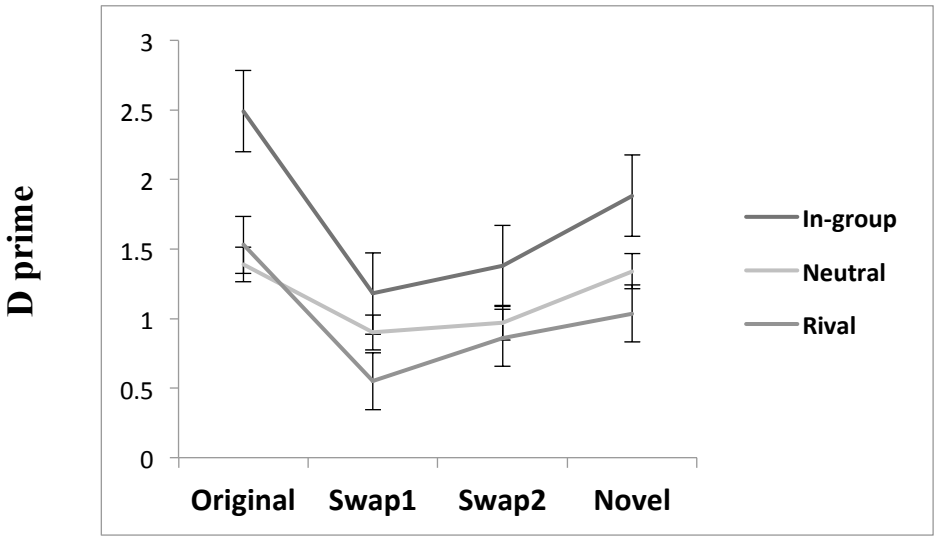


Figure 11. **Behavioural performance in Experiments with rowers.** (a). Mean RT for the match trials the Experiment 1 & 2 with rowers . (b). Mean d prime for the Experiments with rowers. Error bars represent standard error.

Table 8

Mean reaction time and accuracy for the match trials in Experiments 1 & 2 with rowers.

Group	***RT***				***ACC***			
	Original	Swap1	Swap2	Novel	Original	Swap1	Swap2	Novel
Oxford	585(65)	656(63)	638(81)	615(47)	.92(.08)	.77(.19)	.83(.15)	.88(.14)
Cambridge	658(75)	711(67)	692(56)	666(56)	.75(.15)	.51(.15)	.60(.13)	.69(.13)
Newcastle	685(80)	705(89)	662(61)	680(57)	.65(.18)	.62(.16)	.67(.21)	.70(.16)

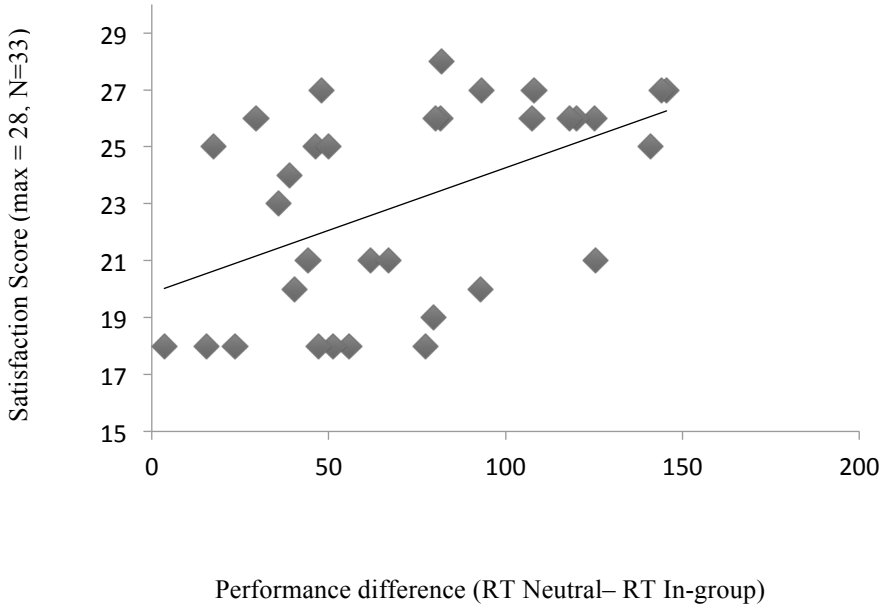
Note. Mean (SD) Reaction Times (RT) and Accuracy (ACC) for *match pairs* as a function of in-group across different association (Original vs. Swapped & Novel associations) in Experiment1 & 2 with Rowers. Note that standard deviations appeared in parentheses. In Swap1 condition, Oxford and Newcastle swapped their colour and Cambridge remained its original colour. In Swap 2 condition, Oxford and Cambridge swapped their colours and Newcastle remained its original colour.

Correlation analyses

Our results indicated that performance was enhanced for in-group matches relative to neutral and rival matches. I next investigated how this enhanced performance for the in-group related to scores on the subcomponents of the in-group identification questionnaire. The differences between the RT for each participant's own team and the rival and neutral teams were used as measures of "*in-group bias*". I tested whether the in-group biases in the matching task correlated with subcomponents of the in-group identification questionnaire using the data from Experiment 1 with the original pre-learned associations. I found a positive correlation between the in-group biases and the satisfaction subcomponent of in-group identification questionnaire, $r = .818$, $n = 33$, $p < .001$ (contrast with the neutral team), and $r = .493$, $n = 33$, $p < .004$ (contrast with the rival team). The higher the satisfaction with the in-group, the larger the difference in RT on in-group matches vs. the neutral and rival teams. For the in-group bias (contrast with the neutral team) the correlations with solidarity, $r = .03$, $n=33$, $p < .87$, centrality, $r = .04$, $n=33$, $p < .80$, self-stereotyping, $r = .11$, $n=33$, $p<.54$ and group homogeneity, $r = .21$, $n=33$, $p < .23$, were not significant. Similarly, for the in-group bias (contrast with the rival team), the correlations with solidarity, $r = .06$, $n=33$, $p < .73$, centrality, $r = .11$, $n=33$, $p < .54$, self-stereotyping, $r = .17$, $n=33$, $p < .34$, and group homogeneity, $r = .27$, $n=33$, $p < .13$, were not significant.

There were no correlations between in-group bias and the rated familiarity ($r = .13$, $n= 33$, $p < .35$, $r = .05$, $n= 33$, $p < .78$), nor was there any significant correlation between the reported liking score for the in-group colour ($r= .03$, $n = 33$, $p < .84$; $r = .14$, $n= 33$, $p < .45$) for both in-group biases (contrasting with the neutral and rival teams respectively). The results of the correlation analyses are shown in Figures 12a & 12b.

a



b

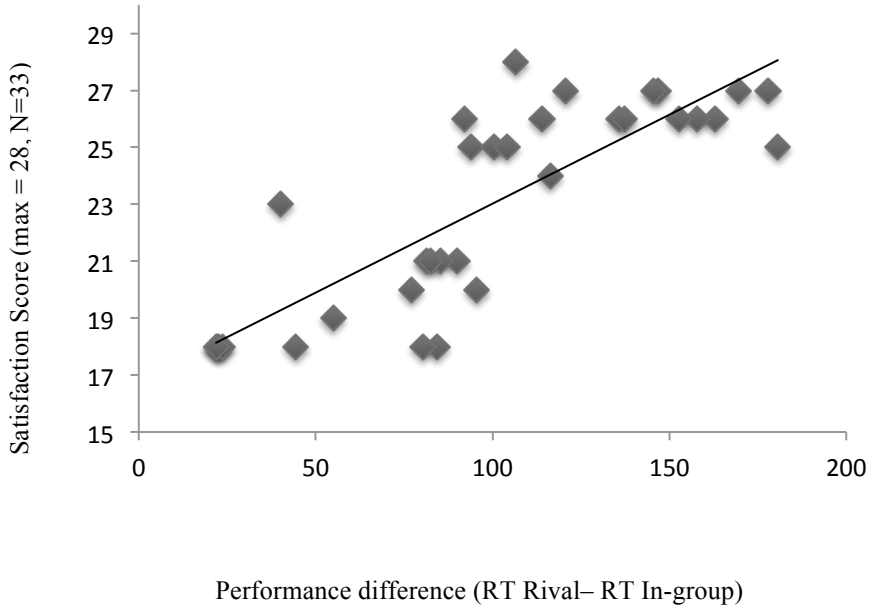


Figure 12. Correlation between the satisfaction and behavioural advantage for in-group. (a).The correlation between in-group satisfaction ratings and the advantage in RT for matching in-group over neutral team. (b). The correlation between in-group satisfaction ratings and the advantage in RT for matching in-group over rival team.

Discussion

In this experiment, I tested whether there was an effect of in-group favouritism on simple perceptual matching and whether this effect was modulated by employing stimuli with pre-learned associations vs. when the learned associations were re-assigned. I used two different sets of associations between colours and team labels. In the experiment with original associations, the real-world team colours were associated with the corresponding team labels. In the swap experiment, for half of the participants, the in-group label was paired with the original colour of the rival team; and for the other half, the in-group label was paired with the original colour of the neutral team.

The results showed that performance on match trials was enhanced for associations related to the in-group compared to the other associations. This effect was present in both reaction time and d prime with no evidence of a speed-accuracy trade off. The results regarding d prime confirmed that participants had enhanced sensitivity for discriminating between match and mismatch trials for the in-group team compared to the other teams. Participants were also faster to judge the match in-group pair compared to the other pairs. Such effects of in-group bias were present in both the original and swapped conditions. This suggests that, in cases of both pre-learned and new associations, the perceptual advantage for in-group stimuli was stable.

Although in-group association enhanced performance, there was less evidence for a cost to performance for the rival compared with the neutral team. In the original condition (long-term associated colours), and the neutral swap condition, performance for the rival team did not differ from the neutral team. There was no clear evidence here that there was any-cost to the rival when it had to be re-assigned to the colour of the in-group. The one exception to this was that there was a drop in d prime for rival

stimuli, suggesting some drop in sensitivity. This is consistent with some degree of suppression taking place.

Along with the effects on RTs and d prime, there were some effects on the response criterion. The response criterion was lower for in-group stimuli than for the other items. In the original assignment condition, the criterion was lower in the rival than the neutral condition, while this was reversed in the swap conditions. The response criterion result fits with participants adopting a less conservative criterion when responding to in-group stimuli, as well as showing enhanced perceptual sensitivity. The relations between the response criteria for neutral and rival teams were, however, unclear, and varied across conditions.

The analysis of the questionnaire data indicated that the in-group bias (relative to both the neutral and rival teams) was significantly correlated with participants' satisfaction with their group. This is supportive of the argument that stored knowledge *per se* was less critical than the motivational relevance that comes from being satisfied with being a group member.

Experiment 2: Re-assigning the colour-team associations

In Experiment 2, I tested whether there was still better matching performance for the in-group relative to the other teams when new associations had to be built between the teams and their assigned colours. Here, in contrast to Experiment 1, the teams were assigned completely new colours for associative matching. I tested whether the in-group advantage remained under these conditions.

Method

Participants

Seventeen members of Oxford college rowing teams (six male) took part; mean (SD) age = 23.3 ± 2.5 years (range, 20-28). Participants were all right handed with normal or corrected-to-normal vision.

Stimuli and Procedure

The stimuli and the procedure were identical to Experiment 1 except that the colour associated to each of the three stimuli was novel. In this case any effect linked to the familiarity of the real-world colours was eliminated. Before the experiment participants were asked to rate on a scale (from 1= *not at all*, to 7= *very much*) how much they liked each colour. Participants also were asked to rate how familiar each colour was on a scale (from 1= *not familiar at all*, to 7= *perfectly familiar*). The three novel colours were pink (RGB, 153, 34, 24), orange (RGB, 226, 70, 20) and beige (RGB, 226, 177, 179). The colours assigned to each team were counter-balanced across participants. However, to rule out the effect of colour preference (liking score) on performance, the assignment of the colour to the in-group labels was pseudo-randomized such that the least liked colour was always paired with in-group labels and the other two colours, which received higher liking ratings, were randomly paired with the neutral and the rival words. The same words as in Experiment 1 ("Oxford ", “Cambridge ", and “Newcastle") were used.

Results

For each participant, responses were carefully inspected to filter for both very fast (RTs <150 ms) and severely slow performance (RTs > 950 ms.). This led us to

reject 2% of the total number of trials. Mean (SD) liking ratings, taken before any associations were formed were: pink (4.94±1.1), purple (5.05±1.02), and orange (4.88±.92). These ratings did not significantly differ, $F(2, 32) = .37$, $p < .69$. Neither did the mean (SD) familiarity ratings vary for pink (3.3±1.04), purple (3.17±1.01) and orange stimuli (3.2± .95), $F(2, 32) = .32$, $p < .73$.

RTs

RTs were subjected to a two-way within-subjects ANOVA with two levels of matching condition (match, mismatch) and three levels of group relevance (in-group, neutral, rival). All effects were statistically significant at $p < .05$. There were significant main effects of matching condition, $F(1, 16) = 93.24$, $p < .001$, $\eta 2 = .85$, and group relevance, $F(2, 32) = 8.82$, $p < .001$, $\eta 2 = .35$, on RT. There was also a significant interaction between matching condition and group relevance, $F(2, 32) = 14.58$, $p < .001$, $\eta 2 = .47$, indicating that the difference between RTs on match and mismatch trials varied as a function of group relevance. To decompose the interaction effect, I conducted the *post hoc* comparisons separately on match and mismatch trials. The results showed that, for the match trials, participants were quicker to respond to in-group compared to the neutral, $t(16) = 4.23$, $p < .001$, $d = 1.02$ (Mean difference (SE) = 50± 49), and rival teams, $t(16) = 5.20$, $p < .001$, $d = 1.26$ (Mean difference (SE) = 64 ± 51). There was no significant difference between the neutral and rival teams, $t(16) = 1.34$, $p < .20$. On mismatch trials there was no significant difference between the teams, $.86 < ps < .94$.

D prime and response criterion

Secondly, I tested whether there was any effect of group relevance on d prime. The results revealed that there was a main effect of group relevance, $F(2,32) = 19.12$, $p < .001$, $\eta 2 = .544$. Pairwise comparisons showed that d prime was significantly larger for the participant's own team compared to both the neutral, $t(16) = 3.14$, $p < .006$, $d = .76$ (Mean difference (SE) = .54 ± .71), and rival teams, $t(16) = 6.26$, $p < .001$, $d = 1.51$ (Mean difference (SE) = .84 ± .55). However, d prime was also larger for the neutral team compared to the rival team, $t(16) = 3.08$, $p < .007$, $d = .74$ (Mean difference (SE) = .30 ± .40). In addition I tested whether or not there was any effect of group relevance on the response criterion. The results showed a significant main effect of group relevance, $F(2, 32) = 8.06$, $p < .001$, $\eta 2 = .335$. *Post hoc* comparisons showed that the criterion for the in-group association was significantly lower than for the neutral stimuli, $t(16) = 3.42$, $p < .003$, $d = .82$ (Mean difference (SE) = .37 ± .45) and the rival stimuli, $t(16) = 3.20$, $p < .006$, $d = .77$ (Mean difference (SE) = .30 ± .39). The summary of the results for the RT and accuracy data is shown in Figures 2a & 2b. The mean RTs and accuracy data for Experiments 2 are shown in Table 8.

Discussion

In sum, I found evidence that, with novel colour-team associations, participants were still faster and showed higher sensitivity when matching stimuli for their in-group compared with rival and neutral items. This confirms that the in-group advantage is robust across different contexts and does not require the involvement of pre-learned associations for the advantage to emerge. Compared to the newly learned associations, the advantage for in-group based on pre-learned association was significantly larger, $t(48) = 2.49$, $p < .02$, $d = .35$ (Mean difference (SE) = 36 ±14 ms.).

However the in-group advantage, though smaller than the advantage found for the learned in-group association was still substantial (64ms).

Experiment 3: Performance in individuals unaffiliated with the group (control study)

In Experiment 3, I tested whether associating a colour to a label affected subsequent matching performance in individuals who were not identified with the rowing teams in question. The colours were those used in Experiment 1 but the participants were no longer members of Oxford University, although they retained knowledge of which colour went with which team. If there are intrinsic differences between these colours that make some easier to match than others, then the pattern of results should mimic that found in Experiment 1 (there should be an in-group advantage). On the other hand, the in-group advantage might require that participants are highly identified with the team (note our questionnaire results), in which case the in-group advantage should be eliminated when I use individuals who report little interest in rowing, and who were not members of the universities I used for the associations.

Method

Participants

Twenty-seven participants (five male), mean age (SD) = 21±3 years (range 18-27 years) took part. Participants were recruited via an internal advert at the University of Birmingham. Participants were all right handed with normal or corrected-to-normal vision.

Stimuli and Procedure

The stimuli and the procedure were identical to Experiment 1 with pre-learned associations. Before the experiment, participants were asked to rate on a scale (from 1= *not at all*, to 7= *very much*) how much they liked each colour. Participants were also asked whether or not they knew the associations between the colours and the teams' labels. They also rated the familiarity of each team on scale (from 1= *not familiar at all*, to 7= *very familiar*).

Results

Participants were asked whether they classed Oxford, Cambridge or Newcastle rowing teams as the team they supported, the rival or the neutral team. Participants classed all teams as neutral with no group bias. All participants confirmed that they knew about colour-team associations. For each participant, the responses were filtered to remove both very fast (RTs <150 ms.) and very slow RTs (>950 ms.). This led to the rejection of 6% of the trials. Seven participants were excluded due to very poor overall accuracy (accuracy rate < .30 in more than one condition) and the analysis was conducted on the remaining twenty participants. The mean (SD) familiarity ratings were: Oxford = 4.50 ± .67, Cambridge = 4.30 ± .48, Newcastle = 4.15 ± .36. These ratings did not differ across the three teams, $F(2,38)= 1.93$, $p < .16$, $\eta 2 = .09$. The mean (SD) colour liking ratings were Oxford = 4.12 ± 1.26, Cambridge = 4.55 ± 1.17, Newcastle = 4.37±1.02. Again these ratings did not differ, $F(2,38)= .73$, $p < .48$, $\eta 2=.03$.

RTs

First, I tested whether or not there was an effect of team and match condition on RTs. I used a 2 × 3 repeated measure ANOVA with match condition (match versus mismatch) and team (Oxford, Newcastle, Cambridge) as within-subject variables. The analysis revealed a significant main effect of match condition, $F(1, 19) = 36.80$, $p < .001$, $\eta 2 = .66$. Pairwise comparisons showed that participants were in general faster on match trials compared to mismatch trials, $p < .001$ (Mean Difference (SE) = 42±7). However, there was no significant main effect of team on performance, $F(2, 38) = 1.20$, $p < .32$, $\eta 2 = .06$. The interaction between the match condition and team was not significant, $F(2, 38) = .83$, $p < .41$, $\eta 2 = .04$.

D prime and response criterion

I tested whether there was any effect of team on d prime. The results showed that there was no significant effect, $F(2, 38) = 1.2$, $p < .30$, $\eta 2 = .06$, nor was the effect of team reliable on the response criterion, $F(2, 38) = .68$, $p < .51$, $\eta 2 = .03$. The mean RTs (ms.) and accuracy data are shown in Table 9.

Table 9

Mean (standard deviation in brackets) Reaction Times (RT) and Accuracy (ACC) as a function of match condition (Match vs. Mismatch) in Experiment 3.

Group	RT		ACC	
	Match	Mismatch	Match	Mismatch
Oxford	630(61)	686(61)	.75(.16)	.70(.20)
Cambridge	636(66)	674(68)	.73(.15)	.67(.21)
Newcastle	648(62)	686(67)	.71(.21)	.71(.17)

Discussion

Individuals with no connection to the rowing teams showed no advantage in matching learned associations for the team label and its linked colour – despite the fact that the participants knew the team-colour associations. These results indicate that there were no intrinsic advantages for the in-group colour (Oxford blue) compared with the colours associated with the neutral and rival teams. In addition, the data suggests that having stored knowledge of the associations is not sufficient to generate the in-group advantage – although against this the degree of familiarity individuals had with the colour-team associations was less here than was the case for the rowing-related participants in Experiment 1 (based on subjective ratings of familiarity). Importantly, in none of the experiments was there greater familiarity for the in-group association than the rival association, yet clear differences emerged when participants identified with the in-group. Hence I propose that it is the motivational relevance of the participant's own team (in Experiments 1 & 2) that drives better performance emerging in both reaction time and response accuracy. Stored knowledge

about teams with which one does not identify is not enough to modulate matching performance to learned associations. This is in line with the positive correlation that I found between in-group bias and the satisfaction subcomponent of in-group identification in Experiment 1.

General Discussion

I report data from three experiments showing that, in a simple perceptual matching task, participants show in-group biases. In Experiment 1, participants with strong identification with a university rowing team were faster and had higher sensitivity when matching their in-group team label and colour compared with when they had to match labels and colours for neutral and rival rowing teams. This result was not caused simply by participants linked to the in-group rowing team having much greater familiarity with the learned colour. First, the rated familiarity for the colours of the in-group and rival teams did not differ. Second, in Experiment 2, there remained an in-group advantage for participants associated with the rowing team even when new, neutral colours were introduced. In addition, in Experiment 3 I found that there was no advantage for the learned in-group colour-label association for neutral participants who were not linked to the in-group, although they had knowledge about the group-colour association. This last result indicates that the in-group advantage in Experiment 1 was not due to some intrinsic differences between the colours, to which the neutral participants ought also to be sensitive. It could be argued that the degree of familiarity with the in-group colour was greater for the participants linked to their home-university rowing team, and that was critical, but the data from Experiment 2 cannot be explained in that way. I conclude that differential familiarity was less important than in-group identification for generating the in-group bias.

Extending previous work in this area, I also examined the effects of swapping the learned colour-label assignments. Despite these swaps, there remained an advantage for the in-group stimuli (Experiment 1). These results again suggest that the basic in-group bias effect does not depend on stored knowledge of the sensory properties of the particular in-group stimulus (e.g., here the colour associated with each university rowing team), since the effect survives colour re-assignment (Experiment 1, swap conditions) and it also occurred when in- and out-group stimuli were assigned neutral colours (Experiment 2).

As well as there being a positive bias for in-group stimuli, there was some evidence from the d prime results that there is a cost associated with rival stimuli, although this was not reliable for RTs. It may be that there is some degree of suppression for stimuli associated with the rival team, lowering perceptual sensitivity for these items.

How can in-group identification generate these effects? One account is that in-group identification heightens the salience of the stimulus, enhancing matching for in-group stimuli (Sui et al., 2012). A second is that in-group identification enhances the binding between the two elements making up each stimulus (the colour and the label), with the consequence again being that there is better matching for in-group stimuli (Humphreys & Sui, in press).

There is some evidence for both of these latter effects from work on self-bias, as I outline below. It has been argued that the in-group gains salience via its connection to self (Otten & Epstude, 2006). This could explain why perception prioritizes in-group stimuli in a similar way as it does self-related stimuli (Turner, 1987). As noted in the introduction, Sui, Lui, Mevorach and Humphreys (2013) reported that self-related stimuli generated effects similar to those of stimuli with high perceptual salience, when the stimuli formed hierarchical forms (in this case when global letters made up of local letters). An fMRI study conducted under the same task conditions, further showed that rejection of the self-associated distractor was associated with increased activity in the left intra-parietal sulcus

(compared to when the self-associated stimulus was the target). The region of increased activation overlapped with an area previously reported as being activated when participants reject salient distractors that are made attentionally salient by changing their perceptual properties in hierarchical forms, compared to when the target level is attentionally salient (e.g., the global level of a hierarchical form can be made attentionally more salient by blurring the stimulus; the local level can be made attentionally salient by introducing colour differences between high contrast, local shapes; Mevorach et al., 2009, 2010). This overlap in the neutral responses is consistent with the social association mimicking the effects of altering attentional salience through a perceptual manipulation. I can propose that a similar process applied to in-group rather than self-related stimuli can be responsible for the results presented here.

The second account is that in-group identification can modulate binding between the colour and the label. Sui and colleagues (Sui, Yankouskaya & Humphreys, 2015) have examined perceptual integration under conditions of self-association. In their studies, participants learned associations between shapes and social labels (self, friend, and stranger). The task then was to make an identification response to the stimuli presented on a trial, with trials containing either a single shape or two shapes. When two shapes corresponded to the same person (e.g., two circles were presented, when circle was associated with 'you'), there were redundancy gains in which responses were faster on two-shape trials than when single shapes appeared (e.g., Miller, 1982). Sui et al. report that, specifically for self-associated shapes, there are enhanced redundancy gains and evidence for non-independent (integrated) processing of the stimuli. These results indicate that stimuli associated to the self gain in perceptual integration. Again I may speculate that, if similar processes modulate in-group rather than only self-association, then the in-group bias here may reflect enhanced binding and perceptual integration of colour-shape labels. This was examined in Chapter 4 here. I

note that both arguments rest on in-group biases reflecting similar processes to those mediating self-biases. However, it has been argued that participants may represent in-group stimuli in a manner that is close to their representation of self-knowledge (Otten & Epstude, 2006). Although our proposals require further empirical verification, they are not unreasonable.

In addition to the above accounts, better performance for in-group stimuli could be attributed to the motivation to respond to the in-group pairs. Consistent with this, the in-group advantage varied with participants' ratings of their satisfaction with their group. I suggest that increased motivational relevance for in-group items could both enhance attentional salience and facilitate the binding of the elements, facilitating matching for these items. Motivational processes are at the core of Social Identity Theory (SIT; Tajfel, 1978; Tajfel & Turner, 1979). This theory holds that, when an individual's social identity becomes salient in an intergroup context, it can lead to attentional focus on in-group relevant information (Brown, 2000; Tajfel, 1978). Consequently, this social identity-based motivation is likely to produce an in-group bias (Hewstone et al., 2002). So, in line with SIT principles, the mere presence of a feature associated with an in-group (here the in-group word or colour) may shift an individual's attention toward the in-group stimuli based on the motivation to attend to the in-group (Tajfel 1981) (see also Yzerbyt & Demoulin, 2010). More recent evidence on the effect of group membership on face perception further confirms that the motivational relevance of faces plays a pivotal role in perception and, in turn, results in increased activity in the fusiform face area for new in-group members (Van Bavel et al., 2011). As here, when I paired in-group information with previously neutral colours, the effects are present even at the minimum level of exposure to the in- and out-group stimuli.

Chapter 4

Non-independent processing of sensory signals for in-group but not out-group stimuli

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Abstract

Decision times can be faster when detecting two targets for which the same response is required, compared to when only one of the targets is present - resulting in a redundancy gain. Here I examined for the first time whether redundancy gains are modulated by associating stimuli with in- as opposed to out-group targets. Participants made associations between a shape, a colour and either in- or out-group labels. They then had to discriminate whether in- or out-group stimuli appeared (single or redundant feature). Responses to in- but not to out-group stimuli violated predictions of models in which the associated features are processed independently. These redundancy gains were consistent with in-group stimuli (but not out-group) being processed with '*super-capacity*'. The results provide the first evidence that there is enhanced perceptual integration for information associated with an in-group.

Keywords: redundancy gain, in-group, out-group, capacity coefficient

Introduction

In our everyday life we are constantly flooded by a wide variety of sensory cues, which vary in their social relevance. How do our perceptual systems make sense of social information coming from different sensory channels? For years, investigators have asked whether information from different sources competes or integrates in perception (Ashby & Townsend, 1986; Raab, 1962; Yankouskaya el al., 2014). Previous experiments have established that, when information from two or more sources is linked to a single response, then decision times can be shorter than if only one source of information is available. This 'redundancy gain' has been reliably found across different perceptual contexts and modalities (e.g., Gondan et al., 2005). However, little is known about whether socially relevant information from different channels is integrated or competes for response. Is there social modulation of redundancy gains in perceptual processing? The processing of social information is of particular importance for survival (Insel & Fernald, 2004) and the social relevance of stimuli may help then to be 'perceptually glued' and processed more efficiently (Humphreys & Sui, in press; Sui, Yankouskaya, & Humphreys, 2015). If this is the case, then redundancy gains may be particularly evident if stimuli are socially related. This was investigated here.

Redundancy gains are typically understood in terms of two types of model (see Miller, 1982; Mordkoff & Yantis, 1991; Raab, 1962): so-called race models (e.g., Raab, 1962) and co-activation models (e.g., Miller, 1982). In spite of having some commonalities, these models differ in their accounts of whether or not the information received from each single stimulus can simultaneously activate target responses.

Race models assume that, on redundant-target trials, each stimulus independently activates the target- present response. As stimulus information does not interact, then on any given trial one target will dominate and 'win' the competition over the other one to

trigger the response. Redundancy gains can nevertheless be predicted if there is an overlap in the response distributions of the stimuli across trials, so that an on-average slower stimulus sometimes wins the competition. This will lead to performance that is faster than predicted from mean times to the faster item.

In contrast to race models, co-activation models assume that information regarding each single target can simultaneously activate a target-present response. Co-activation of the response, from both sensory signals, can lead to performance that is faster than can ever be predicted by reaction times to the targets presented in isolation. These different models make formal predictions about reaction times to single and redundant targets which can lead to the rejection of one model class (e.g., Miller, 1982; Townsend & Nozawa , 1995). Interestingly, there is good evidence for rejection of an independent processing model when the stimuli are integrated into a single object (Mordkoff & Yantis, 1993), including the identity and emotional expression of a face (Yankouskaya, Booth, & Humphreys, 2012).

Recently, Sui et al. (2015) examined if redundancy gains were modulated by whether the stimuli are associated to personal labels. They had participants associate two shapes (e.g., circle, square) with each of two personal labels (friend, you). Participants then received single or pairs of shapes (the pairs always conformed to the same person) and they had to decide if stimuli were associated with the friend or their own label (see Sui et al., 2012). Redundancy gains were greater for shapes associated with the self compared with shapes associated with the friend. Furthermore, formal tests of the gains demonstrated violations of independent processing for self- but not for friend-related stimuli. These data suggest that being associated with the self facilitated the perceptual integration of the shapes, generating larger redundancy gains than when the shapes were associated with other people.

In studies of face processing, Yankouskaya, Humphreys and Rotshtein (2014) further showed that perceptual integration was influenced by whether the stimuli belonged to the participant's own racial group. Yankouskaya et al. (2014) had participants identify a target face (with a neutral emotion), a target emotion, or a particular facial identity with the target emotion (the redundant target). They found reaction time gains for the redundant target that violated assumptions of independent processing of identity and emotion. Interestingly this held for faces from the participant's own racial group, but not for faces from a different racial group. This effect of racial group was dependent on visual experience. The magnitude of the redundancy gain was modulated by the level of contact the participant had with contrasting ethnic groups. This suggests that visual experience facilitates the construction of an integrated representation for identity and emotion for faces from our own (familiar) race, which enables identity and emotion to be processed as an integrated percept.

In the present study I ask whether the effects of social grouping on visual processing can also be rapidly established, after people are asked to make arbitrary associations with stimuli. To do this, I used an association procedure similar to that of Sui et al. (2012), except that participants associated one shape and one colour with a label relating to their in-group (Oxford University, for participants who were members of Oxford University) and another shape and colour with a label relating to an out-group (Cambridge University, for Oxford University participants). Subsequently participants saw either single shapes or single colours, or both (with the shape and colour always redundant, referring to the same group). The task was to decide if the stimuli were associated with Oxford University or Cambridge University. I assessed if there were greater redundancy gains for the in-group stimuli (Oxford University coloured shape) compared with the out-group stimuli (Cambridge University coloured shape), and if only

the in-group stimuli gave evidence of non-independent processing (cf. Sui et al., 2015). Note that, since the colours and shapes assigned to the in- and out-group stimuli were arbitrary (and counter-balanced over the conditions across participants), then any differences in redundancy gains cannot be attributed to differential familiarity with the features of the in-group compared with the out-group. In previous work, I (Moradi et al., 2015) have established that perceptual matches for in-group shape associations are made more efficiently than matches for out-group shape associations, and, furthermore, the bias to the in-group correlates with measures of in-group satisfaction. This indicates that the association task is sensitive to factors influencing people's judgements about their links to real-world groups.

Method

Experiment 1: Matching task

Participants

Sixteen Oxford University students (8 males) mean age (SD) = 25± 5.3, range = 19-35, right handed, with normal or corrected-to-normal vision, and no reported neurologic or psychiatric conditions took part. Participants were recruited via an internal advertisement. There was local Ethics Committee agreement. All participants were reimbursed (£10 per hour pro rata). The adequate sample size to produce the power of .80 was estimated in a pilot study. Based on the differences between the mean of the conditions, a sample size of sixteen participants yielded power of .80 (see Murphy et al., 2009). Moreover, regarding the high number of trials (1200 in target detection task) and based on the previous published studies (e.g., Yankouskaya et al., 2014), a sample size of sixteen participants was deemed adequate.

Stimuli

The stimuli consisted of four shapes and four patches of colour. The shapes were a diamond, a square, a hexagon and a circle, each 4.5° of visual angle in size, edged with a white and had black outline (weight 4pt). The patches of colours were 4.5° of visual angle in size and were orange (RGB, 226, 70, 20), beige (RGB, 226, 177, 179) and two different shades of grey (RGB, 128, 128, 128) and (RGB 77, 77, 77). The target shapes were diamond and square, and the target colours were orange and beige, counter balanced to the in- and out-groups across participants. The circle and the grey colour patch were non-targets for all the participants. The stimuli were presented on a white background with a central black fixation cross (1° in size).

All the stimuli had identical mean luminance, and the background colour was constant across all stimuli (Stokes, Anderson, Chandrasekar, & Motta, 1996). Schematic examples of the stimuli used in the experiment are shown in Figure 13.

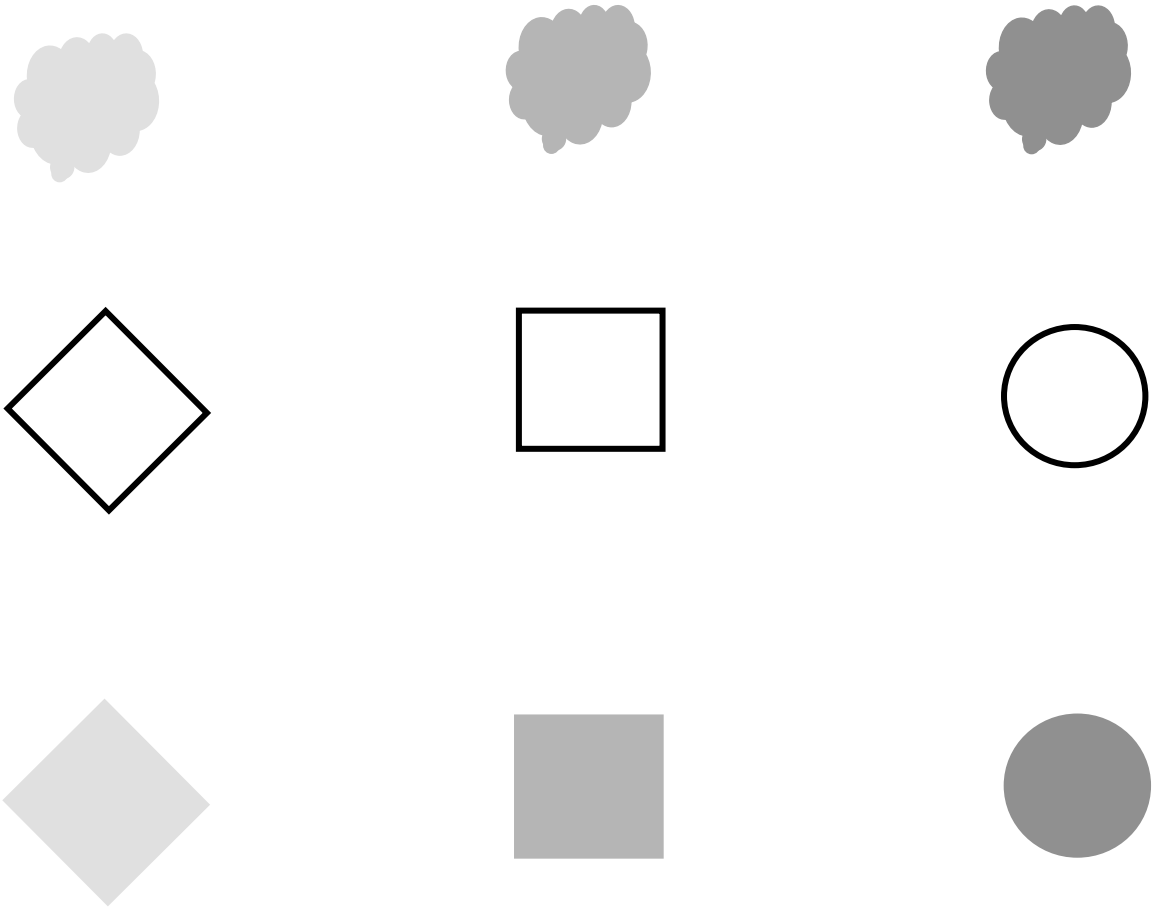

Figure 13. Examples of the stimuli. The colours were beige, orange and grey.

Procedure

To establish the associations to in and out-groups prior to the target detection task, participants performed a short matching task. Participants sat 58 cm away from a 22-inch screen (1920×1080 pixels, 100ppi, 60 Hz refresh rate) in a normal lighted room. The task started with a block of 8 trials in which participants saw each label (OXF) and (CAM) associated with a patch of colour and a shape. The labels represented Oxford and Cambridge and were shortened to match in length. After this, participants performed a short practice block of 8 trials where they saw either match

coloured shape with labels or mismatch pairings (e.g., "OXF" paired with the coloured shape that was associated to Cambridge before). Subsequently there were two blocks for the total of 120 trials (half match, half mismatch). Each trial started with a black fixation cross on a white background for 500 ms. followed by the simultaneous presentation of a coloured shape at 3° above and a label 3° below the fixation for 100 ms. The stimulus conditions (in-group, out-group, match or mismatch) occurred randomly. Participants judged whether the coloured shape and label were as originally paired or whether they were re-paired by pressing two different keyboard keys (n, m). Response key assignment to match and mismatch trials was counterbalanced across participants. The inter-trial interval varied randomly between 800 and 1500 ms. Participants were initially asked to rate their liking for each colour and shape separately (scale 1 (not at all) to 5 (very much)). The experiment was implemented using E-prime software (Version 2.0).

Results

For each participant the responses were filtered for both predictive (RTs <120 ms.) and slow reaction times (RTs) (RTs > 1000 ms.) (1% of the total number of trials). Mean (SD) liking rates for colour patches, taken before any associations were formed were: beige (4.43 ± .51), and orange (4.56 ± .53). These ratings did not significantly differ, $t(15)=.69$, $p< .49$. The mean (SD) liking rates for diamond (4.31 ± .60) and square (4.37±.50) also did not differ, $t(15)=.43$, $p < .67$.

RTs

RTs were subjected to a two-way analysis of variance with matching condition (match, mismatch) and group relevance (in-group, out-group) as factors. There was a

significant main effect of matching condition, $F(1, 15) = 22.53$, $p < .001$, $\eta 2 = .60$, with match trials being responded to faster (mean difference ± SE = 20 ± 4.29). There was also a significant main effect of group relevance, $F(1, 15) = 20.02$, $p < .001$, $\eta 2 = .57$; participants were faster with in-group compared to out-group stimuli (mean difference ± SE = 48± 10.84). The interaction between group and matching condition was not significant, $F(1, 15) = .32$, $p < .58$, $\eta 2 = .02$.

Accuracy

I tested effects on accuracy and on d′ as a measure of sensitivity to differentiate match and mismatch pairs. There was a main effect of group relevance, $F(1,15) = 14.77$, $p < .002$, $\eta 2 = .496$, but no main effect of match decision, $F(1,15) = 1.79$, $p < .19$, $\eta 2 = .107$. The interaction was significant, $F(1,15) = 22.64$, $p < .001$, $\eta 2 = .602$. Post hoc comparisons showed that, on mismatch trials, there was no effect of group relevance on accuracy, $t(15) = 1.38$, $p < .19$. However, on match trials there was a significant effect of group-relevance, $t(15) = 7.72$, $p < .001$, $d = 1.9$ with accuracy higher for in-group compared to out-group match pairs (mean difference ± SD = .22 ± .11). Analyses of d′ also revealed that sensitivity was significantly higher for in-group compare to out-group stimuli, $t(15) = 4.64$, $p < .001$, $d = 1.16$ (mean difference ± SD = .62 ±.13).

Discussion

Participants were faster and showed higher sensitivity when matching in-group compared with out-group pairs. This replicates data reported by Moradi, Sui, Hewstone and Humphreys (2015), who showed in-group biases in perceptual matching for labels of football teams and team badges, for football fans, here, though I used neutral shapes and colours and

stimuli that were equally likable and still found effects of in-group bias. This suggests that the effects of group emerge over and above effects of familiarity and liking.

Experiment 2: Target detection task

Participants

Unless otherwise mentioned the method was the same as for the association task.

Stimuli and Procedure

After the association task, participants were instructed to perform the target detection task. Participants were required to press a response key if the colour, the shape, or both target features were present for each of the categories (Oxford or Cambridge), and to make no response if neither of the target features was present. On the redundant target trials, both features (colour and shape) always belonged to the same category (either Oxford or Cambridge). One key was allocated to respond to an Oxford target and one key to a Cambridge target. Participants were instructed to withhold their response for target-absent trials (trials with non-targets). Responses were made on an external response pad (Cedrus RB 530 response pad, Cedrus Corporation, USA). The response keys were counterbalanced across participants. The response pad was always placed at the same distance from the screen. The assignment of colour and shape to Oxford and Cambridge was counter-balanced across participants and, for each participant, the colour/patch combination always remained as originally learnt in the matching task.

The stimuli appeared 3° above or below the central fixation cross. The single targets were either the shapes or colour patches that were previously associated with Oxford and Cambridge (diamond or square, beige or orange colour patch). Redundant

targets were coloured versions of the shapes. Participants were instructed to press a key on the external button box every time either a single feature (colour patch or shape) or both features appeared for one category of stimulus. Along with the target stimuli participants also received non-target features - circle or hexagon shapes and two different shades of grey (RGB 125, 125, 125) (RGB 77, 77, 77). On a given trial there was a single shape (in/out-group/non-target all outline in black), a single colour patch (beige, orange, grey) or a coloured shape. No combination of target and non-target, and no combination of the two target types (e.g., Oxford and Cambridge) appeared at the same time. At the start of each block participants received a reminder of the target and non-target stimuli.

The experiment started with a block of 12 practice trials. Subsequently the experimental trials were arranged over 5 blocks (1200 trials) with half having a target present and the other half a non-target. Within each block (240 trials) the probability of target/non-target, in-group/out-group and single colour/single shape /redundant target was equal and random. In total, there were 300 trials with in-group targets (100 single shape, 100 single colour, 100 redundant) and 300 trials with out-group targets. Each participant completed one sessions with a mini break of 2 minutes between blocks. Each trial started with a black fixation cross on a white background for 300 ms. followed by a shape/colour at 3 degrees of visual angle above or below fixation for 500 ms. The inter-trial interval varied randomly between 800 and 1200 ms. The experiment was implemented in Matlab (32-bit version R2012a; The MathWorks, Natick, MA).

Data analyses

The data were corrected for very fast responses using the "twin-killing" method with the threshold set at responses < 120 ms. (Eriksen, 1988; Gondan & Heckel, 2008;

Miller & Lopes, 1991; Ulrich et al., 2007). In this method, "*a trial is subtracted from the RT distribution of correct responses whose latency equals or approximates the latency of one of the error trials*" (Eriksen, 1988). I first conducted tests of simple redundancy gains on mean RTs. The second analysis also examined redundancy gains, but compared the mean RT on redundant target trials with the mean RT for the faster of the two single target trials for each subject. The fixed favoured dimension test (see Miller & Lopes, 1988; Mullin, Egeth, & Mordkoff, 1988) is more conservative than the simple redundancy-gain test and controls for the redundancy gains resulting from one attribute being processed faster than the other. I next tested our data for violations of the race-model inequality (Miller, 1982; Mordkoff & Yantis, 1991). Finally I evaluated capacity measures for in and out-group targets to assess whether for the redundant targets the signals interact or are processed in parallel.

Formal tests of non-independent processing

The goodness of fit of the data to independent race models and co-activation models were tested by examining the cumulative distributions of reaction times in the redundant and single-target conditions, comparing the cumulative distribution function (CDF) for redundant target trials relative to the sum of the probabilities for responses to either single target (see Yankouskaya et al., 2014).

According to the independent race model (Miller, 1982) the probability of decisions to the redundant targets within a given time period cannot be greater than the sum of the probabilities for responding to each single target. However, if the probability of decision times to the redundant target exceeds the sum of the probabilities for responding to each single target, then the independent race model is violated. In addition, Townsend and Wenger (2004) suggest that, in order to investigate whether the processes are

independent or interactive, the capacity of the processing system should also be taken into consideration. The capacity is a measure of workload and depicts the efficiency of the performance in the task. The important point here is whether adding extra elements facilitates processing and therefore leads to more accurate and faster decisions, or whether increasing the number of the elements adds extra load to the system and results in less accurate and slower decision times. Increasing the number of elements would lead to more efficient performance (both more accurate and faster decisions) if the elements interact positively and enable the system to operate with super-capacity. On the other hand, if the elements interfere then adding extra elements would cause additional load and reduce performance, indicating that the system operates with limited capacity. A third possibility is that the elements are processed independently from each other. In this case increasing the number of the elements should not affect performance. Here, the system would be said to operate with unlimited capacity.

Based on the capacity formula taken from Townsend and Wenger (2004) (also see Townsend & Ashby, 1983; Townsend & Eidels, 2011), "*the value of capacity is a ratio of the logarithm transformations of two quantities: In the numerator is the natural logarithm of the survivor function—the complement of the cumulative distribution function, of the redundant RTs, and in the denominator is the sum of the natural logarithms of the two survivor functions—one for each channel—for the single-target RTs"*. Therefore, if for the redundant target the processes interact in a facilitatory manner, the capacity coefficient should exceed a value of 1 (demonstrating super-capacity). If the processes are independent the system should operate with unlimited capacity and the capacity coefficient should be equal to 1.If elements interfere, then the capacity coefficient will be less than 1 (demonstrating limited capacity).

Following prior work showing violation of independence for self-related stimuli, I

predicted that there would be greater perceptual integration for in-group stimuli and this would lead to stronger evidence for non-independent co-active (and super-capacity) processing. For targets associated with the out-group, a similar violation of independent processing would not occur.

Evaluating the independent race model

I evaluated the independent race model inequality (Miller, 1982) using cumulative probability density functions (CDFs) of the RTs for each single target and for the redundant targets.

The independent race model. This model holds that:

$$\boldsymbol{G_{SC}(t) < G_{S(t)} + G_{C(t)}}$$

Where G(t) is the probability that a response has been made by time t; SC refers to redundant targets, S and C refer to a target defined by shape or colour, respectively.

The G_{SC} variable, in inequality 1, sets an upper limit for the cumulative distribution function of a correct response at any time (t), given redundant targets (SC). According to the independent race model the redundant target (SC) should not exceed this upper limit because the mean of the minimum of two random variables (SC) is less than or equal to the sum of smaller means of both variables (S and C). However, if the probability of responding to redundant targets exceeds the sum of the probabilities to each single target, then the independent processing model is violated, consistent with two variables co-activating a common response (Miller, 1982). To evaluate these models empirical CDFs for all target conditions were estimated for each participant. The calculation for testing the independent race model inequality was conducted using the algorithm introduced by

Ulrich et al. (2007). First, all 100 RTs generated by each participant for each target condition were sorted in ascending order to estimate 19 percentiles (5^{th}-95^{th} at 5% intervals). Then, these values were averaged across participants to produce the composite CDFs for the redundant targets and for each single-target condition. To produce the sum of CDFs for S and C trials, the RTs for these trials were pooled and 19 quintiles were estimated based on the fastest 100 of the 200 trials. All calculations were conducted with a MATLAB script (Ulrich et al., 2007). To test effects of group association, the same procedure was conducted separately for single (S &C) and redundant (SC) targets representing Oxford and Cambridge. For 19 percentile points the CDFs were calculated for each participant and then averaged to produce the CDFs for the whole group of participants. Finally, paired two-tailed t tests were conducted to assess the reliability of the difference between G_{SC} and the sum of G_S and G_C at each percentile point.

Estimating the capacity coefficient, C(t).

Subsequently I computed the capacity coefficient. The capacity coefficient is a measure for quantifying changes in performance due to 'workload' as a stimulus is processed. The core concept is that, if the capacity coefficient is > 1, then the stimuli are processed with super-capacity; in contrast, if the capacity coefficient is < 1 then there is some limitation in processing redundant stimuli (see Wenger & Townsend, 2001).I used a method of computing the capacity coefficient proposed by Townsend and Eidels (2011) for the OR task used by Yankouskaya and colleagues (2014).

$$\boldsymbol{C_{OR}(t)=\frac{-log[S_{SC}(t)]}{-log[S_S(t)]-log[S_C(t)]}}$$

The original computation was based on the equation introduced by Townsend and Nozawa (1995). Here the capacity coefficient was computed using survivor functions with the survival function of the redundant targets in the numerator and the product of the survival functions of the two single-target conditions in the denominator. First, for each condition I calculated the empirical CDF using 10 ms. time bins. Then the empirical survivor function was computed for each condition at each time bin. This was simply the complement of the cumulative distribution (the proportion of trials that were slower than the specified RT). After averaging the CDFs for the redundant targets and either corresponding single target, the data were converted into survivor functions in order to create integrative hazard functions. The capacity coefficients for targets with regard to their group relevance (in and out-group) were subsequently generated by creating a ratio of the averaged hazard functions at each time bin (Chechile, 2003; Hugenschmidt, Hayasaka, Peiffer, & Laurienti, 2010). Confidence intervals were defined for each capacity coefficient separately for in and out-group targets using a bootstrapping technique. All computations were performed with MATLAB (Townsend & Eidels, 2011).

Results

Mean accuracy

In general, participants were very accurate, with mean miss rates below 5%. Participants did not make more misses on redundant-target trials than they did on single-target trials and the miss rate did not differ for targets representing Oxford compared to Cambridge. Error rates were low and not analyzed further (e.g., Palmer et al., 2000). The mean accuracy rates are shown in Table 10.

Mean RT

I first tested whether there was any overall redundancy gain and whether this was modulated by group association. A 2 × 2 repeated measure ANOVA compared the RTs for redundant targets for in and out-group stimuli to the average of the RTs to single targets. There was a main effect of redundancy, $F(1, 15) = 68.35$, $p < .001$, $\eta 2 = .820$. There was also a significant main effect of group association, $F(1, 15) = 19.23$, $P < .001$, $\eta 2 = .562$. The interaction between group relevance and redundancy was also significant, $F(1, 15) = 9.21$, $p < .008$, $\eta 2 = .380$. To disentangle the interaction I calculated the redundancy gain by subtracting the RTs for redundant targets from the average RTs for single targets and compared the values for the in-and out-group stimuli. The magnitude of the redundancy gain was significantly larger for in-group compared to out-group items, $t(15) = 3.03$, $p < .006$, $d = .75$ (mean difference (ms.) ± SD, 23±30).

The second analysis examined redundancy gains and compared the mean RT on redundant-target trials with the mean RT for the faster of the two types of single-target to control for the favoured dimension. As before, a 2 × 3 repeated measure ANOVA was conducted with group (in vs. out) and target (single colour vs. single shape vs. redundant) as repeated measures factors. The single colour target was chosen as the favoured dimension as it was on average responded to more rapidly than the single target shape (for the in-group the mean RT (ms.) ± SD on single colour targets = 478 ± 62, single shape targets = 532 ± 69; for the out-group the mean RT± SD on single colour targets = 512 ± 65, and single shape targets = 525 ± 68). There was a significant main effect of group, $F(1, 15) = 12.77$, $p < .003$, $\eta 2 = .460$, along with significant main effect of target, $F(2, 30) = 27.61$, $p < .001$, $\eta 2 = .648$.

The interaction between group and target was also significant, $F(2, 30) = 17.39$, $p < .001$, $\eta 2 = .537$. To understand the interaction I conducted separate analyses for in- and

out-group targets. For in-group stimuli, RTs on redundant target trials were significantly faster than those on single colour target trials, $t(15)= 4.51$, $p < .001$, $d = 1.12$ (mean difference (ms.) ± SD = 31±28). Similar results were obtained comparing the RTs on single colour and redundant target trials for out-group stimuli, $t(15)= 4.77$, $p < .001$, $d = 1.19$ (mean difference (ms.) ± SD = 29±24). The results are depicted in Figure 14. Mean accuracy on different targets are shown in Table 10.

Table 10

Mean accuracy on single (colour or shape) and redundant targets.

Group	ACC		
	Colour	Shape	Redundant
In-group	.96	.94	.98
Out-group	.95	.94	.96

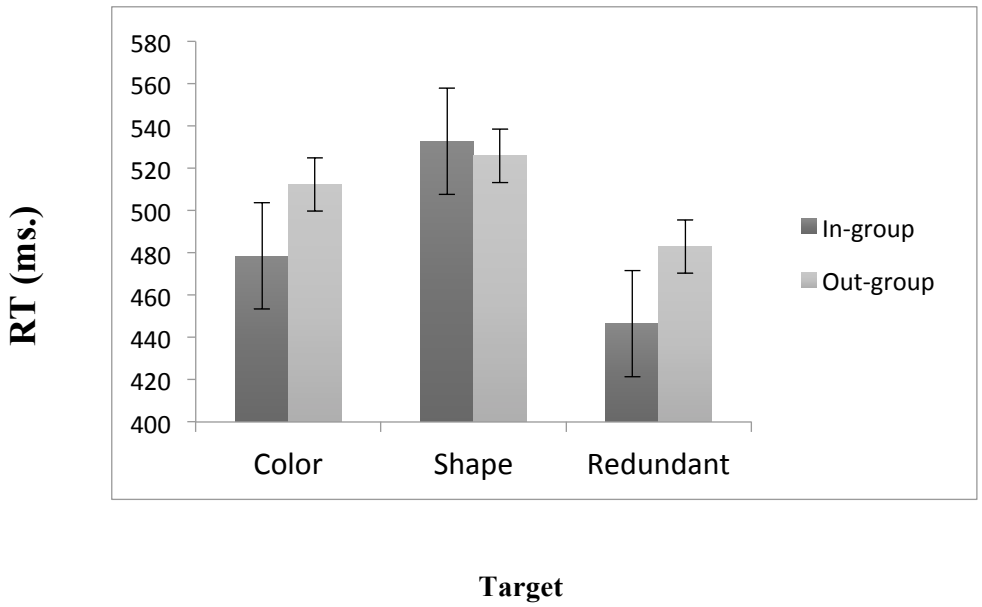

Figure 14. Mean RT (ms.) for single (colour or shape) and redundant targets. The error bars represent standard error.

Tests of the race-model inequality

The independent race model inequality (Miller, 1982) posits that, for the independent race model to hold, the probability of a response in the redundant target condition should never exceed that for the sum of two single targets. Initial visual inspection of the graphical representation of our results revealed that violations of the independent race model occurred at more than one percentile. Therefore, to control for the Type I error in multiple comparisons, I set the significance level at $p < .014$ (Benjamini, Drai, Elmer, Kafkafi, & Golani, 2001).

Out-group target

The CDF for redundant targets associated with the out-group fell to the right of the sum of the single-target CDFs for out-group target. Therefore, the independent race model was satisfied (Miller, 1982) and not violated. There were no quantile points at which the redundant targets CDF exceeded the sum of the single-target CDFs for out-group target. This was confirmed by the results of paired sample t-test for the first three quintiles ($.20 < ps <. 38$). Graphical representations of the CDFs for redundant targets, the colour target, the shape target, and the sum of the CDF for two single targets for in-group are depicted in Figure 15 (the left side plot).

In-group target

There was a range of values for which the race-model inequality was violated. These violations were statistically significant at the first, second and third quantiles for in-group targets. For 3 of the 19 quintiles tested the observed violation was significant, $ps < .01$ (for the first percentile, $t(15) = 3.07$, $p < .008$, $d = .76$, mean difference (ms.) ± SD = 21 ± 27, for the second percentile, $t(15) = 2.99$, $p < .009$, $d = .74$, mean difference ± SD =

16 ± 22, for the third percentile, $t(15) = 3.75$, $p < .002$, $d = .93$, mean difference ± SD = 18 ± 20). Graphical representations of the CDFs for redundant targets, the colour target, the shape target, and the sum of the CDF for two single targets for in-group are depicted in Figure 15.

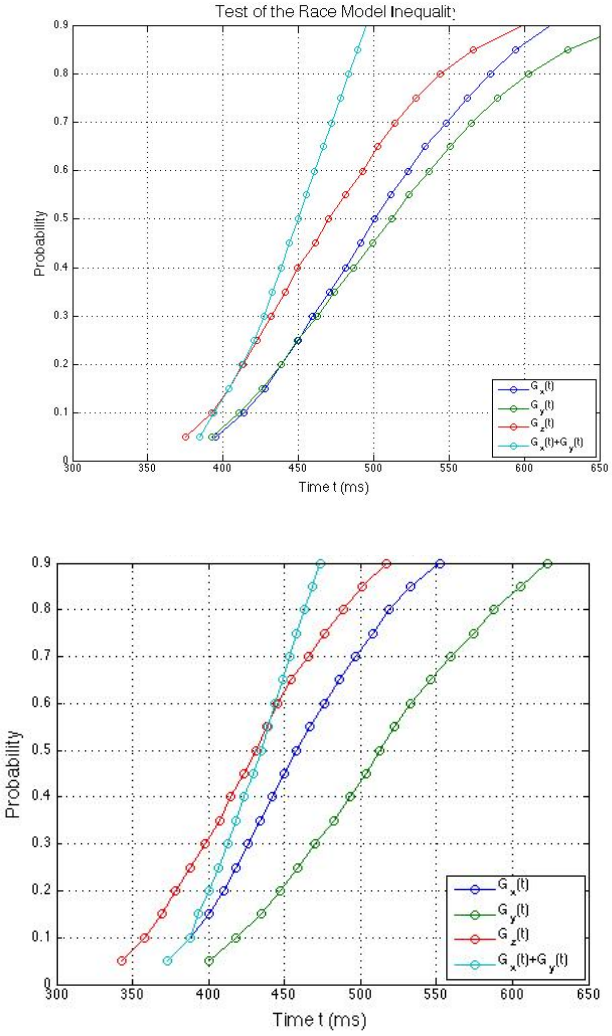

Figure 15. Graphical representation of the redundancy effect at the group level. The graph at the top represents out-group and the one at the bottom represents in-group target. In the graph, x represents the colour target, y represents the shape target and z represents the redundant target.

Testing the capacity coefficient

The overall capacity coefficient was calculated from the mean capacity coefficients between two endpoints using a bin size of 10 ms. The lower endpoint was the maximum of the 5th percentiles for the three conditions (redundant-target, a colour and a shape) and the upper endpoint was the minimum of 95 percentiles for the three conditions. The overall capacity coefficient (defined on the group level similar to Yankouskaya et al., 2014) for in-group targets was 1.97 (Figure 4). This indicates super-capacity in processing a combined shape and colour associated with the in-group (capacity>1). In contrast, the overall capacity coefficient for the out-group targets was 0.92, suggesting unlimited capacity processing (capacity = 1; Figure 16) (Townsend & Wenger, 2004; Wenger & Townsend, 2001). The results suggest that, when information about two in-group signals is pooled together, this results in increased processing speed and more efficient processing. In contrast, increasing number of stimuli associated with out-group targets does not affect the efficiency of processing. It has to be noted that the peak capacity (C=4.2) for the in-group targets (defined as the maximum point for capacity) corresponds the earlier time of response (≈ 380 ms.), whereas the peak capacity (C=1.21) for the out-group targets appears at later (≈ 420 ms.) response time (Figure 16). This may indicate that the integration of in-group signals occurs at earlier stage of processing.

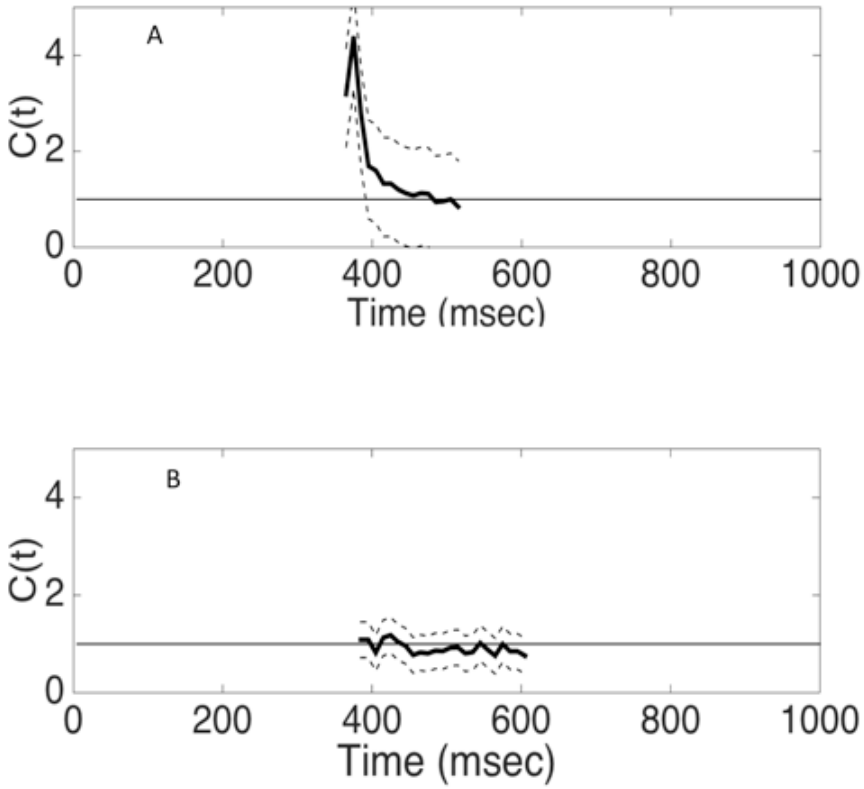

Figure 16. Capacity coefficients for the in-group target at the group level. The figure at the top represents the in-group target and the figure at the bottom represents the out-group target. The horizontal line at C(t) _ 1 indicates the reference value for unlimited capacity. The grey line features the capacity coefficients at a given time bin; the confident interval for capacity coefficient is shown in light grey.

Discussion

I tested whether group association with neutral targets had any effect on the interactions between the processing of colour and shape. I found that an average redundancy gain in the processing of colour and shape was present for both in and out-group targets. However, the effect was significantly larger for in-group compare to the out-group targets. Our results are in line with the previous findings by (i) Yankouskaya and colleagues (2014), who showed larger redundancy gains with the faces belonging to

the participant's own-race compared to that of the other races, and (ii) Sui et al. (in press), who found larger redundancy gains for shapes associated with the self- compared with other people. While Yankouskaya et al. (2014) showed that the magnitude of the redundancy gain for displays containing both identity and expression targets varied as a result of experience with other-race faces, I found effects of novel associations established to in- and out-groups.

I demonstrated that the independent race model was violated for redundant in-group targets but not for targets associated with the out-group. The violation of the race model inequality for in-group targets rules out models assuming independent processing regarding each target feature. This further confirms that higher level social factors such as group relevance affect perception. I used an OR task (Townsend & Eidels, 2011), in which either target can elicit a positive signal for target detection. However, if both dimensions of the same target are present it can strengthen the target present signal, generating a faster response. Our data indicate that this strengthening of the target present signal occurs for in- but not out-group stimuli. Given that violations of non-independent processing are more prevalent when features belong to a single compared with multiple objects (Mordkoff & Yantis, 1993; Yankouskaya et al., 2012, 2014), I argue that integration of the perceptual features of the stimuli is greater for in-group compared with out-group items (see also Sui et al., 2015).

In accounting for their evidence with self-associated stimuli, Sui et al. (2015) proposed that self-association acts as a form of 'perceptual glue', than helps to integrate features. The integrative glue provided through self-association can also help explain the literature on enhanced memory for self-associated items compared with stimuli associated with other stimuli (Conway, 2005; Conway & Pleydell-Pearce, 2000; Cunningham, Turk, & Macrae, 2008). Here I propose a similar account for in-group as opposed to self-

association. I suggest that in-group association provides enhanced 'perceptual glue' that facilitates the integration of stimulus features, and this in turns generates non-independent processing of the features when they redundantly signal the presence of a target. It is interesting to note that the capacity analyses complement this argument, indicating that in-group stimuli are processed with super-capacity. For out-group stimuli, however, there appeared to be unlimited independent processing (average capacity value close to 1). In their study using redundant shapes, Sui et al. (2015) reported capacity limitations in processing shapes associated with non-self items (e.g., a friend) (average capacity values < 1). The evidence for unlimited capacity here may arise because colour and shape stimuli are drawn from separate rather than a single visual dimension. There is prior work indicating that colour and shape can be processed and attended independently (e.g., Garner & Feldody, 1970).

The current results can be interpreted in terms of the saliency of the in-group relevant signal. From an evolutionary point of view it can be argued that any signal relating to the in-group is of great importance for the individual's survival (Spoor & Kelly, 2004). Being in a group provides an individual with more resources and therefore the group signal may automatically gain saliency for perception (Dunbar, 1993; Neuberg & Cottrell, 2006). This results in faster responses and better information integration for in-group relevant signals in the environment.

I can also speculate on the conditions under which there is unlimited perceptual capacity for out-group targets, noting that this might hold predominantly when the out-group target does not signal threat (Cottrell & Neuberg, 2005). When the out-group is threat related, then either attention may focus on a single feature and there may be limited capacity processing or there may be enhanced capacity processing of both elements. This remains a question for future research.

Another point deserving extra attention is the effect of familiarity that previously was shown to play a pivotal role in processing in and out-group face targets (Yankouskaya et al., 2012, 2014). I ruled out the effect of familiarity in redundancy gains for the in-group as, with similar levels of familiarity and liking attached to the shapes and colours, I still found effects of in-group relevance. This finding is important in that it confirms that the motivational relevance of in-group is enough to facilitate the perception for in-group target.

Overall, the findings provide strong evidence against an independent race model of target discrimination and suggest there is integration of target features which is modulated by in-group bias.

Chapter 5

In-group identification modulates inhibitory control over saccades

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This chapter is *under revision* in the *Quarterly Journal of Experimental Psychology.*

Abstract

I used eye-tracking to study the effects of in-group identification on pro- and antisaccades. Using a central coloured cue, football fans were instructed to look at the target on prosaccade trials or its mirrored position on antisaccade trials. The targets were badges of either the favourite team of the fans (the in-group), its closest rival (the out-group) or a non-local (neutral) team. On antisaccade trials participants made more directional errors for the in-group badge compared to the badges of neutral and rival teams. Moreover, participants took longer to correct their directional errors for in-group stimuli compared to similar corrections for neutral and rival teams. Correlational analyses revealed that the number of directional errors to in-group stimuli on antisaccade trials was positively correlated with vicarious reward and satisfaction toward the participant's own team. A control study with individuals who were not football fans did not yield any significant differences between the contrasting badges, ruling out effects of low-level, stimulus-related differences. The findings suggest that in-group identification can modulate inhibitory control over antisaccades, making it difficult to resist making an eye movement to an in-group related stimulus. The correlation between antisaccade directional errors and the satisfaction and vicarious reward scores further confirms that the effects can be explained in terms of reward and motivational relevance of in-group stimuli. Eye-tracking technique can offer a useful means of evaluating implicit in-group bias.

Keywords: Prosaccade, Antisaccade, In-group, Out-group, Prejudice

Introduction

Eye-movements are an intrinsic part of human social cognition (Chartrand & Bargh, 1999; Frith & Frith, 2006; Itier & Batty, 2009) – for example, serving as attentional cues as to stimuli that others find of interest in a scene (Frischen, Bayliss, & Tipper, 2007). In addition, the eye movements an individual makes within a scene can provide information about their social interests (Itier & Batty, 2009; Yarbus, 1967).

Within eye movement research, many studies have examined the contrast between pro- and antisaccade tasks. Prosaccade tasks represent the 'natural' action in viewing scenes, which is to direct an eye movement to a new imperative stimulus. Antisaccade tasks are the opposite and require participants not to make the natural response (the prosaccade) but to look away from the stimulus. Therefore, to perform an antisaccade action, there needs to be inhibitory control over the naturally occurring prosaccades (Everling & Fischer, 1998). In line with this, previous studies have shown poor antisaccade performance in a variety of clinical populations with impaired inhibitory control (including patients with Parkinson's disease (Briand, Strallow, Hening, Poizner, & Sereno, 1999), Alzheimer's disease (Amieva, Phillips, Della Sala, & Henry, 2004; Fletcher & Sharpe, 1986) attention deficit hyperactivity disorder (O'Driscoll et al., 2005), and schizophrenia (Hutton & Ettinger, 2006; McDowell et al., 2002).

Impaired performance on antisaccade tasks as a result of poor inhibitory control has been also reported in healthy children (Munoz, Broughton, Goldring, & Armstrong, 1998) and older adults (Butler & Zacks, 2006). For over five decades, a large body of research have been conducted into the neural structures underlying the generation and control of saccadic eye movements (for example, see Ettinger et al., 2008; Gaarder, Krauskopf, Graf, Kropfl, & Armington, 1964; Munoz & Everling, 2004).

Together these studies have found a large distributed network in the brain supporting pro- and antisaccade eye movements including but not limited to the intraparietal sulcus (IPS), the frontal eye fields (FEF), the supplementary eye fields (SEF) and the dorsolateral prefrontal cortex (DLPFC) .More importantly in both human and primates, frontal structures including FEF have been shown to particularly involve in preparation and inhibitory control of antisaccades (Everling, & Munoz, 2000; Rivaud, Müri, Gaymard, Vermersch, & Pierrot-Deseilligny, 1994). This is consistent with the line of research into the specific role of frontal cortex in inhibitory control (for example see, Aron, Robbins, & Poldrack, 2004) with the evidence suggesting that damage to this area leads to impaired performance in antisaccade task (Guitton, Buchtel, & Douglas, 1985).

The contrast between pro- and antisaccades can also be informative about the attention-demanding properties of stimuli (Kissler & Keil, 2008). For example, the emotional relevance of the stimuli has been shown to differentially modulate pro and antisaccades. Kissler and Keil (2008) had participants make pro- and antisaccades towards or away from highly arousing pleasant and unpleasant pictures. They found that high emotional content in the pictures (both pleasant and unpleasant) facilitated prosaccades but disrupted antisaccades (generating more incorrect eye movements to the stimuli). Emotional disorders such as anxiety and social phobia have also been shown to disrupt inhibitory control over antisaccades and to expedite the execution of prosaccades (Ansari & Derakshan, 2011; Wieser, Pauli, & Mühlberger, 2009). These findings provide evidence that, along with low-level physical stimulus properties that are known to affect the deployment of spatial attention and subsequent eye movements, more complex factors such as the emotional relevance of the of stimuli can also modulate the eye movements.

Recent studies have also shown that eye movements are sensitive to the social relevance of stimuli to the observer. For example, in a visual search task, Alexopoulos, Muller, Ric and Marendaz (2012) had participants detect a target (here letter O) in a display containing three distractors (letter Q). Before the onset of visual display, a spatial cue was presented (Muller & Butera, 2007) for a very short time (235 ms.) and was either the participant's own name, the name of a familiar person or the name of a stranger. Across three different experiments, Alexopoulos and colleagues (2012) showed that participants were faster looking at the target proceeded by own – name as a valid (spatially relevant) cue compared to targets spatially cued by another person's name. Since the cueing time was short they suggest that this effect was automatic and beyond the reach of intentional control (see Briand, 1998). Indeed, using as a cue the name of a familiar known person did not result in a similar advantage to that brought about by the own name cue. From this the authors argued that the effect was not mediated by the familiarity of the self-relevant cue. In addition, in an antisaccade version of the task (where the cue consistently fell on the opposite side of fixation to the target), Alexopoulos and colleagues (2012) found that participants made more errors by incorrectly directing eye movements toward their own name (cue) compared to another person's name (see also Morand et al. (2010) for evidence on the difficulty of making antisaccades away from faces as social stimuli). Together these studies seem to suggest that social relevance attracts the visual orientation and therefore reduces the inhibitory control over antisaccdes.

In the present study I assessed whether these effects of socially important stimuli on pro- and antisaccades extend beyond own name and face stimuli to include effects of stimuli associated with in- and out-group relationships. To do this, I had participants carry out pro and antisaccade tasks to stimuli associated to their in-group

(the badge of their favourite football team), a rival out-group (the badge of the local rival team) and a neutral out-group stimulus (the badge of a team that participants rated as having no importance to them). I asked whether there was any advantage on the latency and accuracy of prosaccades toward the badge of the participant's own team compared with the other teams. I further asked whether there was any effect of in-group identification on performance in the antisaccade task. For example, does the motivation to look at one's favourite football badge result in a higher number of directional errors in the antisaccade task for own vs. rival/neutral badges? Moreover, I asked whether the familiarity of badges per se was enough to drive the differential pattern of looking behavior or whether the in-group identification was necessary. To disentangle the underlying mechanisms that might affect the inhibitory control in visual orientation I used two sets of questionnaires. The first questionnaire measures the strength of different subcomponents of in-group identification (Leach et al., 2008). The second questionnaire measures the different facets of in-group identification in football (Funk, Ridinger, & Moorman, 2004).

I report two experiments. In Experiment 1, football fans performed mixed blocks of pro and antisaccades in response to the badges of the football club they supported, its closest rival or a neutral team. In Experiment 2, a group of participants with no connection to the teams, but who were familiar with the badges, performed the same task.

I hypothesised that the fans would make faster prosaccades toward the badge of their favourite football team but also slower antisaccades away from it. This pattern on pro-and antisaccade trials should be reversed for the badge of the closest rival team (i.e., participants should look away faster and make slower saccades toward the rival badge). I also predicted that the urge to look at in-group badge would result in more

directional errors on antisaccade trials for these stimuli compared with the rival and neutral badges. This might reflect the attraction and pleasure attached to in-group stimulus (here favourite football team).

Experiment 2 provided a control study to test whether psychophysical differences in the stimuli per se, and/or differential familiarity with the stimuli was critical, rather than in-group identification.

Experiment 1: A study with football fans

Method

Participants

There were sixteen participants all male, mean (SD) age = 37± 6, range = 26-45, right handed, with normal or corrected-to-normal vision, and no reported neurologic or psychiatric conditions. Participants were recruited via an online advertisement.
Prior to the experiment, all participants signed a written consent form approved by the University of Oxford research ethics committee.

Apparatus

Eye movements and pupil diameter were recorded from the left eye using a Tobii eye-tracking equipment (TX300, Tobii, Stockholm) running at 300Hz. This equipment works based on photo-electronic method. First, a nine-point calibration procedure was conducted, presenting a spinning ball of 2° of visual angle in size, all with accompanying sounds. The calibration routine was followed by a verification procedure with more animations presented at five screen locations. I included data if the verification procedure indicated fixation locations no further than 2° from the target's centre. In all cases, the accuracy was well within this limit. Calibration was repeated if the participant failed to

fixate on fewer than seven points out of nine within the defined accuracy limit. The experiment was ceased if the calibration failed for three times.

Stimuli

The target stimuli were football badges, 2 ° of visual angle in size, appearing at 9 ° of visual angle on the horizontal axis. The badges were Oxford United (In-group), Swindon Town (Rival) and Liverpool (Neutral). All the images were presented against 50% grey background. The overall luminance for the display of each image was similar in RGB space.

Procedure

Prior to the experiment participants were asked to identify each badge. They also rated the level of familiarity they had which each football club using a scale from 1 (not familiar) to 7 (perfectly familiar). Furthermore, they rated how much they liked each team from 1 (not at all) to 7 (very much). Participants also filled in the in-group identification scale, which was adopted from Leach et al.'s multicomponent in-group identification survey (Leach et al., 2008) and the football interest survey adapted from Funk et al. (2004). In both surveys participants expressed their agreement with each statement on a 7-point Likert scale from 1(strongly disagree) to 7 (strongly agree).

Participants sat 58 cm away from a 22-inch screen (51×32 degree of visual angle, 1920×1080 pixels, 100ppi, 60 Hz refresh rate) in a normally lit room with their chin on a chinrest. The experiment was implemented and run in Matlab (32-bit version R2012a; The MathWorks, Natick, MA). Each participant was tested in one experimental session, lasting about 40 minutes.

Each trial started with a black fixation cross (1° of visual angle) at the centre of the screen for 500 milliseconds. Central fixation was defined as a maintained eye position

within 2° of the cross for at least 100 milliseconds. The fixation-cross remained on the screen for a maximum of 1 second. Upon 100 ms. of successful fixation on the fixation-cross, the turned either to green or red. If it turned to green participants were asked to make a prosaccade to the target when it appeared. If the cross turned red the task was to look away (make an antisaccade) from the target. The coloured cue remained on the screen for 500 ms. Then the target appeared after a gap of 200 ms. and remained on the screen for 500 ms. An Inter-Trial Interval (ITI) of 1 to 2 second was inserted after each trial to avoid trial-to-trial directional effects (Barton, Goff, & Manoach, 2006). The timeline of a trial is presented in Figure 17, including examples of the targets. Prosaccade and antisaccade trials were presented in a random order. Each participant performed 6 blocks of 48 mixed pro- and antisaccade trials, making 288 in total. Participants were instructed to take a one-minute break after each block. Prior to the test block, there was a short practice block for the participants (12 trials) to familiarize them to the task.

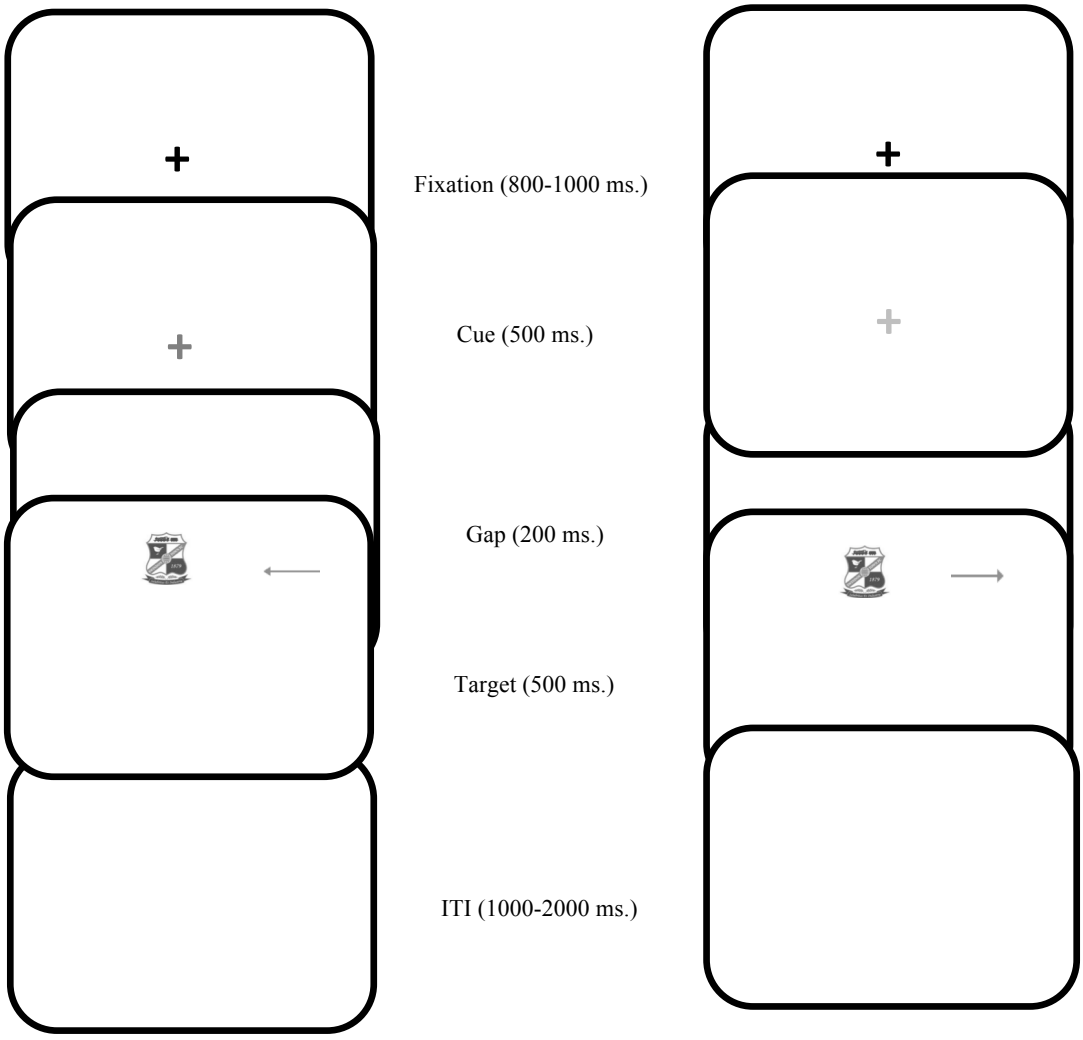


Figure 17. Example (Left) prosaccade and (Right) antisaccade task used in the Experiment. The original background was fifty percent grey and the badge was yellow and the blue representing *Swindon town football club* (Original colour red and white). The green fixation cross was used to cue the target for pro-saccade and the red was used for ant-saccade task.

Data Processing

The program sampled the eye position every 30 ms. and defined saccades as any point when the eye moved 30º of visual angle or faster per second. If the eyes did not fixate the central cross prior to cue onset the trial was discarded. This led us to reject 5 % of the trials. Trials were excluded from the analysis if there was no fixation on the cross prior to

cue onset (13 % of the trials), and if the saccadic movement had started more than 2° away from the central fixation cross (1% of the trials). On less than 1% of the trials, the eye tracker failed to register the eye movements. Trials were excluded if the saccade latency was shorter than 100 ms. or longer than 800 ms. or if saccades had starting positions more than 1° away from the central fixation cross (2% of the trials). In the remaining valid trials, I calculated the directional error rate[6], the saccade latency, saccade accuracy (amplitude) and peak velocity. I combined a custom made MatLab code together with GazeAlyze (Berger, Winkels, Lischke, & Höppner, 2012) to extract and align the eye-tracking data.

Results

All participants classed Swindon Town football club as the rival to Oxford United football club (the in-group team) and all classed Liverpool as being neutral. Each participant had been a supporter of the candidate local football club (Oxford United) for at least ten years at the time of testing (mean (SD) time= 28 ± 9, Range 14 to 42 years). On average 70% of the participants reported that the team they supported was their family's favourite too. On average participants reported that they went to 28 matches per season (range 8 to 40). The mean (SD) score for the subcomponents of the in-group identification questionnaire were solidarity = 19.68 (±1.40, max 21), satisfaction = 21.12 (±5.15, max 28), centrality = 16.62 (±4.30, max 21), in-group homogeneity = 7.93 (±2.97, max 14) and self-stereotyping =9.95 (±2.78, max 14).

The mean (SD) familiarity ratings were in-group = 6.72± .1, rival = 6.75 ± .44 and neutral = 5.5 ± .72

[6] Directional errors are responses with a horizontal vector in the wrong direction (e.g. left instead of right).

These ratings differed significantly, $F(2, 30) = 49.78$, $p < .001$, $\eta 2 = .76$, with both in-group $t(15) = 8.59$, $p < .001$, $d = 1.39$, and rival teams $t(15) = 6.61$, $p < .001$, $d = 1.65$, being rated as more familiar compared to the neutral team. The mean (SD) liking ratings were: in-group = 6.87± .08, rival =2.43±15 and neutral = 3.88 ±. 18. These rating also differed significantly, $F(2, 30) = 285.29$, $p < .001$, $\eta 2 = .95$. The differences were due to the in-group being rated as more liked than both the neutral, $t(15) = 16.43$, $p < .001$, $d = 4.10$, and rival teams, $t(15) = 24.40$, $p < .001$, $d = 6.10$. Also, the neutral team was rated as being more liked compared to the rival team, $t(15) = 7.06$, $p < .001$, $d = 1.76$. A summary of the results are shown in Table 11.

Table 11
Mean (SD) latency (ms.) and error rate (percentage) as a function of group relevance (In-group vs. Neutral and Out-group) in Experiment 1.

Group	Latency		Error rate (%)	
	Prosaccade	Antisaccade	Prosaccade	Antisaccade
In-group	163(22)	252(28)	1.81(1.10)	25(14)
Neutral	167(36)	249(29)	1.68(.70)	20(15)
Out-group	162(34)	248(30)	5.00(3.28)	18(15)

Directional errors

I used a 2×3 repeated measure ANOVA with trial type (pro vs. antisaccade) and team (in-group vs. neutral and rival) as the factors. I first tested whether there was any effect of trial type and team on the rate of directional errors. Our analysis revealed a

significant main effect of trial type, $F(1, 15) = 27.29$, $p < .001$, $\eta 2 = .64$, with more errors occurring during antisaccade trials (on average 22% ± 3 % on antisaccade trials vs. 4% ± 1% on prosaccade trials). There was also a significant main effect of team, $F(2, 30) = 4.30$, $p < .024$, $\eta 2 =. 22$. In addition the interaction between trial type and team was significant, $F(2, 30) = 17.44$, $p < .001$, ŋ2 =. 54.

To disentangle the interaction I conducted a one way repeated measure ANOVAs on pro- and antisaccade trials with team as the within-subject variable. The results on antisaccade trials showed a significant main effect of team on directional errors, $F(2, 30) = 9.37$, $p < .001$, $\eta 2 =. 39$. Post hoc comparisons revealed that this effect was due to participants making more directional errors to in-group targets compared to both the rival team, $t(15)= 2.89$ $p < .001$, $d = .72$ (mean difference (SE) = 7% ± 7.5 %) , and the neutral team, $t(15)= 3.94$, $p < .012$, , $d = .98$ (mean difference (SE) = 5% ± 7 %) , the rival and neutral teams did not differ, $t(15) = 1.40$, $p < .18$.

Analyses of directional errors on prosaccade trials revealed a significant main effect of team, $F(2, 30) = 19.70$, $p < .001$, $\eta 2 = .57$. Post hoc comparisons showed that participants made more directional errors for the rival team badge compared to both the neutral team, $t(15) = 4.58$, $p < .001$, , $d = 1.14$ (mean difference (SE) = 3%± 2.8%) and the in-group team, $t(15) = 4.39$, $p < .001$, $d = 1.09$ (mean differences (SE) = 3%± 2.5%), which did not differ from one another, $t(15) = .80$, $p < .44$. The results regarding directional errors are shown in Figure 18.

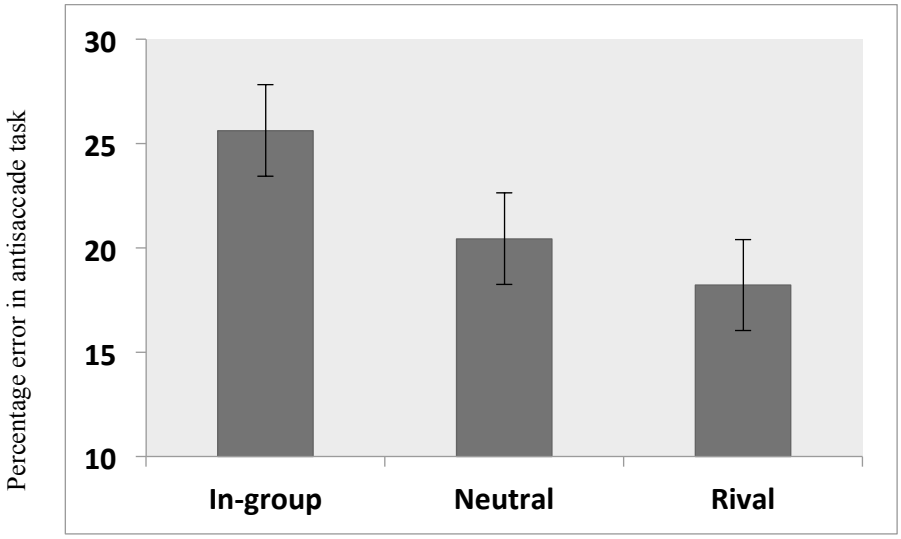


Figure 18. Mean percentage error rate in antisaccade task in Experiment 1. Error rates change as a function of group relevance. Error bars represent standard error.

Corrective saccades

Next I tested the time that it took participants to correct their directional errors. This analysis was performed only on antisaccade trials for two reasons. First, as mentioned earlier, the percentage of directional errors was much lower on prosaccade trials compared to antisaccade trials. Second, an initial inspection showed that, on prosaccade trials, participants rarely corrected their mistakes (mean (SD) = 10% ± 9%), whereas on antisaccade trials participants normally corrected their directional errors (mean corrections (SD) = 53% ± 17% of the trials). The analysis of the reaction times for corrective saccades revealed a significant main effect of team, $F(2,30) = 6.38$, $p < .005$, $\eta 2 = 30$. Post hoc comparisons revealed that, on average, participants took longer to correct their directional errors on antisaccade trials for in-group stimuli compared to both neutral, $t(15) = 3.00$, $p < .009$, , $d = .75$ (mean difference (SE) = 27± 36 ms.) and rival targets, $t(15) = 2.97$, $p < .009$, , $d = .74$ (mean difference (SE) = 19 ±26 ms.); the latter

conditions did not differ significantly, $t(15)= .98$, $p < .34$. The results regarding the latency of corrective antisaccades are shown in Figure 19.

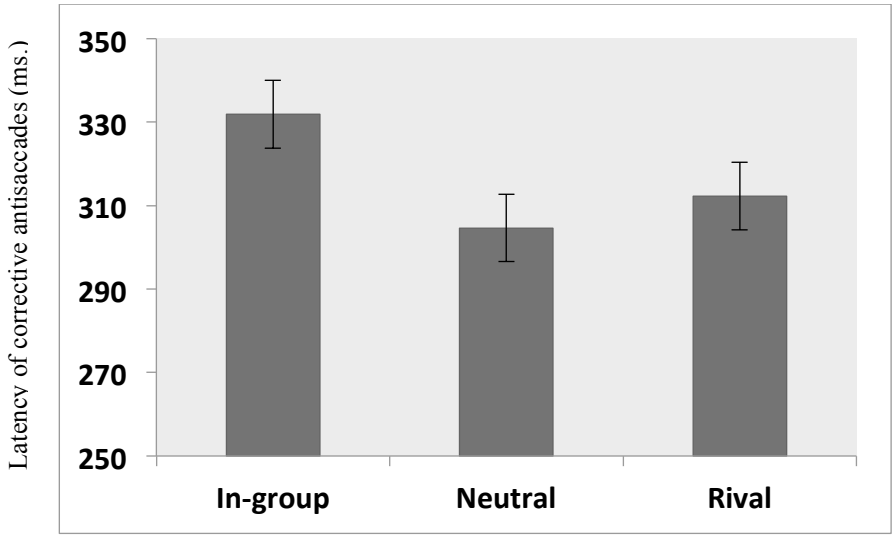


Figure 19. Mean latency (ms.) of corrective antisaccades in Experiment 1. The mean latency of corrective saccades change as a function of group relevance. Error bars represent standard error.

Latency

I used a 2×3 repeated measure ANOVA to test whether there was any effect of the trial type as well as the team on the time to initiate a saccade in a correct direction for pro- and antisaccade trials. Our results revealed that there was a significant main effect of trial type on saccade latencies, $F(1,15) = 83.84$, $p < .001$, $\eta 2 = .85$. Antisaccade trials were significantly slower than prosaccade trials (mean difference (SE) = 86 ± 29 ms.). However, there was no significant main effect of team, $F(2,30) = .04$, $p < .96$, $\eta 2 = .002$, and no interaction, $F(2,30) = .24$, $p < .78$, $\eta 2 = .016$.

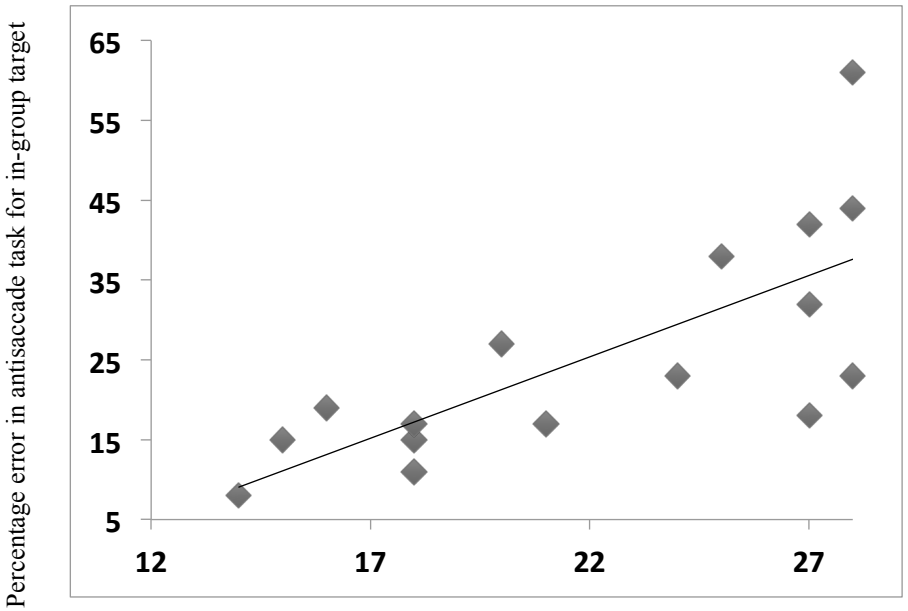
Amplitude

There was no significant main effect of trial type on the amplitudes of the eye movements, $F(1,15) = .38$, $p < .54$, no effect of team, $F(2,30) = .63$, $p < .53$, and no interaction , $F(2,30) = .61$, $p < .51$, $\eta 2 = .039$.

Correlational analyses

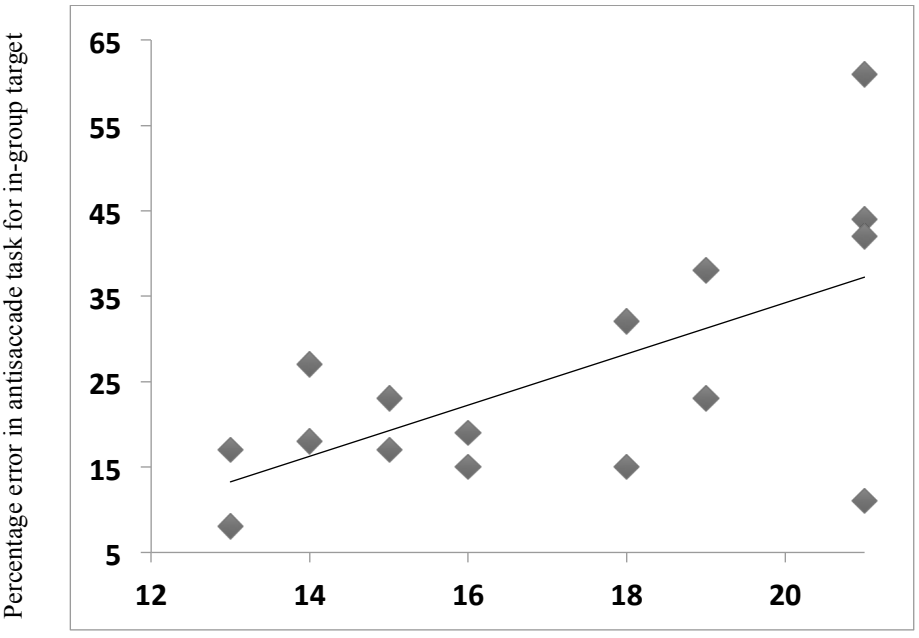
Our results indicated that the percentage of directional errors in the antisaccade task was greater for in-group stimuli relative to neutral and rival stimuli. I next investigated how this effect on directional errors might be related to subcomponents of both in-group identification and interest in football. I found positive correlations between the percentages of directional errors for in-group stimuli on antisaccade trials and both in-group satisfaction, $r = .734$, $p < .001$, $N=16$, and the vicarious achievement (VIC) subcomponent of the questionnaire on interest in football, $r = .626$, $p < .01$, $N=16$. I further investigated whether or not there was a correlation between the directional errors on the antisaccade task for in-group stimuli and directional errors on prosaccade trials for the rival team. There was no evidence for this, $r = .08$, $p < .75$, $N=16$. The results for the correlational analyses are shown in Figure 20a & 20b.

a



Satisfaction (max = 28, *N=16*)

b



Vicarious achievement (max = 21, *N=16*)

Figure 20. Correlations between antisaccade errors and behavioural measures of in-group identification. (a)The correlation between in-group satisfaction ratings and the percentage error in antisaccade task in Experiment 1. (b).The correlation between vicarious reward ratings and the percentage error in antisaccade task in Experiment 1.

Experiment 2: A control study

Experiment 2 was conducted with individuals who were not fans of Oxford United but who were familiar with football. Were there effects used based on the colours and shapes of the badges, even for non-supporters? Were there effects of familiarity outside of whether the stimuli were associated with the in-group or rival teams?

Method

Unless otherwise mentioned, the method was the same as that in Experiment 1.

Participants

Sixteen students (all male) from the University of Oxford (mean age (SD) = 27±5 years) participated. Participants were all right handed, and had normal or corrected to normal visual acuity. None of the participants reported any neurologic or psychiatric conditions. The study was approved by ethic committee of university of Oxford and prior to the experiment written consent form was taken from all participants. Participants were asked to indicate (Yes/No) whether or not they actively support a certain team and attend the matches or instead in their leisure time they watch the football matches on Television.

Results

All participants confirmed that they were interested in football and had a certain favourite team but they were not connected to any of the three teams; in addition, none had a family member who supported any of the teams. All participants also indicated that they did not attend the matches by their favourite team actively and instead they watched only some of matches on television.

The mean (SD) familiarity ratings were Liverpool = 5.1 ± .57, Oxford United = 3.93 ± .67 and neutral = 3.56 ± .62. These ratings significantly differed, $F(2, 30) = 45.00$, $p < .001$, $\eta 2 = .75$. Liverpool was rated as more familiar than Swindon Town, $t(15) = 7.34$, $p < .001$, , $d = 1.83$ and Oxford United, $t(15) = 7.26$, $p < .001$, , $d = 1.81$ Oxford was also rated as more familiar than Swindon, $t(15) = 3.00$, $p < .009$, , $d = .75$. The mean (SD) liking ratings were: Liverpool= 4.18 ± .65, Oxford United = 4.25 ± .68 and Swindon Town = 4.06 ±. 57. These rating did not differ significantly, $F(2, 30) = 1.18$, $p < .321$. Compared to the football fans, participants on Experiment 2, scored lower on the questionnaire regarding interest in football, $t(30) = 5.81$, $p < .001$, , $d = 1.06$ (Mean difference (SE) = 2.20 ± 1.4). The summary of the results are shown in Table 12.

Table 12

Mean (SD) latency (ms.) and error rate (percentage) as a function of group relevance (In-group vs. Neutral and Out-group) in Experiment 2.

Group	Latency		Error rate	
	Prosaccade	Antisaccade	Prosaccade	Antisaccade
In-group	186(94)	258(101)	13(16)	23(13)
Neutral	190(104)	238(97)	11(13)	20(14)
Out-group	192(93)	250(95)	11(11)	24(11)

Directional errors

As in Experiment 1, I used a 2×3 repeated measure ANOVA with trial type and team as within-subject variables. Our results revealed there was a significant main effect of trial type, $F(1, 15) = 12.15$, $p < .003$, $\eta 2 = .45$, with more errors occurring on antisaccade trials (on average, 23% ± 3 % of the antisaccade trials and 10% ± 2% of the prosaccade trials were initiated in the wrong direction). There no significant main effect of team, $F(2, 30) = 3.40$, $p < .065$, $\eta 2 = .18$. The interaction between trial type and team was not significant, $F(2, 30) = 1.09$, $p < .34$, $\eta 2 = .06$.

I further investigated whether familiarity played a pivotal role in driving the differential directional errors to the in-group team in Experiment 1. The difference in the familiarity scores for the highest and lowest familiarity teams in Experiment 1 (Oxford United vs. Liverpool) did not differ from the difference between the highest and lowest familiarity teams in Experiment 2 (Liverpool vs. Swindon), $t(30) = .22$, $p < .82$. Given this, I assessed whether there was a greater contrast in directional errors in

Experiment 1 compared to Experiment 2, which then would be independent of the relative familiarity of the stimuli. I conducted an ANOVA on the directional error rates in the antisaccade task with two levels of familiarity (Oxford vs. Liverpool for Experiment 1, and Liverpool vs. Swindon for Experiment 2) and a between participants variable of Experiment. The results showed no significant main effect of familiarity, $F(1, 30) = .24$, $p < .63$, $\eta 2 = .003$, and a significant interaction between familiarity and Experiment, $F(1, 30) = 12.26$, $p < .001$, $\eta 2 = .30$. As our prior analyses showed, there was an effect of familiarity in Experiment 1 (directional errors for Oxford > for Liverpool) but not for Experiment 2 (Liverpool vs. Swindon). Since the differences in familiarity were match across the experiments, this effect can be attributed to the motivational significance of the in-group team (Oxford, for Oxford supporters in Experiment 1), not the relative familiarity of the stimuli.

Corrective saccades

Taking only antisaccade trials (as in Experiment 1) I failed to show an effect of team, $F(2,30) = .94$, $p < .40$, $\eta 2 =. 05$.

Latency

There was significant main effect of the trial type on the latency of saccades, $F(1,15) = 24.72$, $p <.001$, $\eta 2 =.62$. The antisaccade trials were significantly slower than the prosaccade trials (mean difference (SE) = 58 ± 13 ms.). However, there was no significant main effect of team, $F(2,30) = .65$, $p < .54$, $\eta 2 = .04$, and there was no interaction, $F(2,30) = 2.06$, $p < .15$, $\eta 2 =.12$.

Amplitude

There was no significant main effect of trial type, $F(1,15) = .37$, $p < .56$, or the group, $F(2,30) = 2.10$, $p < .14$, $\eta 2 = .11$, and no interaction $F(2,30) = 1.55$, $p < .23$, $\eta 2 = .09$.

Discussion

In contrast to the data from Experiment 1, when the performance of football fans was assessed, there was no effect of presenting the former in-group, neutral and rival team badges on eye movements of the participants here, who were not fans of any of the teams used. This indicates that effects on eye movements in Experiment 1 could not be due to the psychophysical properties of the stimuli that were used (e.g., the colours of the Oxford United badge vs. that of Liverpool or Swindon Town). If the yellow and blue of the Oxford United badge had automatically attracted attention, then I should have seen equivalent effects here to those I observed earlier. I did not.

A second interesting aspect of the study is that the participants here did show differential familiarity for one of the teams (Liverpool) over the others (Oxford United, Swindon Town). This is not surprising given that, at the time of testing, Liverpool play in the Premier League and Oxford United and Swindon Town in lower divisions of the English football hierarchy. The differential familiarity favouring Liverpool over Swindon Town was at least as high as that favouring Oxford United over Liverpool for the participants in Experiment 1, and greater than the rated difference in favouritism for Oxford United over Swindon Town in the earlier study. Despite this there was no evidence of eye movements being attracted to the Liverpool team badge here, and the attraction to Liverpool over Swindon Town here was less than that for Oxford United to Swindon Town in Experiment 1 (although Oxford Town and Swindon Town were rated as equally familiar [as rival teams] by the participants in Experiment 1). These data

provide direct evidence against the idea that the effects of the in-group badge, in Experiment 1, were due to familiarity.

I finally note that I did find standard effects of pro- vs. antisaccades here; antisaccades were slower to initiate and more likely to be in the wrong direction than prosaccade trials. However, unlike Experiment 1, the effects were not modulated by in-group identification.

General Discussion

Our findings are the first to show that in-group favouritism affects the inhibitory control of looking behaviour. Experiment 1 used fans of Oxford United football team and compared pro- and antisaccades to badges of Oxford United, Swindon Town (the rival team) and Liverpool (neutral team). Despite rating the badges of Oxford United and Swindon Town as equally familiar, eye movements to the two badges differed. Prosaccades were more likely to be directed to the in-group badge (Oxford United) and the neutral team badge (Liverpool) relative to the rival team badge (Swindon Town), this suggests a bias against looking at the rival team badge. In addition, antisaccades were more difficult to make (generating more directional errors) to the in-group badge compared to the rival and neutral team badges. This indicates that either there was an automatic pull of saccades to the in-group associated stimulus or that it was more difficult to inhibit any tendency to orient to such stimuli. Furthermore, once a directional error was made on an antisaccade trial, participants tended to look longer at the in-group badge compared with the out-group and neutral team badges. This is consistent with the in-group badge not only attracting attention (and an incorrect prosaccade on an antisaccade trial) but also holding attention to the stimulus, once the stimulus was fixated.

In contrast to the data from football fans (Experiment 1), I found no differential effects of the badges in Experiment 2, when I tested participants who were not fans of the specific teams I used. There are two interesting points here. One is that the null effect of the badges indicates that it was not the intrinsic visual properties of the badges (their shape or colour) that led to the varying effects on eye movements in Experiment 1, otherwise the same effects should have been found here. The second is that the participants in Experiment 2 rated their familiarity with Liverpool as being higher than that with the other teams, and the difference in familiarity between the teams was higher than that between the in-group and rival teams in Experiment 1 and at least as high as that between the in-group and neutral teams in that experiment. Despite this, the badges did not differentially affect eye movement behaviour in Experiment 2. The data indicate that performance was not affected either by the psychophysical properties of the stimuli or by differences in familiarity.

Two other results in Experiment 1 were that positive correlations were found between the percentages of directional errors for in-group stimuli and both in-group satisfaction and the degree to which individuals experienced vicarious achievement in relation to their in-group team. These findings suggest that a critical factor in driving the results was the in-group motivational association participants had with their favourite football team. Individuals experiencing greater in-group satisfaction and vicarious achievement will have a higher degree of motivation related to the team. In-group relevant stimulus has been shown to automatically associate with positive concepts (for review see Olson & Fazio, 2003). This might indicate that in-group relevant stimuli evokes pleasure and satisfaction and this in turn impairs the inhibitory control over antisaccdes away from in-group stimuli.

Our data indicate that in-group relevance has an automatic effect on eye movement behaviour, disrupting the task-specific requirement to look away from the team's badge, on antisaccade trials. Alongside this, there was also some evidence for a bias away from the rival team, on prosaccade trials. However, I did not find any relation between such errors and measures of in-group identification. Also the prosaccade errors to the rival team did not correlate with the antisaccade errors to the in-group team. These null correlations might be because prosaccade errors were relatively few in number, generating insufficient variance to detect using a correlatory approach. Since I did not measure any negative views on rival, I was unable to interpret these errors based on the potential underlying attitudes against the rival team. A further possibility is that the questions I used were not sufficiently sensitive to detect a difference between those participants more prone to bias against the rival team. These caveats aside, however, the lack of correlation between the pattern of directional errors on pro and antisaccades trials might suggest that these are independent factors. In other words, individuals can be biased toward their in-group without being biased against the rival or vice versa. Consistent with this notion, previous studies have reliably showed that in-group favouritism is not the flip side of out-group derogation (Buttelmann & Böhm, 2014; Hewstone et al., 2002; Lewis, Kandler, & Riemann, 2014).

Future research may start to examine the generalizability of these effects and whether the effects of in-group identification on basic aspects of eye movement behaviour can predict prejudice in real life. However, since our measure of in-group favouritism was not apparently tied to prejudice against the out-group, unravelling the interaction between these two factors in the context of visual attention will be challenging.

Chapter 6

An implicit window into in-group bias: Evidence from pupillary responses and directional saccade errors

Abstract

The implicit effect of in-group motivation on saccadic behaviour is largely unknown. Here, I explored this issue in pro and antisaccade tasks using simple abstract targets - circles in different colours - representing different university rowing teams (in-group team, neutral team, rival team). I found a higher rate of directional errors in the antisaccade task for the in-group compared with the rival team. I also examined the changes in pupil size as a function of task and in-group motivation. Pupil diameters increased for the more difficult, antisaccade task. In addition, pupil diameters were also increased for the in-group even on the prosaccade task, dissociating this pupil diameter effect from the effect of task difficulty. Furthermore, at a late time window the effects of the group were modulated by the task, with group differences decreasing in the antisaccade relative to the prosaccade procedure. The data indicate dissociable effects of task difficulty and positive motivation on pupil responses, along also with a late-acting suppression of the motivational response when the motivated action has to be inhibited (on antisaccade trials). The procedure provides a new way to study implicit in-group favouritism, with general application to the field of psychobiology.

Keywords: In-group, Out-group, Pupil, Directional errors, Prosaccade, Antisaccade

Introduction

Recent studies have revealed that motivational factors including reward and group relevance modulate the nature of saccades (Watanabe, Lauwereyns, & Hikosaka, 2003). For example, it has been shown that group relevance affects the latency and accuracy of saccadic eye movements towards target items (Ciardo, Marino, Rossetti, Actis-Grosso, & Ricciardelli, 2013; Liuzza et al., 2011; Wu, Laeng, & Magnussen, 2012).

In addition to this, the emotional and social relevance of stimuli (Karatekin, 2004; Porter, Troscianko, & Gilchrist, 2007; Silk et al., 2012) has been shown to affect pupil size. For instance, pupil diameters increase when an observer views members of his or her in-group (e.g., a face from the same racial category) relative to when members of an out-group are viewed (e.g., a face from a different racial category; Azevedo, 2012; Avenanti et al., 2010; Brown, Bradley, & Lang, 2006; Yabar et al., 2006). For example across different studies, larger pupil dilation has been reported when viewing out-group faces as oppose to in-group ones (for example see Wu et al., 2012). Since most tasks in this vein are focused on memory for faces this differential pupillary response for in- vs. out-group faces could reflect both the ease of encoding of own race faces as well as more positive emotion toward in-group faces.

There is also evidence linking pupil size to the difficulty of the cognitive task. For example, pupil diameters are typically larger when participants perform more difficult tasks (for example, Beatty, 1982; Porter et al., 2007). While the effect of task difficulty has been linked to the amount of effort required and the recruitment of additional processing resources for a task, the effects of in- vs. out-group membership can be linked to factors such as a positive emotional and motivational response to the stimulus. Therefore, variations in pupil size can provide involuntary, implicit measures

of both task effort (e.g., Kahneman & Beatty, 1966) and in-group bias.

Here I examined how task factors (e.g., task difficulty) interact with social mediators of performance, measuring this interaction through saccade performance and pupillary responses. Normally in-group stimuli are associated with an approach rather than an avoid response. In line with this, activation of approach and avoidance motor behaviours has been shown to be affected by group relevance (Neumann, Hulsenbeck, & Seibt, 2004; Paladino & Castelli, 2008). For example, Paladino and Castelli (2008) had participants to use different keys to perform a categorization task in response to faces of in- and out-groups. The keys were placed to the side of the participant's right hand such that using the front key produced an approach-like movement and using the back key produced an avoidance-like movement. The task had two phases. In the first phase, half of the participants responded by pressing the approach key for the in-group faces and the avoidance key for out-group stimuli and vice versa for the other half of the participants. In the second phase, the instructions for the task were reversed. Paladino and Castelli found that, overall, participants were faster to perform approach-like motor actions for in-group stimuli and avoidance-like actions for out-group members. These findings suggest that, when the task requires an avoidance response to the in-group stimulus, it becomes more difficult and requires more effort. Unlike this, avoidance is facilitated for out-groups. However there is little knowledge on how the natural approach response to the in-group and the avoidance response to the out-group can affect saccadic behaviour.

The current study explored the effect of in-group bias on approach and avoidance using pro- and antisaccade tasks. Following Bannerman, Milders and Sahraie (2009) I argue that prosaccades reflect an approach-like action while antisaccades reflect an avoidance-like action. Recent work indicates that prosaccades are facilitated by the presence of an emotional target stimulus (threat relevant words), while antisaccades are

disrupted, fitting the idea that emotional stimuli induce an approach-like response (e.g., see Gutiérrez & Calvo, 2011; Nummenmaa, Hyona, & Calvo, 2009). I examined whether similar effects would be induced from the positive motivational response to an in-group related stimulus.

To assess this I had participants carry out either a prosaccade to a stimulus (an approach response) or an antisaccade away from the stimulus (an avoid response). The stimuli had a pre-learned in/out-group relationship to the participant, based on the rivalry between Oxford and Cambridge rowing teams. Participants were members of the Oxford University rowing team and so Oxford stimuli comprised the in-group items and Cambridge stimuli the out-group items. A third team, based on Newcastle University, was chosen as the neutral team (the Oxford University rowing team does not have any long-standing rivalry with Newcastle). As the antisaccade task is relatively difficult, I predicted more errors on antisaccade compared to prosaccade trials. Moreover, given that an approach response should be triggered to in-group items, I predicted more directional errors on antisaccade trials for in-group stimuli (Oxford University colour) compared with the other items (Cambridge and Newcastle team colours), with the fewest directional errors being made to the rival team (weakest motivation drive to attend).

Regarding the pupil diameters I predict that the diameters would be larger for the anti- relative to the prosaccade task, given that antisaccades are more difficult (Hutton & Ettinger, 2006; Olk & Kingstone, 2003). Moreover, the propensity to approach rather than avoid in-group associated items should make antisaccade tasks particularly difficult for in-group items (see above), making pupil diameters particularly large in this case. On the other hand, there may also be effects of positive emotion and motivation for the in-group, which increase the pupil diameter to in-group stimuli particularly in the

prosaccade task, when an approach response is made. Thus, if there is an independent contribution of social association to the effects of task difficulty, then the effects of in-group should emerge on the pro- as well as the antisaccade task. Dynamic changes in these different effects can also inform us about how the task modulates effects of social association. For example, for early portions of the pupil response are the effects of group the same for pro- and antisaccades, consistent with an initial positive emotional and motivation 'driver', which occurs irrespective of whether the response requires an approach or an avoid action? For late portions of the pupil response a different picture might emerge if there is late-acting suppression of the response to the in-group, when the saccade has to be made in the opposite direction (in the antisaccade task). In this case, the increase in the pupil response to the in-group stimulus might be larger in the pro- than the antisaccade task, despite the antisaccade task being the more difficult.

Method

Participants

Twenty-one participants all females, mean (SD) age = 22± 2.5, range = 19-27, right handed, with normal or corrected-to-normal vision, and no reported neurologic or psychiatric conditions took part. All the participants were current members of the University of Oxford rowing team and had had this position for at least 2 months (mean (SD) time= 10.5 ± 9, Range 2-42 months). Participants were recruited via an internal advertisement. Prior to the experiment a written consent form approved by the University of Oxford research ethics committee was completed by all participants. The study was approved by the ethics committee of the University of Oxford and, prior to the experiment, written informed consent was taken from all participants.

Apparatus

Eye movements and pupil diameters were recorded from both eyes using Tobii eye-tracking equipment (TX300, Tobii, Stockholm) running at 60Hz. This equipment works based on infra-red technology (highlighting the subject's eye by infrared light and projecting the image onto a photo-receiver). The pupil diameter was sampled at 60 Hz from stimulus onset to 1 second after stimulus offset. For each trial, baseline corrections were performed by subtracting the first sample (at trial onset) from each of the following pupil samples.

First, a nine-point calibration procedure was conducted, presenting a spinning ball of 2° of visual angle in size, with accompanying sound. The calibration routine was followed by verification of the calibration. I included data if the verification procedure indicated fixation locations no further than 2° from the target's centre. In all cases, the accuracy was well within this limit. Calibration accuracy was measured as the distance between a participant's fixation location and the centre of the target location (for each target presented). Calibration was repeated if the participant failed to fixate on fewer than seven points out of nine within the defined accuracy limit.

Stimuli and procedure

Participants sat 58 cm away from a 22-inch screen (51×32 degree of visual angle, 1920×1080 pixels, 100ppi, 60 Hz refresh rate) in a normally - lit room with their chin on a chinrest. The experiment was implemented and run in Matlab (32-bit version R2012a; The MathWorks, Natick, MA).

The stimuli were coloured circles, 2° of visual angle in size and were presented on a 50% grey background (RGB 128,128,128) at 9.5° eccentricity either to the right or

left of the fixation cross (1° of visual angle in size) which was located at centre of the screen. Three colours were used. The colours were chosen to represent the identity of the three university boat teams: Oxford University (RGB 0, 33, 71; dark blue), Cambridge University (RGB 163, 193, 173; light blue), and Newcastle University (RGB 11, 18, 238). The neutral team was chosen so that its colour sat mid-way between the other two. The present study used grey as a background colour to prevent chromatic aberration (Charman, 1991).

Each trial started with a black fixation cross (1° of visual angle) at the centre of the screen for 800ms. Participants were instructed to keep fixating on a black fixation cross which remained on the screen for 800 ms. A fixation was defined in terms of the eye position being maintained within 1.5° of the cross for at least 100 ms. and the trial was aborted if this was not achieved. If fixated successfully, the trial proceeded. The fixation cross remained on the screen for 1200 ms. Following successful central fixation, a coloured cue cross was then presented for 500 ms: green for prosaccade trials and red for antisaccade trials. There was then a gap of 200 ms. The target subsequently appeared and stayed on the screen for 600ms. Participants were instructed to look toward (prosaccade) the target if the fixation cross turned to green. However, if the cross turned red they needed to look away (antisaccade) from the target to the same location on the opposite side. A gap of 1 second was introduced after each trial to avoid trial - to - trial directional effects (Barton, Goff & Manoach, 2006). The timeline of a trial is presented in Figure 21, including examples of the targets. The session comprised 240 trials, with two blocks of the prosaccade task (60 trials each) and three blocks of the antisaccade task (40 trials each) in an alternating order. The pro- or antisaccade task was blocked, consistent with prior work (Antoniades et al., 2013). Looks to the left and right were equally probable, and were presented in a random sequence. Prior to the test block, all

subjects had a practice session of 10 trials. Each participant was tested in one experimental session, lasting about 30 minutes. To avoid tiredness, participants were instructed to close their eyes and take a break for at least 2 minutes after every block.

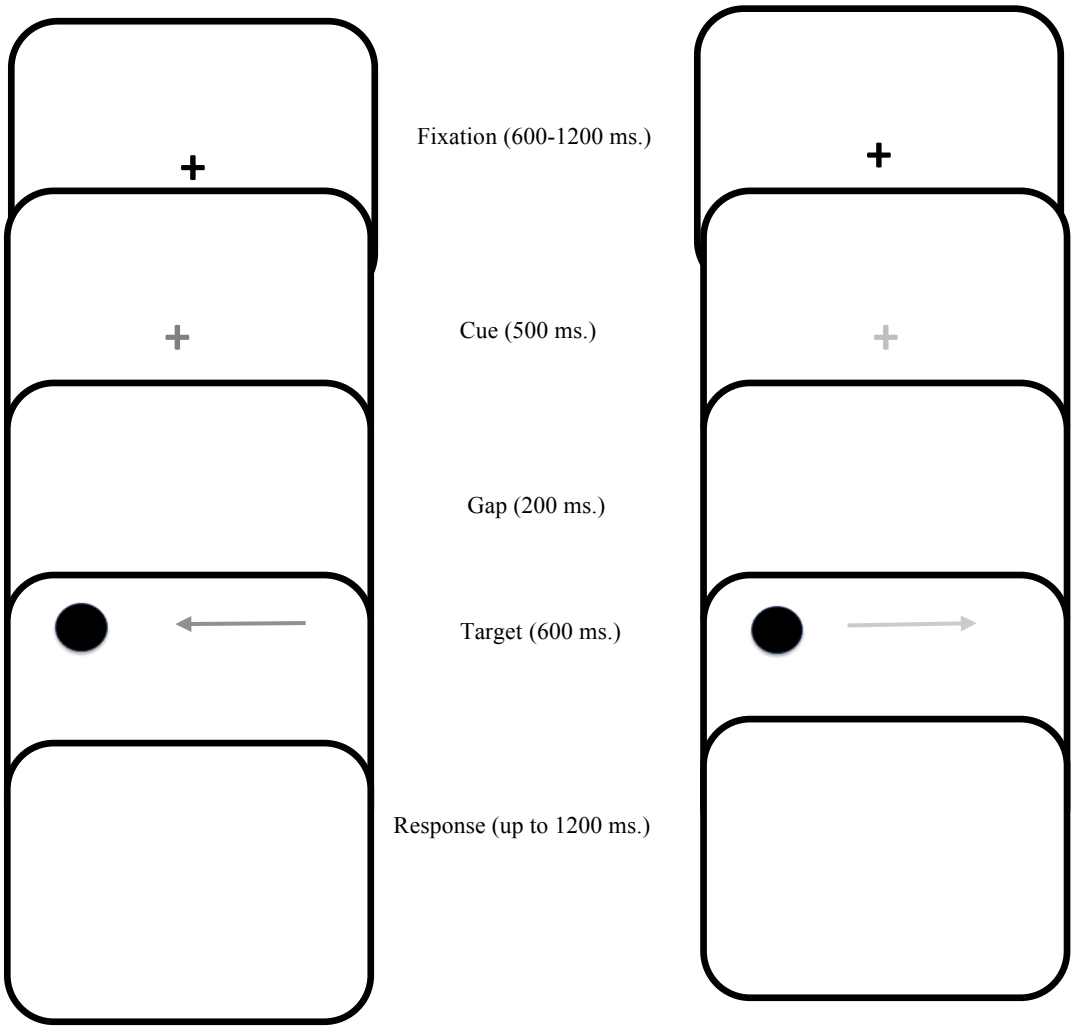


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Figure 21. Example (Left) pro-saccade and (Right) anti-saccade task, used in the experiment. The original background was fifty percent grey and the shapes were dark blue, (representing *Oxford University Boat team*), light blue (*Cambridge University Boat team*) and medium blue (*Newcastle University Boat team*). The green fixation cross used to cue the target for pro-saccade and the red was used for ant-saccade task.

Data Processing

Trials were excluded from the analysis if there was no fixation on the cross prior to cue onset (in total 15 % of the trials), and/or if the saccadic movement had started more than 2° away from the central fixation cross (1% of the trials). Pupil diameter data were smoothed using a 17-point median filter and linearly interpolated for blinks, periods when the eye-tracker failed to report a valid gaze position within the screen area or when the pupil diameter exceeded 5mm. Saccades were detected for each trial and only trials with a correct directional saccadic movement were used in the analysis of pupil diameters. A saccade onset was defined as the time point for which the eye moved 30º of visual angle or faster per second.

Results

I examined the implicit effect of group motivation on looking behavior and pupil responses.

Antisaccade task

One participant was excluded from the analyses due to the high number of invalid trials. The analyses were then conducted on the remaining twenty participants. I tested the effect of group relevance on the magnitude of directional errors in antisaccade tasks using a repeated measure ANOVA. Our results showed that there was a significant effect of group relevance on the number of directional errors in the antisaccade task, $F(2, 38)= 168.20$, $p < .001$, $\eta 2 = .89$. Post hoc comparisons revealed that, in the antisaccade task, participants made fewer directional errors for the target representing the rival group compared to both in-group, $t(19) = 20.47$, $p < .001$, $d = 4.57$ (mean difference (SE) = 8.00 ± 1.74) , and neutral targets, $t(19) = 12.33$, $p < .001$, , $d = 2.75$ (mean difference (SE) = 7.68 ± 2.76), which did not significantly differ from one

another, $t(19) = .23$, $p < .82$. The results are depicted in Figure 22.

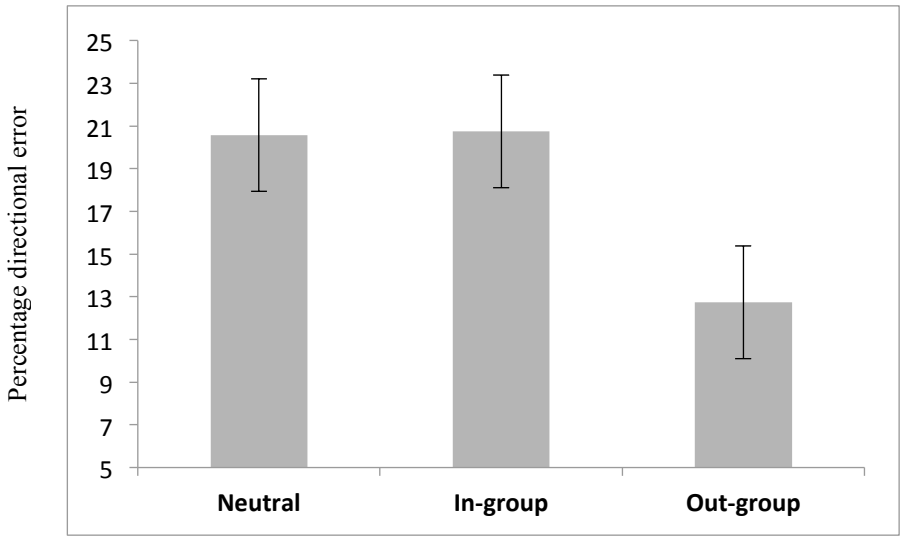


Figure 22. Mean opercantage directional error in the antisaccade task.

Prosaccade task

On average, participants made 10% predictive saccades (latency less than 80 ms.), 20% express saccades (latency between 80-120 ms.) and 10% slow saccades (latency > 400). I tested the effect of group relevance on saccades latency in the prosaccade task. Although the mean saccade latency was faster for both in-group and rival target stimuli (mean (SD) = 157 ± 27, 156 ± 21 respectively) compared to the neutral stimuli (mean (SD) = 178± 63), the effect of group relevance on latency was not statistically significant, $F(2, 38)=2.004$ $p<.14$, $\eta 2=.09$. I further investigated the directional errors in the prosaccade task. On average, participants made fewer than 10% directional errors, most of which (approximately 80%) were express saccades. Since, on average the error rates were very low, no further analysis was conducted. The mean error rates on prosaccade trials are shown in Table 13.

Table 13

Mean (SD) percentage directional error in prosaccade task.

Group	Percentage directional error
Neutral	7(±2)
In-group	4(±1)
Out-group	6(±4)

Pupil responses

For each trial, a baseline value for the pupil diameter was obtained from the average pupil diameter over a time window of 500 ms. after the onset of the fixation cross. The baseline value was then subtracted from the average pupillary size across a trial, calculated over a time window of 1500 ms. after the onset of the corresponding target. The change in pupil size (positive and negative) was used as the dependent variable in the subsequent analyses. The mean pupil sizes across time are plotted in Figures 23.

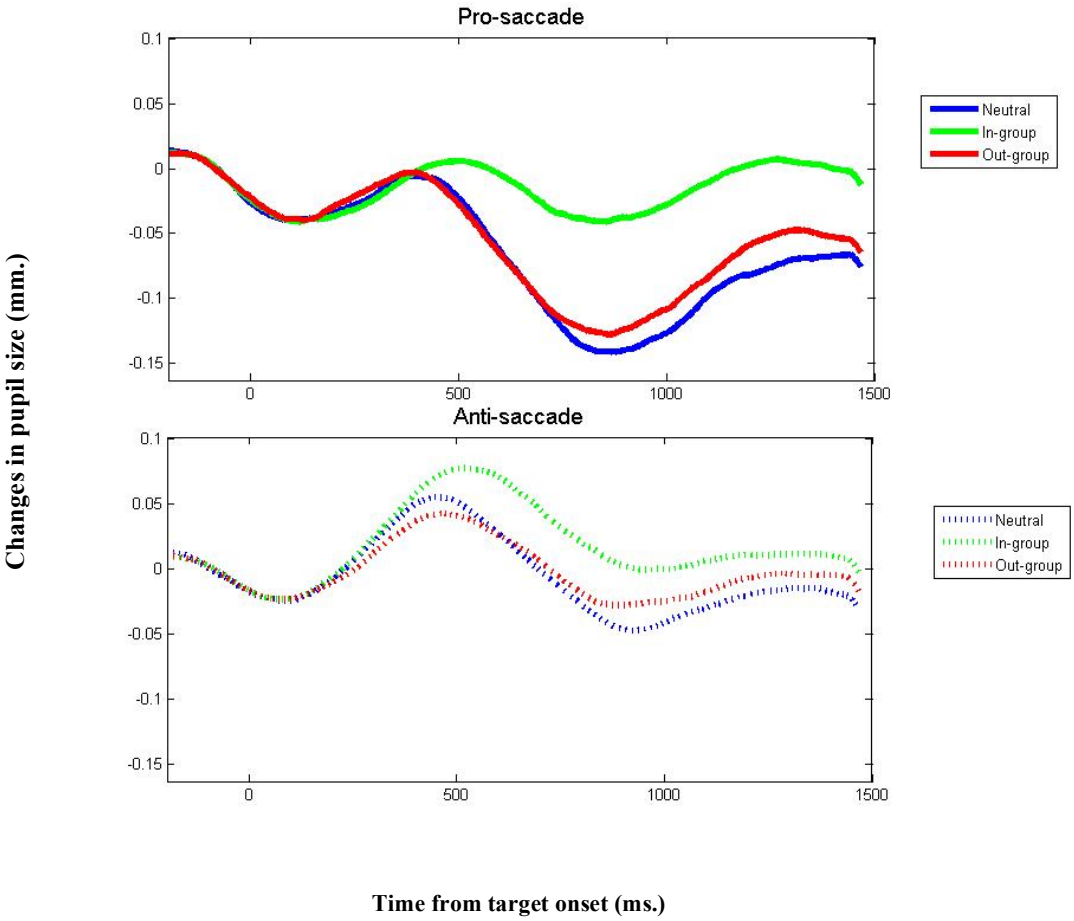


Figure 23. Changes in pupil size relative to the target onset. For the pro-saccade (top) and anti-saccade (bottom) tasks over the time course of 1500 ms. after the target onset (shown as 0 on the horizontal axis), for Neutral, In-group, and Out-group targets.

The pupil size data were divided into three different time windows, according to the time from the onset of the target, with each period lasting 500 ms. The time windows were: Period 1: From target onset to target offset (0-500 ms.); Period 2: early time window after the target offset (500-1000 ms.); Period 3: late time window after target offset (1000-1500 ms).

To investigate the effect of group (in-group vs. neutral and out-group) and task difficulty (prosaccade vs. antisaccade) on the pupillary response a 3 × 2 ANOVA was conducted on the amplitude of pupillary responses for each of the three defined time windows. The results revealed that for the first time window (0-500, from the target onset to its offset) there was no significant main effect of group, $F(2, 38) = .074$, $p < .93$, $\eta 2 = .004$. However, there was a significant main effect of task difficulty, $F(1,19) = 22.86$, $p < .001$, $\eta 2 = .546$. The pupil size was larger for antisaccade compared to prosaccade responses. The interaction between group and task difficulty was not significant, $F(2, 38) = 1.4$, $p < .27$, $\eta 2 = .006$.

For the second time window (500-1000 ms.) there were significant main effects of group, $F(2, 38) = 50.61$, $p < .001$, $\eta 2 = .72$, and task difficulty, $F(1, 19) = 102.72$, $p < .001$ $\eta 2 = .844$. The interaction between group and task difficulty was not reliable, $F(2, 38) = 2.96$, $p > .05$, $\eta 2 = .135$. For prosaccade responses the changes in pupil size for the in-group were significantly different from those for the neutral, $t(19) = 5.93$, $p < .001$, $d = 1.32$, and out-group stimuli, $t(19) = 7.19$, $p < .001$, $d = 1.60$, which did not differ from each other, $t(19) = .038$, $p < .97$. Similarly, in the antisaccade task the changes in pupil size for in-group stimuli were significantly different from those for the neutral, $t(19) = 6.82$, $p < .001$, $d = 1.52$, and out-group stimuli, $t(19) = 6.55$, $p < .001$, $d = 1.46$ which did not differ significantly, $t(19) = .30$, $p < .76$.

For the third time window (the late time window after target offset) there were significant main effects of group, $F(2, 38) = 63.00$, $p < .001$, $\eta 2 = .768$, and task difficulty, $F(1, 19) = 29.63$, $p < .001$, $\eta 2 = .610$. The interaction between the group and task was also significant, $F(2,38) = 14.67$, $p < .001$, $\eta 2 = .436$. Post hoc comparisons were conducted separately on pro and antisaccade tasks. In the prosaccade task pupil size was larger for the in-group relative to the neutral, $t(19) = 8.38$, $p < .001$, $d = 1.87$,

and out-group conditions, $t(19) = 7.17$, $p < .001$, $d = 1.58$, which did not differ from each other, $t(19) = 2.43$, $p > .05$ (Bonferronni corrected). In the antisaccade task, pupil sizes were again larger for in-group compared to neutral, $t(19) = 6.10$, $p < .001$, $d = 1.36$, and out-group stimuli, $t(19) = 4.21$, $p < .001$, $d = .94$, which did not differ significantly, $t(19) = 2.06$, $p > .05$. The interaction arose because the contrast between the in-group stimuli and the other stimuli was greater on pro- relative to antisaccade trials (see Figures 23 and 24). The average pupillary response as the function of task difficulty and group relevance for the whole time window from target onset to 1500 ms. after the target onset is depicted in Figure 24. This figure clearly shows the differential pupillary response to the in-group and its interaction with task difficulty. More importantly, the figure shows that the pupil responded very similarly to the out-group and neutral stimuli. Since these targets were different colours, this further confirms that the differential pupillary response does not reflect the difference in colour of the stimuli.

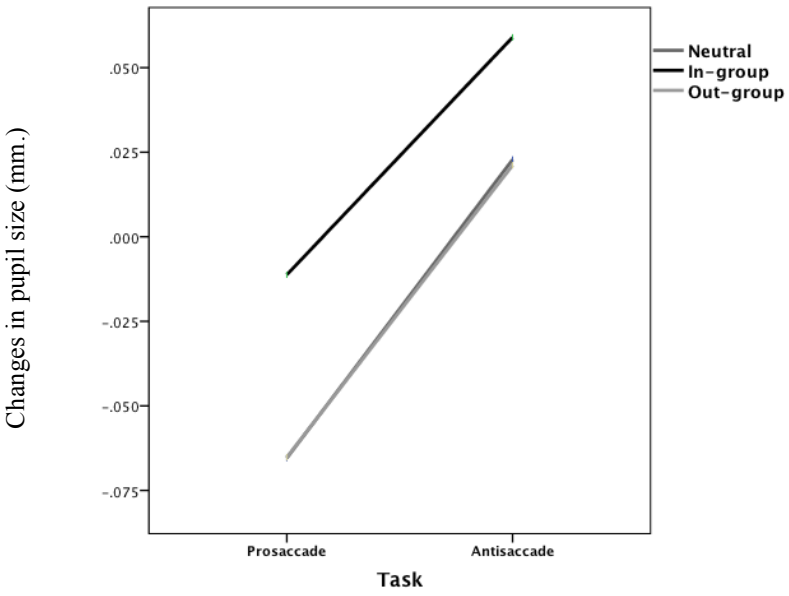


Figure 24. Mean changes in pupil size for the pro- and antisaccade tasks, averaged across 1500 ms. after the target onset.

Discussion

I investigated the effects of in-group bias on eye movement and pupil size in pro- and antisaccade tasks. Consistent with known effects of task difficulty (Kahneman & Beatty, 1966), pupil sizes were larger on the difficult (antisaccade) task compared with the easy task (pro-saccade). Also pupil sizes were larger for in-group compared with out-group stimuli, as expected from the effects of positive emotional/motivation bias (Siegman & Feldstein, 2014). Most interestingly, the pattern of the results changed across the time course of a trial, when pupil responses were measured. In the early part of the function the group effect did not emerge. Across the medium period (500-1000 ms.), pupil sizes were larger for in-group than out-group stimuli, and this held for both the anti- and prosaccade tasks. The effect on prosaccade trials is interesting as prosaccades to in-group stimuli were not more difficult than those to the other stimuli,

so this effect cannot be attributed to the mediating effects of task difficulty. Rather the data fit more with the proposal that there is a positive emotional and motivation-based response that increases pupil size to in-group related items, at least when an approach response is made to such stimuli. In the later part of the function, however, different profiles emerged for pro- and antisaccade responses. In this part of the function, the effect of in-group vs. out-group (rival and neutral teams) was greater in the prosaccade task than the antisaccade task, even though antisaccades were more difficult to execute and more directional errors occurred for in-group compared with rival stimuli. Thus the decrease in the effect of group on antisaccade trials seems unrelated to the effects of task difficulty per se. An alternative view is that there is a late-acting suppression of the response to in-group stimuli on antisaccade trials, to resist the natural approach response to such items. This leads to a decrease in pupil size selectively for in-group stimuli. When the suppression response is not recruited (e.g., on prosaccade trials), the pupil diameters remain large for in-group stimuli, reflecting the positive emotional/motivation response to these items when an‘approach’ eye movement (a prosaccade) must be made.

Our results also indicated that antisaccades were more difficult to make (generating more directional errors) to the in-group badge compared to the rival badge; the in-group and neutral stimuli did not differ. These data suggest that there was a reduced approach response for the out-group (rival) stimuli, and hence a reduced tendency to make directional errors by making a saccade to the target on an antisaccade trial. There was a tendency for a reduction in directional errors to neutral compared with in-group targets too, but this was not reliable. Nevertheless, the late-acting reduction in pupil responses for in-group stimuli on antisaccade trials fits with the idea that participants were particularly affected when the normally natural approach response to in-group stimuli violated the task instruction (to make an antisaccade).

Previous studies have identified a connection between inhibitory control and implicit in-group bias. Using an anti-saccade task, Payne (2005) found a positive correlation between directional errors in an anti-saccade task to neutral stimuli implicit racial bias scores derived from an Implicit Association Test (IAT) (Greenwald et al., 1998). In this case, poor general inhibitory control of behaviour (in the antisaccade task) was linked to greater racial bias (measured in two tasks including weapon identification and word evaluation tasks) – either because individuals with lower cognitive control are more prone to racial bias or because lower cognitive control means that racial bias is more likely to permeate IAT performance.

Given the variation in the effects of group at different intervals in the pro- and antisaccade tasks, it is difficult to attribute these results to variations simply caused by the different colours used to define the in- and out-groups with our participants. Instead the results indicate that colour-based identification with their group modulated approach-avoid responses in our participants (university rowers), with these effects varying over time. The data indicate the sensitivity of pupil responses for measuring these changes over time. The data concur with the notion that the implicit in-group biases are outside intentional control and awareness and can occur automatically across different contexts (Amodio & Devine, 2006; Hewstone et al., 2002). In addition, these findings suggest that even an abstract feature of in-group (here, its associated colour) is enough to affect saccadic eye movements.

Chapter 7

Resting state functional connectivity of the left anterior insula and inferior frontal gyrus predicts in-group bias

Abstract

I examined whether biases in perception favouring in-group stimuli reflect learned changes in neural resting state activity (RSA). I examined differences in pre- and post-task RSA after football fans performed perceptual matching with in- or out-group associated stimuli. Functional connectivity was assessed from resting state fMRI scans based on three major networks in frontal cortex, the insula and parieto-occipital areas. Compared to pre-task activity, post-task functional connectivity increased between the left AIC and the inferior frontal gyrus (IFG) and post-task connectivity was positively correlated with in-group bias in behavior. Post-task functional connectivity was significantly weaker between left anterior insula cortex (AIC) and dorsolateral prefrontal cortex (DLPFC), but this was unrelated to behavioral biases. These results suggest that functional connectivity between the AIC and IFG facilitates processing of the motivationally salient stimuli and this might explain the underlying mechanisms of enhanced performance in in-group perception.

Keywords: In-group bias, Anterior Insula, Inferior Frontal Gyrus, Motivational salience

Introduction

Whether watching a football match involving a favourite team, recognizing the voice of a friend in a noisy environment or smelling the perfume of a loved one in a party, the brain is involved in processing personally-relevant social information, which can stand out from other irrelevant information that is present (Insel & Fernald, 2004). There is now considerable evidence on the effects of social relevance on attention, memory, learning and decision making across different contexts (for example see, Sui, et al., 2012; Wentura, Rothermund, & Bak, 2000; Wyer & Srull, 2014; Yankouskaya, et al., 2014). These findings indicate that social information can have raised saliency for perception and attention (Behrens, Hunt, Woolrich, & Rushworth, 2008; Frith & Frith, 2012; Vrtička, Sander, & Vuilleumier, 2012), with enhanced processing of stimuli that are personally relevant - for example whether stimuli are associated to self (Northoff et al., 2006; Sui, et al., 2012), a loved one (Cheng, Chen, Lin, Chou, & Decety, 2010) or one's in-group (Gutsell & Inzlicht, 2010; Morrison, Decety, & Molenberghs, 2012;Van Bavel et al., 2008).

Sui and colleagues examined effects of social saliency in simple perceptual matching tasks (Sui et al., 2012; Sui, Rotshtein, & Humphreys, 2013). Participants were asked to learn to associate three different arbitrary shapes with the labels self, friend or stranger (e.g., circle, square, and triangle). Subsequently participants had to decide whether shape-label pairs were as originally shown or re-paired (circle-friend, square-stranger, and triangle-self). Matching performance was considerably better for self-related stimuli than for stimuli related to other people (friend, stranger). This advantage for self-related stimuli mimics the effects of changing perceptual saliency (e.g., increasing local contrast) in both behavioural performance and brain activity (Sui, Rotshtein, & Humphreys, 2013). Moradi et al. (2015) extended this result to show that

the perceptual matching advantage occurs for in-group as well as self-related stimuli (Moradi et al., 2015). In a series of studies they had football fans associate the badges of their favourite team, a rival team, or a neutral team with simple geometric shapes. The fans showed faster and more accurate matches for stimuli associated with their own team as opposed to other teams; this effect was not present in participants who were not football fans (for other evidence on the effects of in-group association on perception see also, Molenbergh et al., 2012; Sporer, 2001; Wilson & Hugenberg, 2010).

The improved perceptual matching for in-group stimuli may reflect enhanced attention, which may in turn be brought about by increased positive emotional responses to such stimuli and/or their increased motivational significance (Fazio, Jackson, Dunton, & Williams, 1995; Moradi et al., 2015). In line with this, previous studies have shown that the increased motivational significance of an in-group influences social responses and behavior such as empathy. For example, Xu and colleagues (2009) demonstrated that racial group modulated the neural response in the so-called brain's 'pain matrix' including the anterior cingulate cortex (ACC), the inferior frontal gyrus (IFG) and the insula. Neuronal activity (measured based using the BOLD response) was increased when participants observed a member of their in-group (i.e., a same race face) receiving painful stimulation. However, when pain was given to a member of an out-group (the face of an individual from a different race), the activity in these regions (specifically in the ACC) was attenuated. These findings are consistent with in-group membership modulating affective concerns for others. Other studies have shown that in-group identification impacts on range of cognitive and affective functions including, empathy, theory of mind and action-perception interaction (for a review see Molenberghs, 2013). Reliable effects of in-group driven differential neural activity have been associated with the amygdala (Cunningham et al., 2004), the temporoparietal

junction, the posterior cingulate cortex and precuneus (Cavanna & Trimble, 2006; Denny et al., 2012; Ochsner et al., 2004; Saxe, 2006). There are questions, however, about whether the neural bases of in-group bias can be established in more basic perceptual tasks and with stimuli not involving a social dimension (e.g., simple perceptual matching of shape and team-associated stimuli). In addition it is unclear whether and how neural activity may change as in- and out-group decisions are made. These issues were examined here.

In the present study I used resting state functional connectivity analyses to assess how neural activity and connectivity were modulated by participants making decisions regarding in- and out-group stimuli. It has been established that there are strong correlations in low-frequency neural activity in different regions of the brain even when no task is being performed (Deco et al., 2013; Mantini, Perrucci, Del Gratta, Romani, & Corbetta, 2007). This activity can reflect the functional connections between brain regions which operate in coordination as a part of an underlying neural network (Damoiseaux et al., 2006; Taylor et al., 2009) - including a so-called default network (active when the participants are not performing any specific task but inactive while the task is being performed (Fox & Reichle, 2007; Fox et al., 2005; Raichle & Snyder, 2007) and networks related to attentional orienting and stimulus saliency (Fox et al., 2006). There is evidence that coordinated fluctuations in the default mode network can reflect self-referential processes (see Damasio, 2003; Northof & Bermpohl, 2004; Sui Rotshtein, & Humphreys, 2013; Sui, Lui, Mevorach & Humphreys, 2013; Vogeley et al., 2004). However no studies have examined whether synchronized fluctuations in brain activity in the resting state could also reflect group-related decision making.

The current study investigated whether resting state activity in the brain was related to in-group biases in perception – focusing on whether changes in resting state

activity, after participants performed perceptual matching with in- and out-group stimuli, correlated with in-group biases in behavioral performance.

I applied a two-stage analyses approach. First, I selected regions of interest (ROIs) by the areas activated in an event-related fMRI with a social perceptual matching task. Second, I used these ROIs as seeds to explore the changes in resting state functional connectivity before and after a perceptual matching task involving in- and out-group stimuli. I further investigated neuronal linkages between changes in functional connectivity and enhanced performance on in-group stimuli. Our participants were life-long football fans. I predicted that the fans would show enhanced behavioral performance for in-group stimuli. I assessed whether behavioral performance was reflected by changes in resting state activity in brain regions associated with processing emotions. By comparing resting state activity before and after the in- and out-group matching task, I also evaluated changes in underlying functional activity controlled for between-individual differences at baseline. The changes in resting state activity were then correlated with the strength of in-group biases in perceptual matching, proving a link between neural activity and enhanced in-group perception.

Method

Participants

Twenty healthy right-handed volunteers (one female) with normal or corrected-to-normal vision and with no history of neurological condition (age range 21-45, Mean (SD) = 31 (7.50), took part. Prior to the experiment a written informed consent form approved by University of Oxford medical science ethic committee was signed by all participants.

Stimuli and task

Three geometric shapes (pentagon, square, and triangle) were presented with each shape paired with a badge for three different football teams. The teams were the participant's favourite football team (the in-group), the closest rival team (the out-group), and a neutral team (which participants neither liked nor disliked but were familiar with). In total I used twelve badges of different teams (listed and depicted in the supplementary materials), with badge assignment to condition determined by the participant's ratings of liking. Participants were asked to associate each shape with one of the badges. The assignments of the shapes to particular badges (in-group, neutral, rival) were counterbalanced across participants. Each shape and badge (160×160 pixels, corresponding to 4.5 × 6.5 degree of visual angle) was presented randomly at approximately 3˚ above or below the fixation cross (1˚ x 1˚) at the center of the screen on a fifty percent grey background. Stimuli were presented on a screen situated 1.5 meters away from the subject, inside the magnetically shielded room; stimuli were displayed via projector (refresh rate 60Hz) situated outside the room. Stimulus presentation and timing were controlled using Presentation software (Neurobehavioural Systems, Albany, CA). In an initial block of 12 trials participants were trained to associate the three shapes with the badge of (i) their favourite team, (ii) the traditional rival team, and (iii) a neutral team. Each trial began with a fixation cross for 500 ms. followed by the simultaneous presentation of a badge and shape, one above and one below the fixation cross for 500 ms. with the positions of the badge and shape being randomly determined. There was a response time limit of 1500 ms. During a period of 2000 to 6000 ms. (jittered), a fixation point was presented on the screen. Participants were trained on the task using a set of 3 pairs (badge and shape), briefly prior to scanning. The associations for each stimulus were maintained throughout the scanning

session. Scanning runs consisted of 81 trials per run. All participants completed 6 runs for the total of 486 trials.

Image Acquisition

The images were acquired using a 3-T SIEMENS MRI scanner (Erlangen, Germany) using a 24-channel SENSE head coil. T1-weighted anatomical images were acquired (TR = 2040 ms., TA: 5:56 (minutes), TE = 4.7 ms. flip angle = 8°, FOV = 192 mm, slice thickness 1.0 mm). Functional images were acquired with a gradient echo T2*-weighted echo-planar sequence (TR = 2300 ms. , TA: 7:08 (minutes), TE = 30 ms. , flip angle = 90°, FOV = 192 mm, slice thickness 3.0 mm, with no slice gap). A total of 42 axial slices (3 mm thick) were sampled for whole-brain coverage. There was one run under resting state conditions before the task and one run after the task. In each run, 183 volumes were acquired. During the two resting state data acquisition periods (before and after the task) each lasting around 7:08 minutes, participants were asked to stay still and keep looking at the white fixation cross in the middle of the black screen.

Data preprocessing

The collected magnetic resonance data were preprocessed using SPM8 (Wellcome Trust Centre for Neuroimaging, Ashburner & Friston, 2011). Functional images were realigned, unwarped, slice-timing corrected, and co-registered to the participant's T1 scan. Low- frequency signal drift was corrected for by applying a high-pass temporal filter with a cut-off of 128 s. The coregistered images were subsequently normalized onto the Montreal Neurological Institute (MNI) template with a spatial resolution after normalization of 3 × 3 × 3 mm. The resulting normalization parameters were applied to all the resting state images. The functional data were spatially smoothed

using an 8-mm isotropic Gaussian Kernel. The movement parameter was visually inspected and fell under the maximum limit of 3 mm for all participants. Following the normal preprocessing procedure I applied the signal processing procedure developed by Mantini et al. (2011).

The Region of Interest

Following the pre-processing, a general linear model was conducted to regress the activation for perceptual matching task relevant to rest. A high-pass filter with a cutoff of 128 s was used to remove slow signal drifts. Voxel-wise analysis was conducted for each participant. The ROIs were defined based on a task-related fMRI data set in the same group of participants (*N=20*). The statistical significance threshold for selecting the region of interest was set to $p<0.005$ and a cluster size minimum of 70 voxels for the contrast between in-group and rival stimuli (see Sui et al., 2013a). To define regions for our resting state connectivity analysis, I chose the peak voxel with the highest t-score ($t>3.00$) inside the activated cluster. Based on this procedure I then created the ROIs using the Marsbar toolbox (http://marsbar.sourceforge.net). The ROIs composed of 6-mm radius spheres centered on the selected predefined peak voxels. The size of the spheres was based on previous studies using the same method (Solesio‐Jofre, et al., 2014). I selected the following ROIs: the left anterior insular cortex (AIC), the left inferior frontal gyrus (IFG), the left dorsolateral prefrontal cortex (DLPFC), the left precuneus, the left fusiform gyrus and the right temporoparietaal junction (TPJ) - all regions previously shown to be engaged in processing social stimuli (Cavanna & Trimble, 2006; Denny et al., 2012; Ochsner et al., 2004; Saxe, 2006). The ROI, the relevant cluster size, coordinates and peak t-scores are listed in Table 14.

Table 14

MNI coordinates. X: right/left, Y: anterior/posterior, Z: superior/inferior. These regions were used as seeds in resting state functional connectivity analyses.

Seed Region	X	Y	Z	BA	t-score
Left Inferior Frontal gyrus	-51	20	10	45	3.06
Left Anterior Insul (AI)	-39	17	1	-	3.92
Left Precuneus (Posterior)	-8	-63	38	7	3.95
Left Dorsolateral prefrontal Cortex (DLPFC)	-36	14	31	9	4.16
Left Fusiform gyrus	-33	-61	-14	37	4.54
Right Temporoparietal Junction (TPJ)	48	-43	22	39	4.07

Functional connectivity analyses

Functional connectivity analysis was performed in the following steps. First, the functional rfMRI time series across all voxels in each ROI were averaged. Next, the correlation strength between every pair of ROIs was calculated using Pearson correlation coefficients. These processes were repeated for the pre-task resting state as well as the post-task resting state. Next, the correlation between each region was compared pre- vs. post task, to investigate whether performance in the task altered the strength of functional connectivity of certain areas within the clusters defining our ROIs. The Pearson correlation values were converted to Z-scores by Fischer's R-to-Z transformation (Zar, 1998). Random-effects analysis was used to create group-level correlation matrices (Pravata et al., 2011). For subsequent analyses, all connections with a significant correlation (at $p < .05$) were selected and correction for multiple

comparisons was applied using the False Discovery Rate (FDR, $p < .01$) method (Genovese & Wasserman, 2002). Here, independent-samples t-tests were used to calculate direct comparisons of the strength of functional connectivity before and after the task - based on a random-effect analysis between the whole brain connectivity maps for the different seed ROIs in the pre vs. post task conditions. Finally, correlations from significant ROI pairs were extracted to investigate whether functional connectivity was linked to the enhanced performance for in-group stimuli in the task.

Results

A general linear model analysis of the functional data collected during performance in the matching task revealed statistically significant ($p < .005$, minimal cluster size 70 voxels) activations of three brain networks in the frontal, insula and occipital cortices. Figure 25 provides an example of the activation map in the fMRI task.

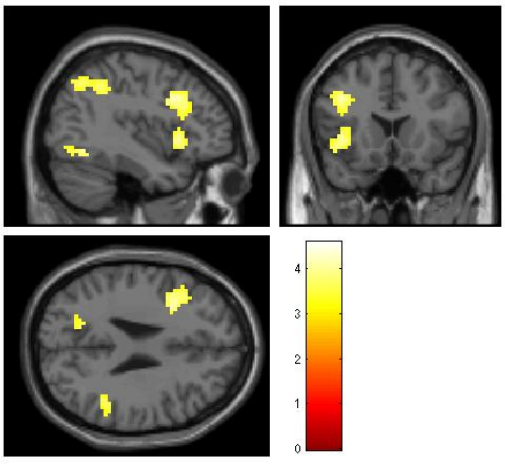


Figure 25. Example activation map in three main networks. The activated clusters were located in insular, frontal, and parieto-occipital regions related to task performance vs. rest (*N=20*). The coloured bar shows the value of the t-test in different regions of the brain.

I then compared and contrasted the strength of functional connectivity between the pairs of ROIs under rfMRI conditions before and after the task.

The significance level was corrected for multiple comparisons of the twenty-one pairings of ROIs that I compared. After the correction for multiple comparisons only pairs with a t-score > 1 and $p < .003$ (.05/15) were counted as significant.

Our results showed that, compared to the pre-task activity, the strength of functional connectivity between the left AIC and the left IFG increased significantly, $t(19)= 2.80$, $p < .003$, $d = .62$. Furthermore, there was a reliable decrease in the strength of functional connectivity between the left DLPFC and the left AIC, $t(19)= -3.34$, $p < .001$, $d = .74$, in the post- compared to the pre-task condition. The result matrices for pre-task, post-task and for the post vs. the pre-task are depicted in Figures 26a, 26b and 27 respectively.

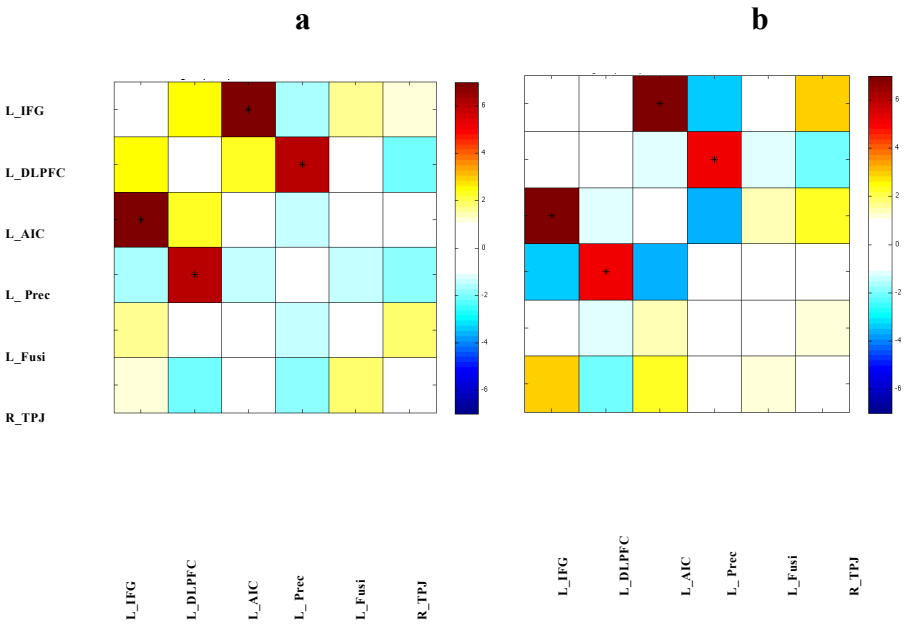


Figure 26. Resting state functional connectivity map. (a). Pre-task random effect functional connectivity analyses**.** (b). Post-task random effect functional connectivity analyses (Bonferroni corrected, $p < .01$).

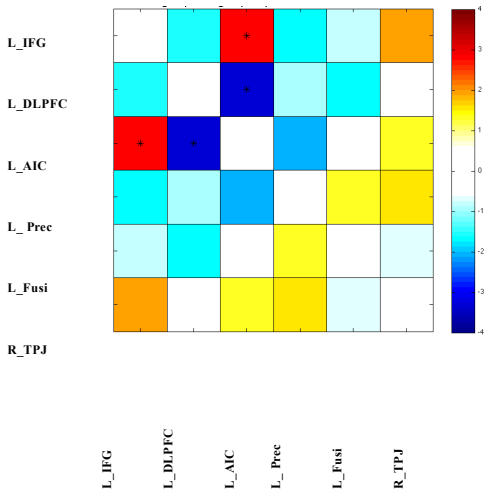


Figure 27. Altered functional connectivity with regard to the task. The map shows the changes in functional connectivity in the seeds of interest in the post- task compare to the pre-task (uncorrected, $p<.05$).

Next I tested the relations between functional connectivity and behavioral performance. To find any potential linkage I conducted correlation analyses on the strength of post-task functional connectivity (using the t-score of the post-task functional connectivity for each pair of ROIs) with the difference in RT for in-group vs out-group stimuli in the task. Our results showed that the strength of the post-task functional connectivity between the left AIC and left IFG was significantly correlated with the size of the in-group bias on reaction times, $r= .50$, $p < .02$, $N = 20$. In contrast the correlation between the in-group bias and the DLPF/AIC post task functional connectivity was not reliable, $r= .06$, $p < .80$, $N = 20$. There was also no correlation between the increase in the functional connectivity between (i) the IFG and the AIC and (ii) the decrease in connectivity between the AIC and the DLPFC, $r = .10$, $p < .66$, $N = 20$. The results for the correlation analyses are shown in Figure 28.

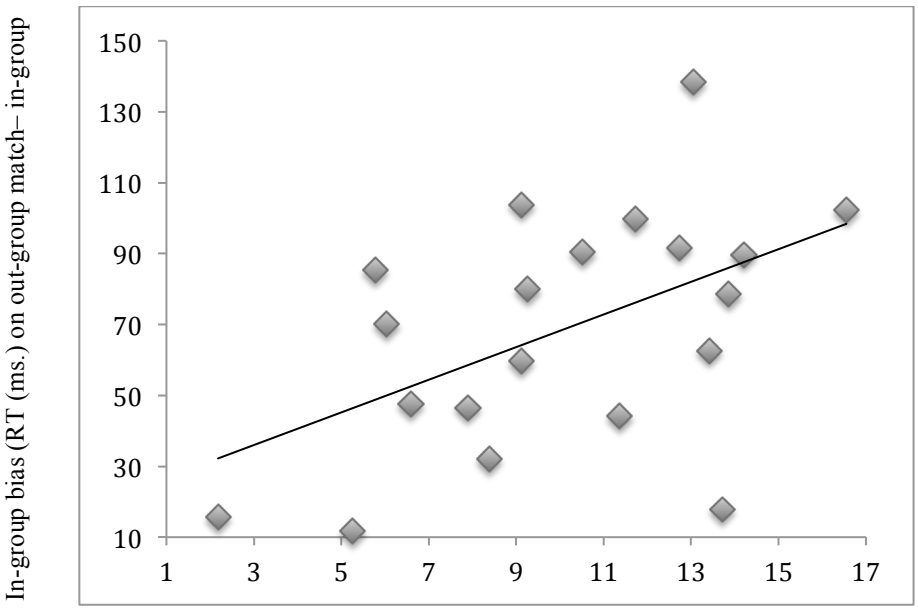


Figure 28. Correlation between post-task functional connectivity and in-group bias. Positive correlation between the strength of the post-task functional connectivity for AIC/ IFG pair and the size of in-group bias based on the RT difference for in vs. out-group stimuli.

Discussion

I assessed whether, in a group of passionate football fans, performance perceptual matches of stimuli associated with an in-group or an out-group alters functional connectivity in the brain. Our results revealed that the strength of functional connectivity was significantly increased between the AIC and the IFG, and this was correlated with behavioural measures of in-group bias. Notably there was a significant positive correlation between the strength of post-task functional connectivity between (i) the left IFG and AIC and (ii) the size of the in-group bias, based on the reaction time

difference for in versus out-group stimuli. I further found a decrease in functional connectivity between the IFG and the DLPFC post-task compared to pre-task, but this was unrelated to task performance.

The findings regarding the IFG and AIC suggest that functional *hyper* connectivity with a fronto-insula network is related to the enhanced performance for matching in-group stimuli. Previous studies have reported evidence for functional connectivity between the IFG and the insula. For example, using Granger Causality Modeling, Jabbi and Keysers (2008) showed that activity in the IFG was associated with responses in the AIC to emotional faces. More importantly, recent insights into the functional synchronization of activity in the AIC and IFG indicates that coherent co-activation of these areas arises across a wide variety of contexts (for a review see Craig, 2009) consistent with the two regions acting as a "*fronto-insular junction*" in social and emotional processing. In relation to this view, I suggest that the positive emotion attached to in-group stimuli (here the favourite football badge) facilitated the response to in-group stimuli in the perceptual matching task. This in turn enhanced AIC-IFG connectivity.

A growing body of research based on the studies in healthy participants as well as human lesion studies has provided evidence that the anterior insula plays an important role in responding to stimulus saliency (Menon & Uddin, 2010), emotional signals (Craig, 2009; especially for self-generated emotions Damasio et al., 2000), and social perception (Couto et al., 2013). Recent studies also highlight the role of the left IFG in social perception. For example, Keuken et al. (2011) found that repetitive transcranial magnetic stimulation, applied to supress the activity in the left IFG, resulted in significantly longer reaction time in a social perception task (Keuken et al., 2011). Age related increases in activity in this area have also been linked to enhanced social

cognition in individuals with high functioning autistic traits (Bastiaansen et al., 2011).

There is anatomical evidence that connectivity between the AIC and IFG is served by a series of U-shaped tracts, which connect different regions of the frontal operculum with the insular cortex. Within this 'fronto-insula' system, the anterior insula is connected to the pars triangularis area of IFG (our selected seed BA 45) via one of the shortest of the U-shaped tracts (for details see Catani et al., 2012). I speculate that this anatomical shortcut can contribute to the rapid learning of social associations (e.g., the shape and the badge used here).

One other possibility is that the functional changes in AIC-IFG connectivity here reflect disgust. There is evidence that AIC and IFG have are involved in processing disgust (Wicker et al., 2003) and in aversive reactions to negative stimuli and events (Carretié, Albert, López-Martín, & Tapia, 2009). Here increases in functional connectivity between the two areas might suppress performance on out-group stimuli, an effect mediated by disgust, which in turn generates an increased advantage for self-related stimuli.

The evidence for changes in IAC-IFG connectivity was confined to the left hemisphere. Evidence for left-hemisphere dominance in perceptual matching to social stimuli has been observed before (Sui, Rotshtein, & Humphreys, 2013). While previous studies have used shape-label matching, here I employed non-verbal stimuli making it less likely that the left hemisphere dominance arose due to verbal labels being used. A different account can be formulated from the proposal made by Craig (2005) that the left hemisphere mediates *group*-oriented (affiliative) emotions, while the right hemisphere modulates negative emotions and arousal. The changes in left hemisphere activity I observe fit with group-based positive emotion enhancing responses to in-group related stimuli.

However, my findings are not consistent with the previous studies that suggested a role for the ACC and vmPFC in emotional processing (for example, Etkin, Egner, & Kalisch, 2011). Notably, in the cognitive domain previous studies also suggested that the ACC and vmPFC are linked with the learning rate, uncertainty and the value of action during decision making (Rushworth & Behrens, 2008). I suggest that any exact interpretation of null functional connectivity with respect to the previous studies will remain speculative.

I also found that functional connectivity between the AIC and DLPFC decreased after the task was performed compared to prior to the task. This finding might imply that throughout the task participants' response became more automatic and therefore the task performance did not require as much attention as it required to start with – for instance, there may be inhibitory mediation of any emotional reaction to the stimuli in the AIC early-on which decreases with practice on the task. Previous studies related the functional coupling between AIC and DLPFC to memory retrieval (i.e. Assaf et al., 2006) which is consistent with our interpretation of automaticity of retrieval and with reduced effort being required as practice increased on the task.

With regard to the parieto-occipital clusters containing peak activation the matching task, I suggest that this likely reflects enhanced visual attention to the in-group stimuli, which increases early visual processing. Functional connectivity relating to this activity was not changed through experience on the task (Martin, 2007; Puce, Allison, Asgari, Gore, & McCarthy, 1996).

Overall, the main finding of hyper-connectivity between left AIC and IFG suggest an important role of these areas in responding to motivationally salient stimuli, even in simple perceptual matching tasks, and that the modulation of neural connectivity between these regions through learning can alter behavioral biases to in-

group stimuli. I conclude that alterations in resting state AIC-FG connectivity may be the underlying neural substrate of learned in-group bias.

Different factors contribute to the limitations of resting state studies and our study is no exception. First the resting state functional connectivity analysis is not completely free of different types of noise. The low frequency fluctuations in the BOLD signal captured in resting state fMRI have a high degree of temporal correlation across widely separated brain regions that constitute plausible functional brain networks. Therefore, it should be noted that interpretation of the patterns of functional connectivity retrieved from resting state fMRI studies should be made with caution. The rudimentary pitfall of such a method is that the absence of significant signal change in specific brain area could not reliably be taken as evidence of the absence of neural response. This is so because the signal change in different brain areas is susceptible to a range of variability including scanner and physiological artifacts, as well as individual differences in microanatomy and vascularization of particular brain regions. Therefore, with regard to our findings any theoretical interpretation regarding the exact role of IFG and AIC in social and emotional processing would remain speculative. It is still unclear whether better performance on in-group stimuli is governed by the positive emotion connected to in-group or the negative ones attached to the out-groups. Referring to the evidence from social psychology studies, in-group favouritism and out-group derogation are "*reciprocally related*" (Brewer, 1999, p. 430). According to this view in-group favouritism and out-group derogation are separable and therefore should be accounted as two different phenomena. Future studies may start to shed some light on this issue. The relationship between BOLD and neural events during the resting state is currently of particular interest and knowledge of resting state brain activity may improve our understanding of task induced brain activity.

Chapter 8

Neural correlates of in-group biases reflecting real-world rivalry

Abstract

There is ample evidence for enhanced attention and perception to stimuli that are related to our in-group, but little is known about the neural correlates of such effects. I investigated this issue using functional magnetic resonance imaging in football fans while they performed a simple perceptual matching task in which they discriminated between instructed and uninstructed pairings of a geometric shape and the badge of either their favourite football team, its closest rival or a neutral team. Matching performance was more efficient for in-group associated stimuli. The in-group advantage was linked to increased activity in the left posterior superior temporal sulcus. In contrast, there was a greater activity for rival over in-group associations within the dorsal attentional control network (the left dorsal prefrontal, superior medial and inferior dorsal parietal cortex) and also the anterior insula. Notably, in the mismatch trials the magnitude of the signal change in the left posterior superior temporal sulcus and the left inferior frontal gyrus was significantly larger for the rival team's badge as well as the in-group shape. These results are in line with previous findings suggesting a role of the both posterior superior temporal sulcus and inferior frontal gyrus in processing of socially related items. This framework provides novel insights into the neural basis of in-group biases in the context of real world rivalry.

Keywords: In-group bias, Dorsal prefrontal cortex, Posterior superior temporal sulcus, Anterior insula

Introduction

Previous studies have shown that in-group identification results in differential responses to in- and out-group relevant information across different contexts (Michel, et al., 2010; Molenberghs et al., 2012). Accumulating evidence suggests that in-group identification leads to categorizing the 'self' and the 'others' into in- and out-groups (Tajfel, 1982) and this subsequently affects a range of behaviours - from whether empathetic responses are generated to out-group members (Hein, Silani, Preuschoff, Batson, & Singer, 2010) to whether we trust the information out-group members convey (Tanis & Postmes, 2005). Recent social neuroscience studies have investigated the neural correlates of such biases (Gilbert et al., 2012; Golby et al., 2001; Van Bavel et al., 2008). For example, activity in the ventromedial prefrontal cortex has been observed when individuals categorize in-group as oppose to out-group words (Molenberghs & Morrison, 2012). In-group categorization can also modulate how sensitive people are to configural properties in faces (Bernstein et al., 2007; Cassidy et al., 2011) and it affects early face-specific event-related responses (Cassidy et al., 2014). The face stimuli were randomly selected from previous studies database and therefore participants had no prior experience with the faces. Since the faces of in-group (own-race) and out-group (other-race) members were equally familiar in these studies the categorization effect for in-group stimuli does not merely reflect the familiarity of the faces. In line with this, there is also evidence on the role of limbic areas such as the amygdala as well as frontal lobe structures in the social modulation of in- or out-group faces. For example, Van Bavel and colleagues (2008) instructed participants to memorize arbitrary faces which they categorized as belonging to an in- or out-group, with group assignment manipulated orthogonal to race. They found greater activity in the amygdala, fusiform gyri, orbitofrontal cortex, and dorsal striatum when participants

categorized in-group faces relative to when they categorized out-group faces. They further showed that the activity in orbitofrontal cortex mediated the in-group bias in self-reported liking for the faces. These studies suggest that the in-group modulation of face perception may be explained through the enhanced processing of stimuli that are made motivationally relevant by group assignment.

These studies leave unclear whether in-group bias arises only for stimuli that are socially habituated to and automatically categorize as being related to an in- or out-group (faces), or whether the in-group driven biases will also occur for any stimulus arbitrarily associated with in- or out-group status. The effects of social association on the perceptual matching of arbitrary stimuli has recently been studied by Sui, He and Humphreys (2012). Participants were asked to associate 3 geometric shapes with three personal labels (e.g., circle- stranger, square- friend, triangle - you). Participants then had to judge whether shape-label pairs were as originally instructed or new pairings (circle-friend, square-you, triangle-stranger). Participants were substantially faster and more accurate to respond to stimuli associated with themselves (e.g., triangle-you) compared with stimuli associated with other people (circle-stranger, square-friend). Sui et al. (2013) further demonstrated the neural basis of this effect. They found that self-related stimuli showed enhanced activation in the ventro-medial prefrontal cortex (vmPFC) and in the posterior superior temporal sulcus in the left hemisphere (LpSTS). Sui et al. (2013) argued that vmPFC activity was linked to the activation of self representations (see also Northoff et al., 2006), while the LpSTS activity reflected an increased attentional response to self-related items (see Sui, Rotshtein, & Humphreys, 2013). In contrast, responses to stranger-related items were associated with increased activity in the dorso-lateral frontal cortex and dorsal posterior parietal cortex. These latter regions have been linked to a top-down attentional control network (Corbetta &

Shulman, 2002), which may be recruited when participants respond to the more difficult associations (e.g., for stranger-related stimuli).

This perceptual matching task has recently been used in the context of in-group relations by Moradi et al., (2015). They had football supporters form associations between geometric shapes and the badge of either their favourite football team, the badge of a neutral football club or the badge of their rival football team. The task was then to decide whether a badge and shape were as originally paired or whether the stimuli had been re-paired. They found that matches were more efficient to in-group stimuli than to out-group pairings. This result correlated with the amount of satisfaction participants expressed with their in-group indicating that the measures tap aspects of real-world association felt by participants. Here, I examined the neural basis of this in-group effect on perception.

Previous imaging studies that have examined in-group processes showed that the brain's midline structures including medial prefrontal cortex plays an important role in driving both self and in-group biases (for a review see Molenberghs, 2013). Previous studies have also provided evidence for the prominent role of the amygdala in in-group biases, especially in the domain of race. Numerous studies have reported a link between the neural activity in the amygdala and racial biases (see Lieberman et al., 2005). However, other evidence indicates that amygdala activation in the domain of in-group biases and out-group derogation is context dependent (Ofan, Rubin, & Amodio, 2014) and might reflect attentional biases toward out-group stimuli (Richeson & Trawalter, 2008) or even the perceivers' attempts to exert attentional control over derogatory responses to the out-group (Wheeler & Fiske, 2005).

In-group biases have also been linked to the anterior insula. In particular, co-activation of the anterior insula together with sub-regions in the frontal cortex

(including the anterior cingulate cortex and the medial and lateral prefrontal cortices) has been shown to represent emotional and social related processes to in-group items (Craig, 2009; Lamm & Singer, 2010). Recent models of the neural basis of in-group biases and prejudice suggest that the insula "*supports visceral and subjective emotional responses towards social in-groups or out-groups"* (Amodio, 2014, p. 672).

Although there have been few studies on the role of the anterior insula in in-group biases, its activity is frequently associated with responses to out-group versus in-group members (Lieberman et al., 2005). This finding has been interpreted as evidence for negative emotional reactions, such as disgust, to out-groups (Harris & Fiske, 2006). Harris and Fiske (2006) further emphasize that the absence of activation in mPFC for out-group stimuli supports the claim that activity in the anterior insula reflects the negative emotional reaction upon seeing out-group faces. This research suggests that the anterior insula contributes to the subjective negative affect against an out-group. However, there is also evidence indicating that the anterior insula is involved in empathic responses to in-group members (Hein et al., 2010), attention to both in- and out-groups and choosing an appropriate response in the situation of conflict (Beer, John, Scabini, & Knight, 2006). These findings fit with the idea of the insula acting as an important 'hub' within a social processing network - particularly for integrating emotional and attentional responses to stimuli. Across independent resting state datasets, it has also been shown that the anterior insula plays an important role in switching between the default mode network (DMN) and the executive function network (ECN), indicating interactions between general (ECN) and social (DMN) attention (Sridharan, Levitin, & Menon, 2008). These findings are consistent with the idea that the anterior insula acts as a "*causal outflow hub*" coordinating two rich networks important for mediating attention and emotion (Sridharan et al., 2008, p. 661).

In the current study I evaluated the neural responses to stimuli associated with in- and out-groups in a perceptual matching task. In order to address real-world groups, I tested the supporters of football teams who saw stimuli associated with their team, their local rival team and a neutral team (an out-group but without the negative emotional associations linked to a rival team). I ask: which neural regions respond differentially to in-group and out-group stimuli, and whether there are particular responses to rival as opposed to other out-group items. I tested participants, whilst they underwent fMRI, with the procedure used by Moradi et al. (2015). One line of research suggests that in-group related stimuli elicit positive emotional responses and that there is an overlap between in-group stimuli and the participant's own identity (Decety & Sommerville, 2003; Smith & Henry, 1996). From this I hypothesise that there should be increased activation in brain regions associated with positive emotional responses and self -referential processes such as (but not limited to) the vmPFC and orbitofrontal cortices (Beer et al., 2006; Damasio et al., 2000; Mitchell et al., 2005). I may also expect to see modulation of attentional responses to in-group stimuli similar to those found with self-associated items (e.g., the LpSTS; Sui, Rotshtein, & Humphreys, 2013). An alternative, though not mutually exclusive proposal, is that group differences in attention and perception might be related to the less positive association with the out-group (Avenanti, Sirigu, & Aglioti, 2010; Mathur et al., 2010). This is particularly important in a competitive context such as football rivalry where out-group derogation is an important motivational influence. This might result in activation in areas such as the anterior insula, the anterior cingulate cortex (see Amodio, 2014) and the precuneus (Bruneau & Saxe, 2010), known to modulate attention to out-groups.

Methods

Participants

Twenty healthy right-handed volunteers (one female) with normal or corrected-to-normal vision and with no history of neurological condition (age range 21-45, Mean (SD) = 31 (7.50) took part in this study. Prior to the experiment participants signed a written informed consent form approved by University of Oxford Medical Sciences Ethics committee.

Stimuli

Three geometric shapes (pentagon, square, and triangle) were presented with each shape paired with a badge for three different football teams. The teams were the participant's favourite football team (the in-group), the closest rival team (the out-group), and a neutral team (which participants neither liked nor disliked but were familiar with). In total I used twelve badges of different teams (listed and depicted in the supplementary materials). Participants were asked to associate each shape with one of the badges. The associations between the shapes and the badges were counterbalanced across participants. Each shape and badge (160×160 pixels, corresponding to 4.5 × 6.5 degree of visual angle) was presented randomly at approximately 3˚ above or below the fixation cross (1˚ x 1˚) at the centre of the screen on a fifty percent grey background and the stimuli were viewed from approximately 50 cm. from the screen. Stimuli were presented on a screen situated 1.5 meters away from the participant, inside the magnetically shielded room; stimuli were displayed via projector (refresh rate 60Hz) situated outside the room. Stimulus presentation and timing was controlled using Presentation software (Neurobehavioral Systems, Albany, CA).

Procedure

In an initial block of 12 trials participants were trained to associate the three shapes with the badges of their favourite team, the traditional rival team, and a neutral team. The pairings between shapes and badges were random and counterbalanced across participants. Each trial began with a fixation cross for 500 ms. followed by the simultaneous presentation of a badge and shape, one above and one below the fixation cross (randomly chosen) for 500 ms. after fixation and there was a response time limit of 1500 ms. During a period of 2000 to 6000 ms. (jittered), a fixation point was presented on the screen. The participants were instructed to decide whether the picture and word match or mismatch the initial instruction by pressing two different buttons during the scanning procedure.

Before the experiment, participants were asked to complete a 'badge familiarity' survey. In this survey participants rated the level of familiarity of the badge of 12 different football clubs including their favourite team and the traditional rival team from 1 (*not familiar*) to 7 (*perfectly familiar*). Furthermore, participants were asked to report how much they like/dislike each team. The liking/disliking ratings were based on a 7-point scale from -3 (strongly disliked) to 3 (strongly liked). To assess the nature of each fan's identification with their team, I adapted a multicomponent social identity questionnaire, which measures relatively stable levels of 'belongingness' to relevant social categories (Leach et al., 2008). To evaluate each participant's commitment to the favourite team, participants were also asked to report the number of matches they attend (including home and away matches) per season, at what age they started to support their team and finally whether they donated money to support their football club financially.

Participants were trained on the matching task using a set of 3 stimuli, half an hour prior to scanning. The associations for each stimulus were maintained throughout

the scanning session. Pre-scan training consisted of 1 session during which 12 trials were presented. There were 183 volumes in each run consisting of 81 trials per run (the rest of the trials were null). All participants completed 6 runs for a total of 486 trials.

fMRI data acquisition

The images were acquired using a 3-T SIEMENS MRI scanner (REF) using 24-chanel head coil. The standard 6-channel SENSE head coil was used to acquire whole-brain echo-planar functional images (EPIs). Forty-two axial slices were acquired with the following parameters: time repetition (TR) 2300 ms., echo time (TE) 30 ms., flip angle 90°, field of view (FOV) 192 mm, matrix 64 , slice thickness 3 mm with no slice gap, and yielding voxels of 3 × 3 × 3 mm in size. In addition, T1-weighted anatomical images were acquired to coregister and normalize functional data (TR = 2040 ms. TE = 4.7 ms., flip angle = 8°, FOV = 192 mm, slice thickness 1.0 mm).

Behavioural results

Ratings

The familiarity ratings were based on a 7-point scale from 1 (*not familiar*) to 7 (*perfectly familiar*). The mean (SD) familiarity ratings were: in-group = 6.90 (±.30), rival = 6.35 (±.58), neutral =5.56 (±.48) .These ratings differed across the teams, $F(2,38)= 39.07$, $p < 001$, $\eta 2 = .673$; this was due to the in-group team being rated as more familiar than the rival, $t(19)=3.58$, $p < .002$, $d = .80$ (mean difference (SE) = .55 (±.68)) and the neutral team, $t(19) =10.16$. $p < .001$, $d = 2.71$ (mean difference (SE) = 1.25 (±.55)). Moreover the rival and the neutral team differed significantly in terms of their rated familiarity, with the rival team being rated as more familiar than the neutral team, $t(19) = 4.76$, $p < .001$, $d = 1.06$ (mean difference (SE) = .70 (±.65)). The mean

(SD) liking/disliking ratings were: in-group = 3.00 (±00), rival -2.35 (±.87), neutral =.25 (±.44). These ratings differed across the teams, $F(2,38) = 439.86$, $p < .001$, $\eta 2 = .959$, with the in-group team being rated as more liked than both the rival, $t(19) = 27.34$, $p < .001$, $d = 6.11$ (mean difference (SE) = 5.35(±.87)), and the neutral team, $t(19) = 27.68$, $p < .001$, $d = 6.18$ (mean difference (SE) = 2.75(±.44)). Also, compared to the rival team, the neutral team was rated as more liked, $t(19) = 11.68$, $p < .001$, $d = 2.61$ (mean difference (SE) = 2.6(±.99)). On average the in-group own team was more liked and the rival team more disliked than the neutral team, which was rated close to the mid-point of the scale (0). The mean rated liking scores are shown in Figure 29.

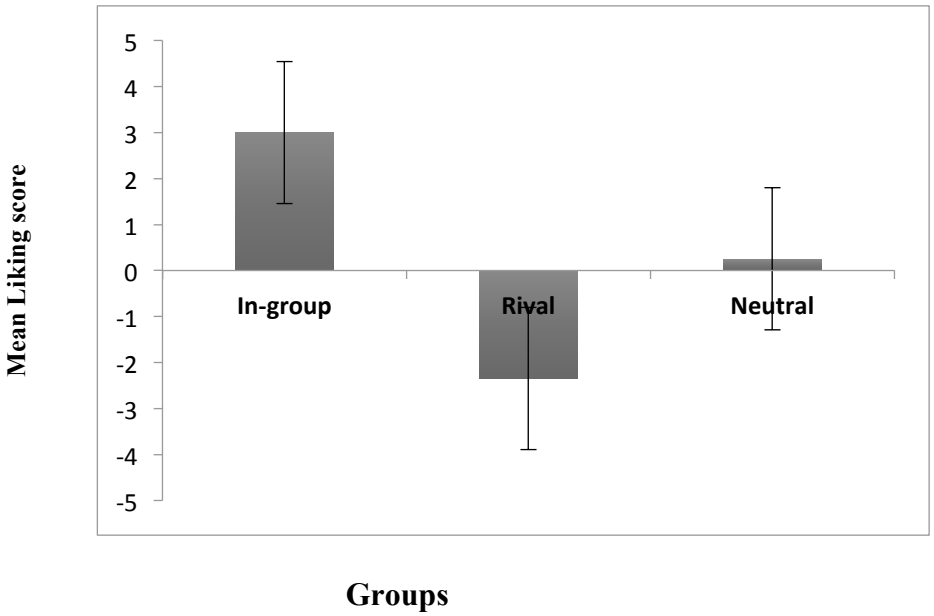


Figure 29. The Mean rated liking score (based on 7-point scale) as a function of group type. The 7-point scale was from -3 (strongly disliked) to 3 (strongly liked). Error bars represent standard error.

On average (mean (SD)) participants attended 28.45(±10.37) matches per year and donated £ 68.50(±58.33) to support their team. On average participants started to support their favourite team at the age of 6(±2.5). The mean (SD) score for the

subcomponents of the questionnaire were solidarity = 18.25 (±2.33, max 21), satisfaction = 24.85 (±2.41, max 28), centrality = 17.30 (±2.90, max 21), in-group homogeneity = 10.45 (±2.35, max 14) and self-stereotyping =10.40 (±2.54, max 14). Across individuals I found positive correlations between the measure of satisfaction with the in-group and the number of matches attended, $r = .81$, $p < .001$, $N = 20$. There was also a reliable positive correlation between the number of matches attended and the money donated, $r = .52$, $p < .02$, $N = 20$. The scatterplots for these correlations are shown in Figure 30.

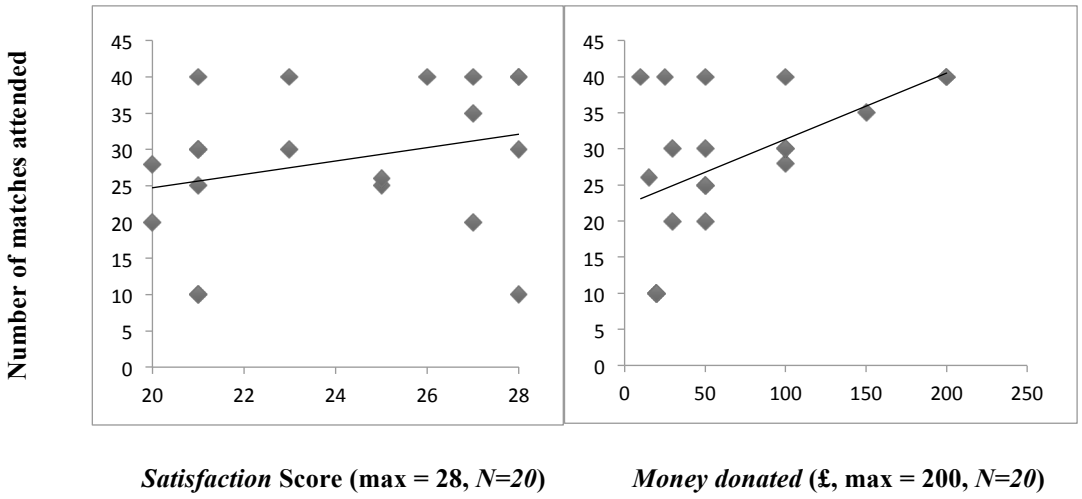


Figure 30. Positive correlations between mean number of matches attended per season (Y axis) and in-group satisfaction score (left) and money donated (right) to support the in-group team.

Accuracy and reaction time

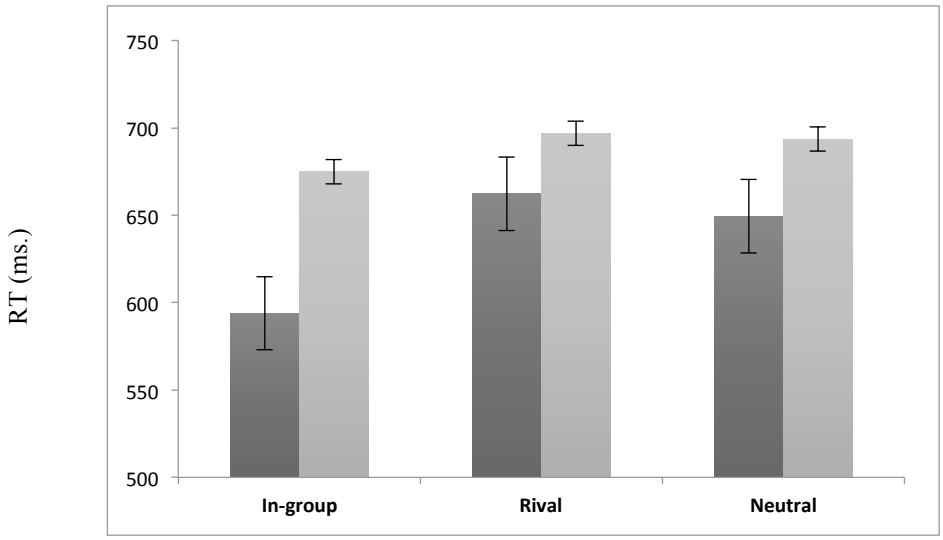
I computed a repeated measure analyses of variance (ANOVA) on reaction times (RTs) with matching condition (match vs. mismatch) and group relevance (in-group vs. rival and neutral) as factors. The mismatch data were organised according to

the badge that was shown. This revealed a significant effect of matching condition, $F(1, 19) = 26.60$, $p < 0.001$, $\eta 2 = .58$, with RTs being faster for the matching compared to the mismatching pairs (mean difference (SE) = 53.37 ± 10.32). Moreover, the effect of group relevance was significant, $F(2, 38) = 36.88$, $p < 0.001$, $\eta 2 = .66$. The interaction between matching condition and group relevance was also significant, $F(2, 38) = 12.74$, $p < 0.001$, $\eta 2 = .40$. To decompose the interaction I conducted post hoc analyses separately for matching and mismatching pairs. Pairwise comparisons on match pairs showed that the responses to in-group pairs were significantly faster compared to those to the rival, $t(19) = 9.03$, $p < .001$, $d = 2.19$ (mean difference (SE) = 68.39 ± 33.86) and the neutral teams, $t(19) = 6.05$, $p < .001$, $d = 1.35$ (mean difference (SE) = 55.55 ± 41.00), which did not differ significantly, $t(19) = 1.24$, $p < .22$ (mean difference (SE) = 12.84 ± 46.07). Pairwise comparisons on mismatch pairs also revealed that responses to the in-group mismatch pairs were significantly faster than those to the rival, $t(19) = 4.12$, $p < .001$, $d = .92$ (mean difference (SE) =22.04 ±23.89) and neutral teams, $t(19) = 3.22$, $p < .004$, $d = .72$ (mean difference (SE) = 18.80 ± 26.09). However, mismatch rival and neutral teams did not differ, $t(19) = .72$, $p < .47$ (mean difference (SE) = 3.24 ± 20.04).

The analysis of response accuracy also showed a significant main effect of matching condition, $F(1, 19) = 8.91$, $p < .008$, $\eta 2 = .32$, as well as group relevance, $F(2, 38) = 24.04$, $p < .001$, $\eta 2 = .56$. Furthermore, the interaction between matching condition and group relevance was significant, $F(2, 38) = 20.85$, $p < .001$, $\eta 2 = .52$. Pairwise comparisons were conducted separately for the match and mismatch pairs. The results showed that, for the match pairs, the accuracy for the in-group pair was significantly higher than for both the neutral, $t(19) = 8.38$, $p < .001$, $d = 1.87$ (mean difference (SE) = .14 ± .07) and rival teams, $t(19) = 5.92$, $p < .001$, $d = 1.32$ (mean

difference (SE) = .12 ± .09), which did not differ significantly, $t(19) = 1.24$, $p < .23$ (mean difference (SE) = .02 ± .09). However, the effect of group relevance was not significant on the mismatch pairs, $p < .70$. The results on accuracy and reaction time for both match and mismatch pairs are shown in Figure 31a and 31b.

a



b

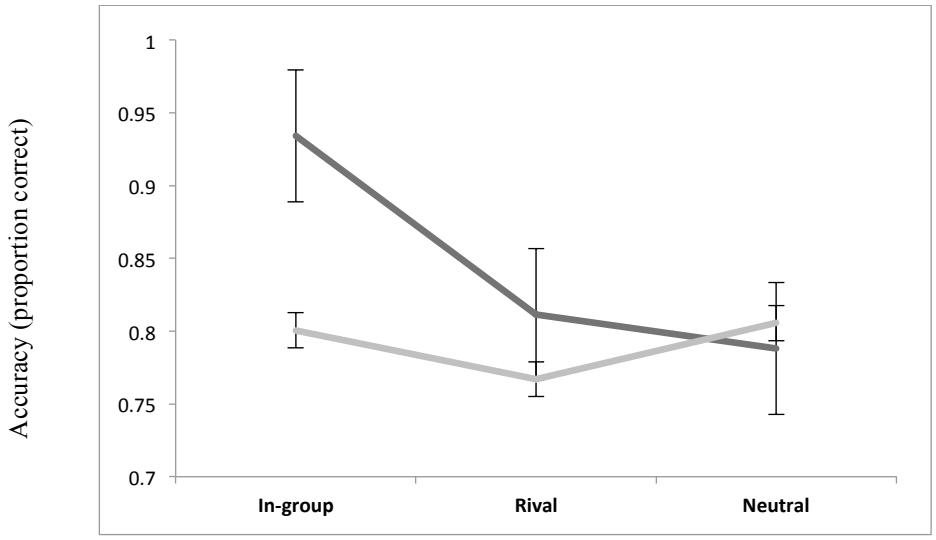


Figure 31. Behavioural performance in the matching task. (a). Mean reaction time (ms.) and (b) mean accuracy (proportion correct) for the match (dark grey) and mismatch (light grey) pairs as the function of group relevance. Error bars represent standard error.

Next, I tested whether there was any correlation between performance and the measures of identification, number of matches attended, age when attendance started and amount of money given to the football team. The difference between the RT for each participant's own team and the rival team was used as a measure of "*in-group bias*"[7]. This was computed separately on match and mismatch trials.

Across individuals the correlation analyses revealed a positive correlation between in-group bias (based on the difference on RT for in-group and out-group match trials), and the subcomponent of satisfaction, $r = .51$, $p < .02$, $N = 20$. However, the correlation between in-group bias and solidarity was not significant, $r = .13$, $p < .57$, $N = 20$. On mismatch trials, in-group bias did not significantly correlate with either the solidarity, $r = .17$, $p < .45$, or the satisfaction measures, $r = .32$, $p < .16$, $N = 20$. The scatterplot for the correlational analyses is depicted in Figure 32.

[7] The contrast was made between the in-group and the rival team here in order to maximise the in-group bias effect whilst equating the stimuli for familiarity (which was match for the in-group and rival teams).

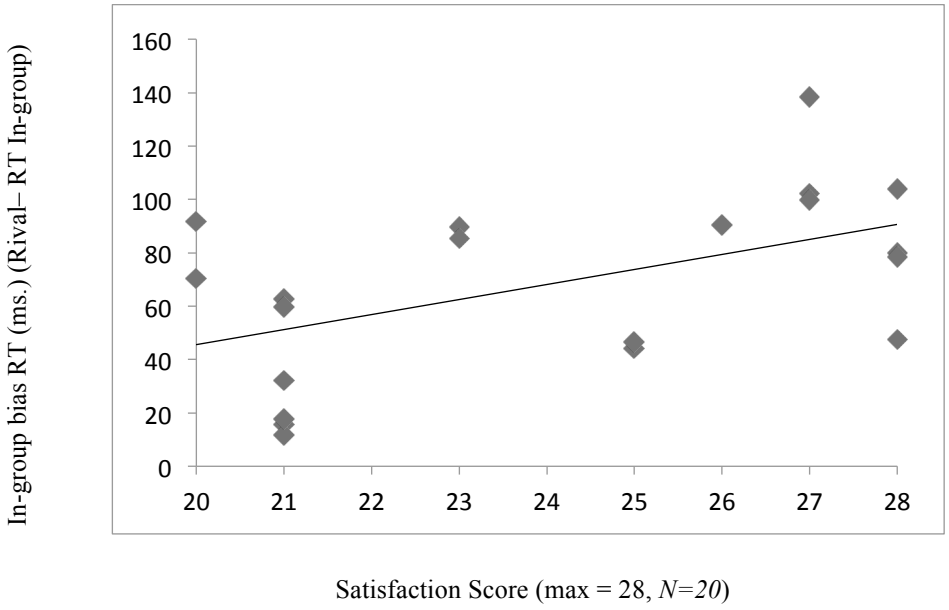


Figure 32. Positive correlation between in-group bias (RT rival – RT in-group) and satisfaction subcomponent of in-group identification questionnaire.

Preprocessing and whole-brain GLM analyses

The magnetic resonance data, collected in the form of 4D volumes, were first converted to 3D files using the MRIcro software (http://www.mricro.com). The data were then analysed using SPM8 (Wellcome Trust Centre for Neuroimaging). Since the obtained EPI data were interleaved, the functional images were corrected for slice-timing acquisition as a part of the preprocessing procedure. The images were then realigned to the first functional image. The T1-weighted images were co-registered to the mean EPI image. Low-frequency signal drift was corrected for by applying a high-pass temporal filter with a cut-off of 128 s. The co-registered data were subsequently normalized onto the Montreal Neurological Institute (MNI) template with spatial resolution after normalization of 3 × 3 × 3 mm. The resulting normalization parameters were applied to all the EPI

images. The functional data were spatially smoothed using an 8-mm isotropic Gaussian Kernel before the statistical analysis. Statistical analysis at the first level was performed using a general linear model (GLM). I then conducted a whole-brain voxel-based analysis across participants using the contrasts defined at the first level. A random effect GLM was conducted. I modelled the onset of each trial in each of the nine badge–shape pairings conditions (three badges × three shapes). These regressions were convolved with the canonical hemodynamic response function. The GLM was used to test for the main effect of the group relevance on contrasts of interest for the match and mismatch trials. The mismatch trials can be organised according to either the badge that was presented or the shape. To assess the effects of the badge, the mismatch conditions were averaged across the two shape conditions for each badge (e.g., in-group badge with rival shape and in-group badge and neutral shape; the same held for the rival and neutral mismatch conditions). To assess the effects of the shape associated with the badge, the mismatch conditions were averaged across the two badges that could be mismatch to the shape (e.g., in-group shape (from the initial association) and rival badge; in-group shape (from the initial association) and neutral badge).

I assessed BOLD activity both when the few errors that were made were taken into account and when they were included; this made little difference to the results (see also Sui et al., 2013). Here, I report findings based on a model for the full dataset, not accounting for accuracy. In the current model I used the same criteria used by Sui et al. (2013), setting the amplitude of voxels surviving at $p < 0.005$ (uncorrected) across the whole brain and an extent threshold of 560 mm3 (>70 voxels). To investigate whether there was a main effect of group relevance on brain activity the whole brain GLM analyses were conducted separately on match and mismatch trials. I tested brain regions

that showed either an increasing (in-group> rival (or neutral)) or a decreasing (in-group< rival (or neutral) response.

Match trials

On the match trials the contrasts between in-group and rival or neutral pairs did not result in any significant activation (in-group vs. rival and in-group vs. neutral). However, the contrast for neutral vs. rival (rival > neutral) resulted in activation in the left parahippocampal gyrus. This finding is shown in Figure 33.

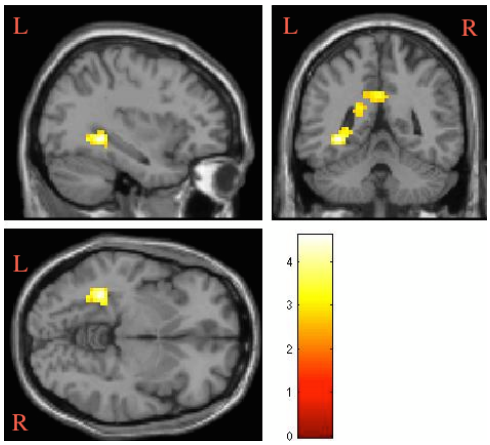


Figure 33. Activation in the left parahippocampal gyrus across twenty participants for the match trials. Voxels more active while responding to neutral as opposed to rival match pairs. The statistical threshold was set at $p<.005$ (uncorrected) with Family Wise Error (FWE) corrected for multiple comparisons ($p<.05$) and a minimum extent of 70 voxels. MNI coordinates (X,Y,Z) can be found in Table 15.

Mismatch trials

I then set the contrasts to test whether there was any effect of group relevance on mismatch pairs. This was done in two different ways: (1) based on the badge of the

teams and (2) based on the shapes that were associated with each team (see above). For both sets of analyses there were 3 different mismatch pairs.

When the data were organized by the badge, there was decreased activity for in-group vs. the rival mismatch pairs (in-group < rival) in multiple clusters including the left lateral frontal and prefrontal cortices, left anterior insula, left intra-parietal sulcus, left precuneus and left fusiform area. Decreased activity was also found for the in-group vs. the neutral mismatch pairs (in-group < neutral) in a distributed network overlapping with some of the regions found for the in-group < rival contrast. The regions containing peak activation differences included the left and right anterior insula, the left inferior frontal gyrus and the left fusiform gyrus. The reverse contrasts (in-group > neural and in-group > rival) did not result in any significant activity. The results regarding this contrast are shown in Figure 34.

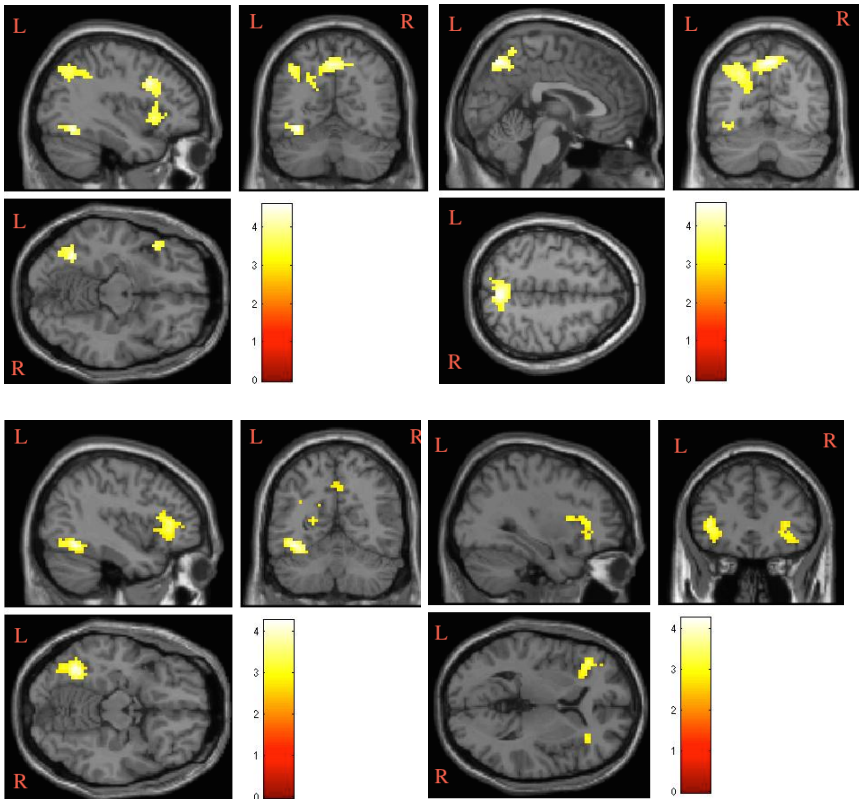


Figure 34. Activation maps across twenty participants for the mismatch trials. Top: Activation map in the left DLPFC, IFG, AIC, precuneus and fusiform gyrus. Voxels for the contrast rival>in-group for mismatch trials organized by badge.Bottom: Activation map in the left and right AIC, left IFG and left fusiform gyrus. Voxels for the contrast neutral>in-group for mismatch trials organized by badge. The statistical threshold was set at $p<.005$ (uncorrected) with Family Wise Error (FWE) corrected for multiple comparisons ($p<.05$) and the minimum extent of 70 voxels. MNI coordinates (X,Y,Z) can be found in Table 15. DLPFC: dorsolateral prefrontal cortex, IFG: inferior frontal gyrus, AIC: anterior insula cortex.

The contrast for the rival versus neutral mismatch pairs (rival > neutral) indicated changes in activation in two regions, one in the right temporoparietal area including the posterior mid temporal sulcus, the TPJ and the angular gyrus. The second site consisted of a small cluster in the left insula. The results are depicted in Figure 35. The reverse contrast (neutral > rival) did not result in any significant activity.

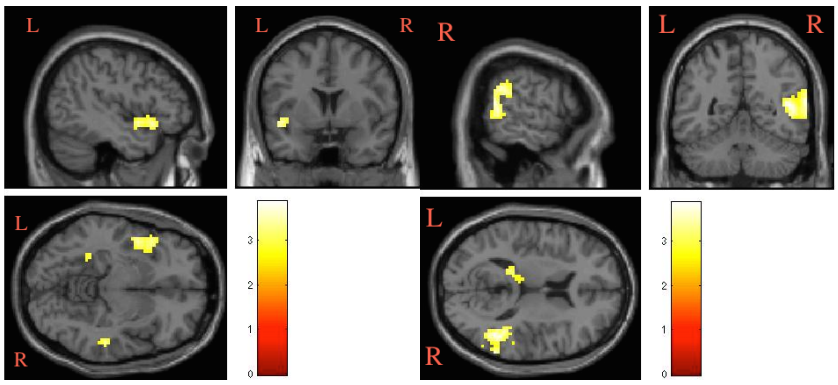


Figure 35. Activation map across twenty participants in the left AIC and the right pSTS . Voxels for the contrast rival > neutral for mismatch trials organized by badge. The statistical threshold was set at $p<.005$ (uncorrected) with Family Wise Error (FWE) corrected for multiple comparisons ($p<.05$) and the minimum extent of 70 voxels. MNI coordinates (X,Y,Z) can be found in Table 15. pSTS: posterior superior temporal sulcus, AIC: anterior insula cortex

When the data were organized by the shape on mismatch trials, the contrast between the in-group and rival conditions (in-group shape > rival) demonstrated reliable activation in the left posterior superior temporal sulcus (LpSTS) extending into the left inferior parietal lobule. There was also a trend for the same contrast in the posterior cingulate. The reverse contrast (rival shape > in-group shape) did not result in any significant activation. The contrasts between the neutral and rival shape trials did not yield any significant results. The results for the contrasts based on shapes are shown in Figure 36. Table 15 provides summary statistics of all the contrasts.

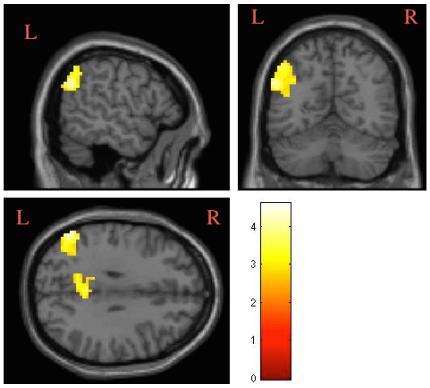


Figure 36. Activation map across twenty participants in the left pSTS. Voxels for the contrast in-group>rival for mismatch trials organized by shape. The statistical threshold was set at $p<.005$ (uncorrected) with Family Wise Error (FWE) corrected for multiple comparisons ($p<.05$) and the minimum extent of 70 voxels. MNI coordinates (X,Y,Z) can be found in Table 15.

Table 15

Activation statistics and MNI coordinates linked to all the badge-shape associations.

Contrast	*Cluster*		*Peak voxel*			
Region	***P-corrected***	**K**	**X**	**Y**	**Z**	**Z-score**
Match pairs						
Rival > Neutral						
Left Parahypocampal gyrus (Extended to Fusiform area)	0.005**	261	-33	-46	-5	4.41
			-18	-40	13	3.63
Mismatch pairs (based on badge)						
Rival > In-group						
Right posterior cingulate	0.001***	627	3	-67	52	4.39
Left precuneus area			-21	-76	46	4.26
			-42	-49	43	3.95
Left fusiform	0.020*	94	-33	-61	-14	4.36
			-39	-73	-11	3.43
			-45	-61	-8	3.32
Left DLPFC (Extending to IFG)	0.001***	270	-36	14	31	4.16
Left AIC			-39	17	1	3.92
			-45	20	-8	3.74
Right pSTS/TPJ	0.004**	158	48	-43	22	3.93
			60	-46	10	3.63
			45	-46	10	3.46
Neutral > In-group						
Left AIC	0.013*	195	-42	32	4	4.11
			-30	29	-2	3.28
Left IFG			-51	20	10	3.06
Left Precuneus	0.017*	182	-15	-67	25	3.47
			-21	-64	13	3.30
			-33	-79	28	3.00
Left Fusiform area	0.016 *	183	-39	-58	-14	4.11
			-27	-31	-23	3.55
			-33	-49	-20	3.40
Right AIC	0.032*	139	30	14	13	3.11
			15	11	22	3.04
			33	32	4	3.00
Rival > Neutral						
Right pSTS/TPJ	0.001**	426	48	-49	10	3.81
			63	-52	13	3.74
			66	-43	25	3.68
Left AIC/IFG	0.057	106	-45	5	-8	3.40
			-45	20	-11	3.31
Mismatch pairs (based on shape)						
In-group > Rival						
Left pSTS (Extended to inferior parietal lobule)	0.009**	221	-57	-31	34	3.62
			-42	-40	64	3.68
			-57	-25	52	3.58
Right posterior cingulate cortex	0.069	96	3	-34	43	3.29
			3	-19	43	3.02

Note that the significance level was set at $p < 0.005$ uncorrected (FWE corrected at $p<.05$) for the whole brain and an extent threshold of >70 voxels. (X= right/ Left, Y= anterior/posterior, Z= superior/inferior). AIC, anterior insular cortex; DLPFC, dorsal-lateral prefrontal cortex; IFG, inferior frontal gyrus; K, the size of voxels; pSTS, posterior superior temporal sulcus; TPJ, temporoparietal junction.

ROI analyses

Region of interest (ROI) analyses were conducted to examine the more specific contribution of the different activated clusters in the univariate analyses to the task. The ROI analyses focused on three brain regions that have been found to be linked to social attention – the left posterior superior temporal sulcus (pSTS) (Sui, Rotshtein, & Humphreys, 2013) , the left anterior insula (AI) (Kurth Zilles, Fox, Laird, & Eickhoff, 2010) and the left inferior frontal gyrus (IFG) (Molenberghs, Cunnington, & Mattingley, 2012) . Each ROI (left pSTS, left AI and left IFG respectively) was defined as a sphere (7 mm.) centered on a peak voxel in the empirical study of Sui and colleagues (2013), the meta-analysis of Kurth et al. (2010) and the meta-analysis of Molenberghs, Cunnington, & Mattingley (2012). MNI coordinates were converted to Talairach coordinates using a non-linear transformation (http://imaging.mrccbu. cam.ac.uk/imaging/MniTalairach). Brodmann areas and brain regions were identified based on the Talairach Atlas (Talairach & Tournoux, 1988). The co-ordinates for the LpSTS region were centered on *x= -52, y=-62, z= 16* (Sui et al., 2013). The co-ordinates for the LAI region were centred on *x= -35, y=18, z= 7* (Kurth et al., 2010). The co-ordinates for the LIFG region were centred on *x= -50, y=20, z= 14* (Molenberghs, Cunnington, & Mattingley, 2012). I conducted three separate ANOVAs to examine whether there was any effect of the group relevance on the magnitude of BOLD response based on the extracted beta values for each ROI.

Mismatch trials organised by badge

For mismatch trials organised by badge the mean (SD) beta values in left pSTS were neutral =.28±1.03, in-group=.19±.74 and rival=.58±.97. The ANOVA results showed that there was a significant main effect of the group on the magnitude of beta

values in the left IFG, $F(2,38) = 5.19$, $p < .010$, $\eta 2 = .215$. Pairwise comparisons revealed that the beta values in the left pSTS were significantly larger for the rival mismatch pairs (organised by badge) than the in-group, $t(19) = 3.46$, $p < .003$, $d = .74$, mean difference (SE)= .39±.11. The beta values in the left pSTS were also larger for the rival compared to the neutral mismatch trials, but the difference was not significant (corrected for multiple comparisons), $t(19) = 2.05$, $p < .054$, mean difference (SE)= .29±.14. The difference between the in-group and neutral conditions was not significant, $t(19) = .80$, $p < .429$.

The mean (and SD) beta values in the left AI were neutral = .72±.69, in-group = .56±.73 and rival=.82±.84. The ANOVA results revealed that there was a significant effect of group on the size of beta values in the left AI, $F(2,38) = 3.78$, $p < .032$, $\eta 2 = .166$. Pairwise comparisons revealed that on average the beta values were larger for the rival compared to the in-group, $t(19) = 2.46$, $p < .023$, $d = .55$, mean difference (SE) = .26±.10. However the effect was not significant (after correction for multiple comparison). The differences between the beta values for the in-group versus neutral, $t(19) = 1.48$, $p < .155$, mean difference (SE) = .15±.10, and neutral versus rival, $t(19) = 1.47$, $p < .157$, mean difference (SE) = .10±.07, were not significant.

The mean (and SD) beta values in left IFG were neutral = .50±.79, in-group = .23±.69 and rival=.66±1.01. The ANOVA results showed that there was a significant main effect of group on the magnitude of beta values in the LIFG, $F(2,38) = 6.18$, $p < .005$, $\eta 2 = .245$. Pairwise comparisons revealed that, for the mismatch trials, the beta values in the left IFG were significantly larger for the rival than for the in-group, $t(19) = 3.56$, $p < .002$, $d = .79$, mean difference(SE)=.42±.11. The beta values in the left IFG were also larger for the neutral than the in-group condition, but this was not statistically significant (corrected for multiple comparison), $t(19) = 2.19$, $p < .044$, $d = .48$, mean

difference (SE) =.26±.12. The beta values in the left IFG for the neutral mismatch team were not significantly different from those of the rival team, $t(19) = 1.27$, $p < .219$.

Mismatch trials organised by shape

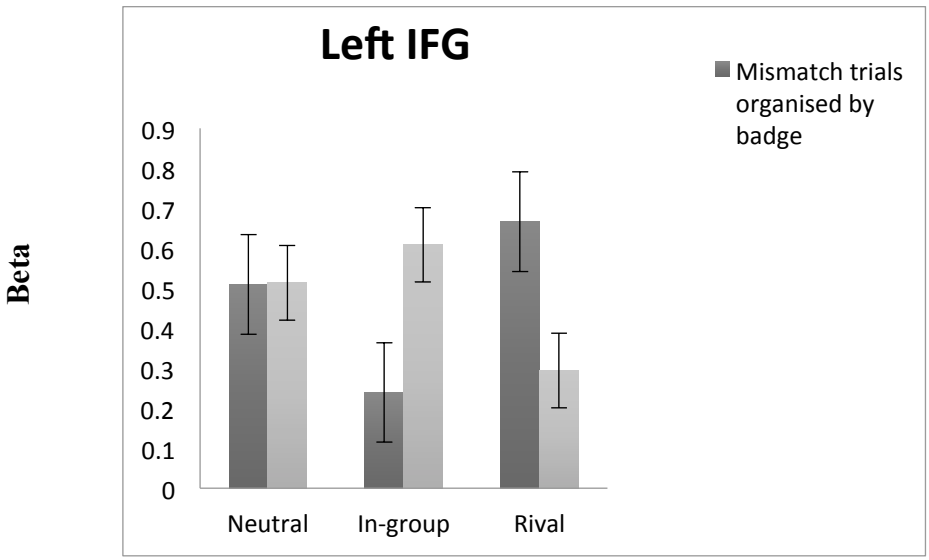
For the mismatch trials organised by shape, the mean (and SD) beta values in the left pSTS were: neutral = .38±1.05, in-group=.50±.95 and rival = .18±.71. There was a significant main effect of the group, $F(2,38) = 3.63$, $p<.036$, $\eta 2=.160$. Pairwise comparisons revealed that the beta values were significantly larger for the in-group shape (on mismatch trials) than the rival shape, $t(19)= 3.05$, $p < .007$, $d = .68$, mean difference (SE)= .31(.10). The difference between the in-group versus neutral shape, $t(19)= .87$, $p < .39$, mean difference (SE)= .11(.13) and neutral versus the rival shape $t(19)= 1.71$, $p < .102$ mean difference (SE)= .20 (.11) were not significant.

The mean (and SD) beta values in the left AI were: neutral = .78±.98, in-group = .68±.65 and rival = .64±.63. The results of the ANOVA showed that the main effect of the group on the magnitude of beta values in the left AI was not significant, $F(2,38)=.78$, $p < .462$, $\eta 2 = .040$.

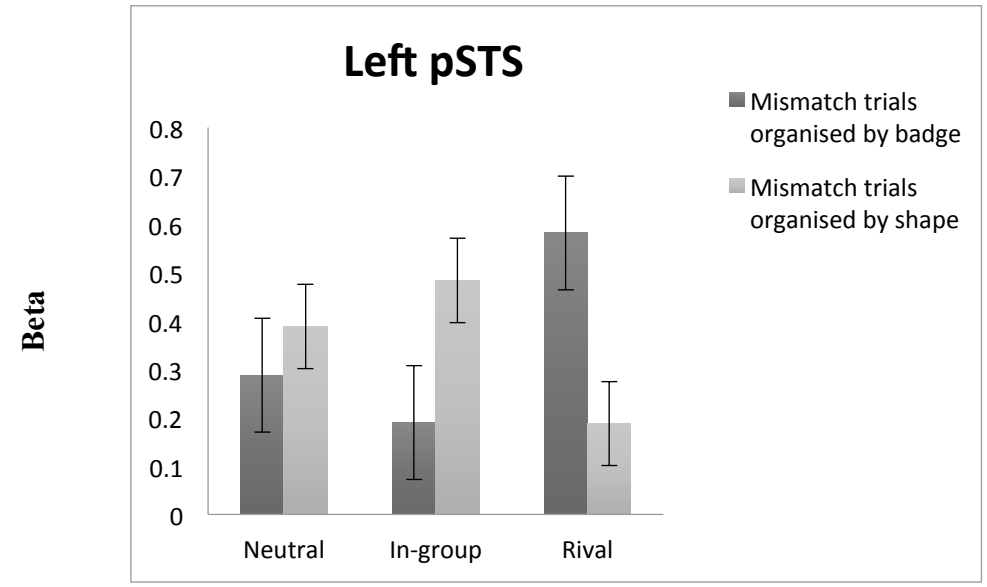
The mean (and SD) beta values in the left IFG were neutral= .51±.99, in-group=.60±.78 and rival = .29±.71. The results of the ANOVA showed that there was a significant main effect of group relevance on the beta values in the left IFG, $F(2,38)=3.61$, $p < .047$, $\eta 2 =.160$. The beta values were significantly larger for trials organized by the in-group rather than the rival shape, $t(19)=3.55$, $p < .002$, $d = .79$, mean difference(SE)=.31±.08. However, the difference between the in-group trials and the neutral trials, $t(19)=.75$, $p < .457$, mean difference(SE)=.09±.12, and between the neutral and rival trials were not significant, $t(19)=1.56$, $p < .134$, mean

difference=.21±.14. The results of the ROI analyses are presented in Figures 37a, 37b & 37c.

a



b



c

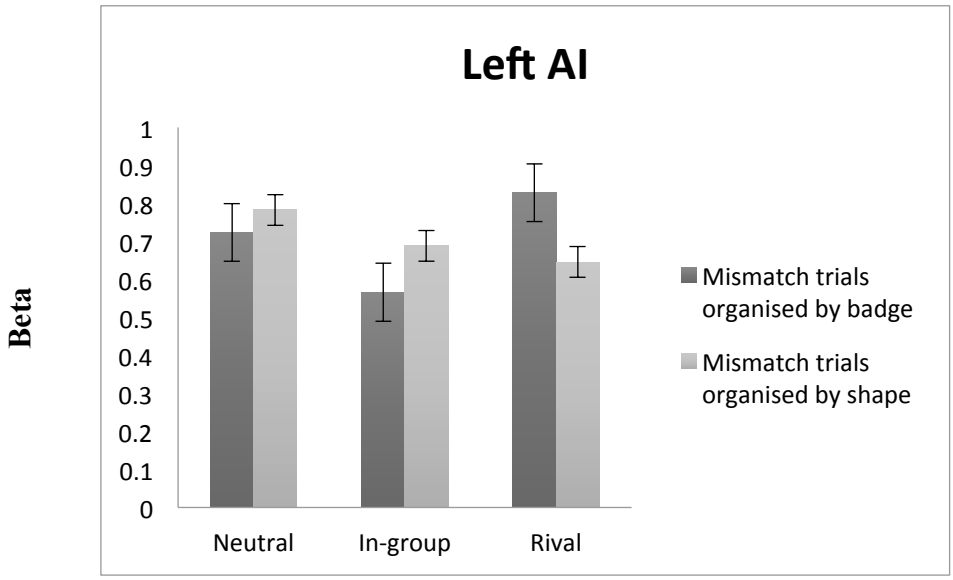


Figure 37. Parameter estimation (beta-values) in ROIs. The ROIs include **(a)** the left IFG, **(b)** the left pSTS and **(c)** the left AI for the mismatch trials organised by badge (dark grey) and by shape (light grey) as a function of group relevance. IFG: inferior frontal gyrus, pSTS: posterior superior temporal sulcus, AI: anterior insula.

I next tested whether there was any correlation between the differences in beta values for in- versus rival team in the left pSTS, left AI and the left IFG on the mismatch trials organised by badge and by shape. For the mismatch trials organised by the badge the results showed that the correlation between the differences in beta values for in- versus rival team in the left pSTS and the left IFG was not statistically significant, r= -.154, p < .516, N=20, neither was the correlation between the left pSTS and the left AI, r= .108, p < .650, N = 20, or the left IFG and the left AI, r = -.051, p < .831, N = 20. For the mismatch trials organized by shape the correlation between the differences in beta values for in- versus rival team in the left pSTS and the left IFG was not significant, r =.287, p < .220, N = 20. There was a significant negative correlation

between the left pSTS and the left AI, r= -.530, p < .016, N = 20. However, the correlation between the left IFG and the left AI was not significant, r = -.154, p < .516, N=20.

Correlation with behaviour

I then tested whether there was any significant relationship between the differences in the beta values for the in-versus rival team in the regions of interest and the behavioural index of in-group bias (i.e. the difference between the reaction time for in-group versus rival team). This was assessed for the mismatch trials organised by badge and by shape. For the mismatch trials organised by badge the correlations between the behavioural index of in-group bias and the neural index of in-group bias (the difference between the beta values for the in-group versus the rival team) in the left pSTS, r = -.175, p < .460, N = 20, left AI, r = -.300, p < .198, N = 20, and left IFG, r = .388, p < .091, N = 20, were not statistically significant. This was also the case when the mismatch trials were organized by shape, r = -.282, p < .231, N = 20, the left AI, r= -.038, p < .873, N = 20, and the left IFG, r = -.021, p < .931, N = 20.

Discussion

I investigated the effect of group relevance on football supporters as they performed a perceptual matching task (matching a geometric shape to the badge of a football team). Participants were both faster and more accurate at matching in-group stimuli compared with matching neutral and rival teams - in line with previous findings (Moradi et al., 2015; Sui, Rotshtein, & Humphreys, 2013). This effect was related to the rated in-group satisfaction.

These behavioural results were complemented by the fMRI data. The whole brain analysis failed to reveal reliable differences between the association conditions for match trials. However there were effects of mismatch trials. When mismatch trials were organized by the badges of the different teams we found increased activity in the IFG, DLPFC, anterior insula, fusiform gyrus, the right TPJ and the precuneus for the rival team badge. Previous studies have shown that activity in the DLPFC and IFG mediate controlled attention (Corbetta & Shulman, 2002). Involvement of these areas for mismatching pairs is consistent with participants requiring increased attention to reject mismatching stimuli. The IFG and DLPFC form part of a dorsal attentional control network that may be recruited when the rival badge is present perhaps because matches to these badges were difficult to make. The anterior insula and precuneus have been associated with a number of different cognitive functions generally involving social cognition. The anterior insula in particular has been linked to the processing of emotions in a variety of social contexts (Kurth et al., 2010). In addition, evidence from animal studies reveals that affiliative emotions can be induced by stimulating anterior parts of the insula in macaques (Caruana et al., 2011). This area in anterior insula is very close to the cluster generating peak activity for rival relative to in-group badges, on mismatch trials. The stronger activation of these regions by the rival team badge may reflect an increased emotional response to the rival team. A somewhat different account of the results for the AIC is that activity in that region stems from feelings of disgust to the rival badge (Adolphs, 2002; Calder et al., 2001). Here I suggest that a strong disgust reaction to the rival team badge may disrupt attention to a stimulus associated with a rival team, slowing responses (compared to responses to stimuli associated with the in-group), I note there that group-dependent biases associated with

football are among those "*Blatant biases that are more conscious, hot, direct and unambiguous*" (Fisk, 2002, p 126).

Other brain areas differentially activated by the rival team badge were the precuneus and the TPJ/inferior parietal cortex (particularly in the right hemisphere). The precuneus has been associated with inhibitory responding to stimuli in order to prevent items from attracting attention (Allen, Humphreys, & Matthews, 2008; Olivers, Smith, Matthews, & Humphreys, 2005). In the present case, there may be inhibition of positive responding to the rival team badge, mediated by the precuneus. Finally, there was also increased activity linked to the rival team badge in the right TPJ and inferior parietal cortex. Corbetta and Shulman (2002) have argued that the right TPJ (also implicated in responding to the rival team badge) reflects bottom-up triggering of attention by strong external stimuli. Here I may argue that there is bottom-up cueing of attention to the presence of the rival badge.

In contrast to these results in relation to the rival team badge, there was evidence of increased activity in the left pSTS and left IFG on mismatch trials involving the in-group shape. Sui et al. (2013) reported enhanced activity in the left pSTS to stimuli matched to the self relative to other people and suggested that this reflect increased social attention to such stimuli. Here the left pSTS response showed increased activity when the shape associated with the in-group appeared with a mismatching badge. This is line with the result that Sui et al.(2013) found and extends their results indicating that left pSTS modulates attention to both self and in-group relevant stimuli. More interestingly, the ROI analyses further confirmed that the magnitude of BOLD response (based on the extracted beta values) both in the left pSTS and the left IFG was significantly larger for the in-group shape than the rival shape. The left IFG has been shown to be involved in response inhibition in the tasks such as Stroop colour-word

requiring attention control (see for example, Milham et al., 2001). Here, I propose that the matching task that I used might also require the inhibition of "*yes*" response for the mismatch trials and this in turn increases the level of activity in the left IFG and the left pSTS.

These results showed that in-group biases modulate basic perceptual matching performance. Effects of in-group bias even on such apparent low-level tasks may make it difficult to moderate group-based biases, but this is clearly an important topic with practical as well as theoretical consequences. Understanding the neural basis of the biases, and how they may change, remains for future work.

Chapter 9

General Discussion

Effect of in-group biases on attention and perception

The motivation to affiliate to a group is among the basic needs of human beings. Across different contexts in-group identification provokes robust effects in favour of one's in-group on attention, memory, learning and decision making (Cikara, Botvinick, Fiske, 2011; Molenberghs et al., 2012; Moradi et al., 2015). In-group identification not only can shape our behaviour and beliefs, but it can also permeate the very basic cognitive functions.

In this thesis I have deliberately recruited different methodologies to be able to study in-group biases from different angles falling within three different themes: 1) The effect of in-group biases on attention and perception (Chapters 2, 3 and 4), 2) In-group biases and inhibitory control in looking behaviour (Chapters 5 and 6). and 3) The neural correlates of in-group biases (Chapters 7 and 8). I will discuss each theme separately and draw some final conclusions on the basis of the three themes.

I started by looking at in-group biases on behaviour in an associative matching task (see Chapters 2, 3 and 4). In Chapter 2, I conducted a study in the field with football fans using a procedure in which participants learned to associate simple geometric shapes with the badge of their favourite team, its closest rival and a neutral team (out-groups). Despite the noisy environment, fans performed more efficiently on the in-group trials as opposed to trials in the other conditions. Similarly, fans showed enhanced performance for in-group related stimuli in the laboratory under controlled conditions. This effect occurred on both RTs and on a measure of perceptual sensitivity (d prime). It also occurred both on simultaneous match trials and with sequential trials in which the badge preceded the shape and participants only responded to the shape (equating for familiarity across the conditions). To have a more reliable effect and to ensure that the effects were not simply driven by the intrinsic properties of the in-group

stimulus or its familiarity I also recruited participants who did not identify with either of the football teams. This control study demonstrated that the in-group advantage did not reflect the intrinsic properties of the particular badges I used (e.g., the colour of the Oxford United badge) as individuals who were not football fans displayed no differences in matching the different badges used in experiments. Furthermore, the results from an extra control study using stimuli that varied more widely in familiarity than the football badges for our football supporters failed to show differences in perceptual matching for familiar and unfamiliar items. Rather than familiarity then, the in-group biases seem to reflect the motivational factors tied to in-group identification. This was further supported by the enhanced performance on in-group items being correlated with a measure of in-group satisfaction.

In the following chapter, I tested whether the in-group biases rely more on stored knowledge about the group features or whether group-driven motivation plays a more important role. Across three experiments university rowers were instructed to respond to the original colours of their team, the rival team and a neutral team paired with team labels. I showed that the rowers consistently performed better for their in-group regardless of whether the pairings between the team labels and the colours were based on a real word association or a newly established association. These results again suggest that the perceptual in-group bias effect does not rely merely on stored knowledge of the sensory properties of the particular in-group stimulus since the effect survives colour re-assignment (Experiment 1, swap conditions) and it also existed when in- and out-group stimuli were assigned new colours (Experiment 2). Better performance for in-group stimuli could be attributed to the motivation to respond to in-group pairs. The correlation between participants' ratings of their satisfaction with their team and the magnitude of in-group bias further supports this notion. This is in line with

the main concepts of social identity theory (SIT; Tajfel, 1978; Tajfel & Turner, 1979). This theory posits that the saliency of social identity results in an attentional focus on in-group relevant information (Brown, 2000; Tajfel, 1978). Therefore, the in-group driven motivation has the potential to produce an in-group bias (Hewstone et al., 2002).

In Chapter 4, I further expanded this view and asked whether increased motivational relevance for in-group attributes could both enhance attentional salience and, through this, facilitate the binding of visual features associated with the stimuli. In this chapter, I took a mathematical approach to test whether group association with neutral targets had any effect on the interactions between the processing of colour and shape. Previous research (Yankouskaya et al., 2014) has shown that decision times are faster when detecting two targets for which the same response is required, compared to when only one of the targets is present - resulting in a redundancy gain. I examined whether in-group associations had any effect on redundancy gains. Participants made associations between a shape, a colour and either in- or out-group labels. They then had to discriminate whether in- or out-group stimuli appeared (single or redundant feature). I found that responses to in- but not to out-group stimuli violated predictions of models, which hold that associated features are processed independently. I further showed that these redundancy gains were consistent with in-group stimuli (but not out-group stimuli) being processed with 'super-capacity'. These findings shows there is enhanced perceptual integration for information associated with an in-group.

The results in Chapter 4 also demonstrated that the independent race model was violated for redundant in-group targets but not for targets associated with the out-group. The violation of the race model inequality for in-group targets rules out models assuming independent processing regarding each target feature. This further confirms that higher-level social factors such as group relevance affect perception. I suggest that

in-group association provides enhanced 'perceptual glue' that facilitates the integration of stimulus features, and this in turns generates non-independent processing of features when they redundantly signal the presence of a target. However, in real life situations different factors might modulate the effect that was found. For example, using faces as more ecologically valid stimuli, Yankouskaya and colleagues (2014) found larger redundancy gains with the faces belonging to the participant's in-group compared to that of out-group. They further showed that the magnitude of the redundancy gain for displays containing both identity and expression targets varied as a result of experience with out-group faces. This is particularly interesting since in broader spectrum, this might indicate that intergroup contact can attenuate perceptual prejudice against out-group.

In-group biases and inhibitory control in looking behaviour

Previous work suggests that in- group biases can be automatic and therefore difficult to control. In Chapters 5 and 6 I assessed whether in-group identification modulates the control of pro- and antisaccadic eye movements. First, I had football fans perform pro and antisaccade eye movements toward or away from the badge of their favourite football team, its closest rival team and a neutral team that participants rated as having no importance to them. I investigated whether in-group identification modulates the speed of making a pro-saccade towards the participant's favourite team as opposed to the team the participant dislikes. Furthermore, I asked whether the motivation to look at one's favourite football badge results in a higher number of directional errors in the antisaccade task for own vs. out-group (rival and neutral) badges. In the second experiment in Chapter 5, I further investigated whether the familiarity of badges or their intrinsic properties (for example, the colour of the badges)

would lead to the differential pattern of looking behaviour or whether the in-group identification was necessary. To answer this question, in Experiment 2, a group of participants with no connection to the teams, but who were familiar with the badges, performed the same task. There were no differential effects of the badges in this case.

Overall these data indicate that football fans made more directional errors on antisaccade trials for the badge of their favourite team (in-group) compared to the badges of neutral and rival teams (out-groups). Moreover, participants took longer to correct their directional errors for in-group compared to similar corrections for neutral and rival teams. In contrast to this, on prosaccade trials, the fans made more directional errors for the badge of the rival team. Conducting correlational analyses I further showed that the number of directional errors to in-group stimuli on antisaccade trials was positively correlated with vicarious reward and satisfaction toward the participant's own team. The findings suggest that the effect of in-group identification on looking behaviour is automatic and related to motivational factors, for example satisfaction with in-group, and this in turn explains why it was difficult to look away from an in-group related stimulus or toward a stimulus associated with a rival group.

In tandem with the findings of Chapter 5, in Chapter 6 I tested the validity and the reliability of the results in a slightly different design. In Chapter 5, I used mixed pro and antisaccade blocks where there was a similar chance of a pro or antisaccade occurring within each single block. Previous studies (for example, see Irving, Tajik-Parvinchi, Lillakas, González, & Steinbach, 2009) showed that, under the mixed design, participants normally make more directional errors compared to when the conditions are blocked (DeSouza, Menon, & Everling, 2003). In Chapter 6, I used blocked conditions. This design also enabled me to ask further questions about whether

the task (pro vs. antisaccade) as well as the in-group motivation modulates changes in pupil size – an index of task difficulty (Goldinger, He, & Papesh, 2009).

In these studies, I used simple abstract targets - circles in different colours- representing different University rowing teams (in-group team, neutral team, rival team). Similar to the effect that I presented before, here I found a higher rate of directional errors in the antisaccade task for the in-group compared with the rival team. Moreover, I showed that pupil diameters increased for the antisaccade task, which is more difficult to perform in comparison to the prosaccade task. Pupil diameters were also increased for the in-group stimuli even on the prosaccade task. This clearly shows that this pupil diameter effect is driven by in-group identification (e.g., a positive emotional response) and it dissociates from the effect of task difficulty.

More importantly, I showed that at a late time window the effects of in-group identifications were modulated by the task, with group differences decreasing in the antisaccade relative to the prosaccade procedure. The findings indicate dissociable effects of task difficulty and in-group driven positive motivation on pupil responses. The data also indicate a late-acting suppression of the motivational response when the motivated action (looking at in-group target) has to be inhibited on antisaccade trials.

Overall, the findings of Chapters 5 and 6 establish that in-group biases can modulate inhibitory control in looking behaviour. The findings are consistent with studies indicating a positive emotional and motivation-based response to in-group stimuli. With regard to the directional errors and inhibitory control in antisaccade tasks, similar results were obtained under the mixed and pure blocks of pro and antisaccades.

Previous studies have identified a connection between inhibitory control and implicit in-group bias. For example, studies have shown a positive correlation between directional errors in an anti-saccade task to neutral stimuli and implicit racial bias

(Payne, 2005). In this context, the greater the racial bias the poorer the inhibitory control. This further supports the notion that in-group biases are automatic and therefore conscious cognitive effort might be required to control them (Amodio & Devine, 2006; Hewstone, et al., 2002). The findings of the studies that I presented in Chapter 5 and 6 are important in that they confirm that even an abstract feature of an in-group (the badge of a football team or a University-associated colour) is enough to affect the inhibitory control in looking behaviour. Furthermore, these findings established that eye-tracking provides a sensitive way to study implicit in-group biases.

Recent neuroimaging studies have investigated the neural regions implicated in inhibitory control. These studies reveal that various brain regions play a role in inhibitory control of eye-movements, with prefrontal regions being suggested to be critical (Munoz & Everling, 2004; Pierrot-Deseilligny, Rivaud, Gaymard, & Agid, 1991). Within the frontal cortex the main areas implicated in inhibitory control of eye-movements are the right inferior frontal cortex, the frontal eye fields, the supplementary eye fields and the dorsomedial frontal cortex (particularly the pre-supplementary motor area). A closer look at the literature shows that these frontal regions are also important in social attention (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999; Sander et al., 2005). This may suggest some overlap between these networks. Future research may start to investigate the neural correlates of inhibitory control of eye-movements under the effect of in-group biases. It would be particularly beneficial for future studies to combine eye-tracking techniques and neuroimaging methods such as functional magnetic resonance imaging to shed light on the underlying neural networks governing visual attention and, in particular, inhibitory control in looking behaviour for socially important stimuli. Future studies might also examine the generalizability of these

effects and whether the effects of in-group identification on basic aspects of eye movement behaviour can predict prejudice in real life.

The neural correlates of in-group biases

So far, across four Chapters I showed that in-group biases modulate attention and perception as well as inhibitory control in looking behaviour. There is now ample evidence on the effects of group relevance on different aspects of cognition and behaviour (for example, Yankouskaya et al., 2014). This line of research suggests that information relevant to in-group stimuli can have raised saliency for perception and attention (see, Amodio, 2014; Frith & Frith, 2012), leading to enhanced processing of stimuli that are socially relevant (related to in-group) (Moradi et al., 2015; Morrison et al., 2012). What are the underlying neural bases of such enhanced perceptual matching for in-group relevant information? In Chapter 7, I investigated this issue using a resting state functional connectivity approach. This approach assesses the evidence showing strong correlations in low-frequency neural activities under resting state conditions while participants are not performing a task (Deco et al., 2013; Mantini et al., 2007). Such interrelated neural activities might reflect the functional relationship between brain regions operating as a part of an underlying neural network related to attentional orienting and stimulus saliency (Fox et al., 2006). In the current study I explored whether the resting state activity in the brain was related to in-group biases in perception. I further asked whether changes in resting state activity after participants performed the perceptual matching task with in- and out-group stimuli correlated with enhanced behavioural performance for the in-group. By comparing resting state activity before and after the task, I also evaluated changes in underlying functional activity controlled for between-individual differences at baseline. I found significant

under-connectivity between the left anterior insula (AIC) and left dorsolateral prefrontal cortex (DLPFC) in post-task compared to the pre-task functional connectivity. I further showed that post-task functional connectivity was significantly stronger between the left anterior insula cortex (AIC) and the inferior frontal gyrus (IFG). More importantly, the strength of post-task functional connectivity between the AIC and IFG was positively correlated with in-group bias (reaction time differences for in- versus out-group). These results indicate that functional connectivity between the AIC and IFG mediates the processing of socially relevant stimuli. In addition to this, the correlation between the strength of post-task functional connectivity between the AIC and the IFG and the performance difference for in versus out-group stimuli suggests that the underlying mechanisms of enhanced performance in in-group perception are governed by the frontoinsular network.

Previous studies have also reported evidence for functional connectivity between the IFG and the insula for processing of emotional and social stimuli (for example see, Jabbi & Keysers, 2008). There is additional evidence on the anatomical interconnectivity of the anterior insula and the IFG (Catani et. al., 2012). This might in turn explain the facilitatory interaction between these areas in processing social and emotional stimuli, here in-group relevant stimuli. However, an alternative scenario might explain the strong connectivity between the anterior insula and the IFG and its relation to the in-group bias in terms of the effects of disgust. In the latter case, rather than positive emotion attached to in-group this strong functional connectivity might indicate the negativity of the out-group. Here increases in functional connectivity between the two areas might suppress performance on out-group stimuli, an effect mediated by disgust, which in turn generates an increased advantage for in-group stimuli. Based on the findings of this Chapter, it was therefore unclear whether

differential performance for in- and out-group stimuli directly shows the positive emotion connected to in-group or the negative emotion attached to the out-group, or whether both of these factors contribute to the effect. This last scenario is particularly interesting to explore since in our study the competition (between rival football teams) was an impotent factor governing in-group biases.

To gain a better understanding of the neural correlates of in-group biases in the last experimental chapter (Chapter 8) I used functional magnetic resonance imaging to measure brain activity in football fans while they performed simple perceptual matching task in which they learnt a pairing between a geometric shape and the badge of their favourite football team, its closest rival or a neutral team. Similar behavioural results to those that I reported in Chapter 2 were observed - performance was more efficient for in-group relative to out-group stimuli. Better matching for newly established in-group associations (using the contrast of in-group shape vs. out-group shape) was linked to increased activity in the left posterior superior temporal sulcus. However rival relative to in-group associations led to stronger activity in several regions including left dorsal prefrontal, superior medial as well as inferior dorsal parietal, and anterior insula cortex.

With respect to the finding of stronger activity in the anterior insula in response to out-group stimuli, previous studies have shown similar results in the context of racial groups (stronger activity in the anterior insula to out-groups). In such studies the activity of the anterior insula has normally been related to the negative emotions against out-groups. In our study, this might also be the case since the fans I studied reported high dislike scores against the rival team.

Despite this I failed to find any direct evidence for the correlation between activity in the anterior insula and the magnitude of out-group dislike. I speculate that

participants might experience some degrees of disgust while responding to out-group pairs and this might consequently have slowed down their responses to out-group stimuli and therefore resulted in enhanced performance for in-group in comparison to out-group. However, it is equally possible that participants found it easier to respond to in-group pairs, while for the out-group they had to put more effort in to perform the task and this might in turn have resulted in stronger activity in the social attention network as it appeared in the areas such as pSTS, fusiform and precuneus along with the insula.

Consistent with the studies suggesting that, together with the ACC, the anterior insula plays an important role in our evaluative system (Eckert et al., 2009), here I propose that the anterior insula might specifically be involved in social evaluation. As the studies highlighting the role of insula in empathy show, if the insula detects the "other" to be close to the self it couples with the regions involved in empathy and therefore produces empathic response. Whereas if the "*other*" falls far away from the "*self*", the anterior insula may reflect rivalry rather than empathy. Empathizing with others is costly (Decety, & Lamm, 2006), and that is why both animals and humans have evolved to reserve the empathic response for close "*others*" including in-group members (Preston & De Waal, 2002).

Overall, the findings suggest that perceptual effects of a new social association rely on a social salience neural network (Carter, Bowling, Reeck & Huettel, 2012; Hare, Camerer, Knoepfle, O'Doherty & Rangel, 2010). The pattern of in-group bias in our study extends the previous findings on self-bias (Sui, Rotshtein, & Humphreys, 2013) that showed that self-associations are perceptually salient.

Conclusion

Across a series of different experiments, using different approaches, I showed that in-group biases permeate very basic perceptual mechanisms. The effects were present at the behavioural performance level reflected in both reaction time and accuracy. Moreover, I provided evidence showing that perceptual integration for different attributes of the same target is mediated by in-group identification. I further showed that in-group identification modulates inhibitory control in looking behaviour. In addition, the results from neuroimaging studies that I presented suggest differential neural correlates for in- versus out-group targets.

In conclusion, better performance for in-group relative to out-group stimuli can be attributed to emotional and motivational factors (Amodio, 2008). The emotional significance of in-group relevant stimuli can modulate perceptual processing (Schupp et al., 2003). Notably I suggest that in-group targets gain a positive emotional tag which in turn leads to better matching performance across the experiments presented in this thesis. Similarly, evidence of a negative bias against the rival group might arise if these items inherit a negative emotional tag. Responses to stimuli with a positive emotional tag may be faster than those with a negative tag.

The correlation between the magnitude of the enhanced performance for the in-group and the rated satisfaction component of the group identification questionnaire further supports the positive emotional tag argument regarding the in-group stimuli. The stronger the satisfaction with the in-group, the more efficient the performance on the in-group as opposed to rival stimuli. The correlational results as well the measure of commitment that I reported in Chapter 8 (fMRI study using the same task) are consistent with the self-investment account of in-group identification (Leach et al., 2008). Self-investment reflects the amount of commitment that one shows for group

activity. For instance, in the fMRI study I showed that individuals who identify strongly with their in-group attended more to matches by their team and donated more money to support their team. It has been proposed by the previous studies that individuals who strongly identify with their in-group are more likely to feel psychological and emotional bonds with their in-group (Lewin, 1948), and they may experience greater reward by acting in relation to the in-group. This latter argument was further supported by the finding of the correlation between vicarious reward and enhanced performance in the studies that I reported in Chapter 3.

The results that I reported on newly established associations also fit with other findings indicating that social categorization produces rapid changes on performance even with stimuli that do not have long-term links to the experimentally manipulated social groups (Van Bavel et al., 2011).

Limitations and future lines of research

We all know that there is no single study, which is perfect. Every study has its own peculiar weaknesses and strengths. There is often one aspect of the study that makes a part of every scientist wish that they could go back and control. Of course, this thesis is no exception. I have made every effort to make sure that I can offer a comprehensive picture of perceptual in-group biases or as the title of my thesis suggest the "*perceptual foundations of prejudice*". However, there still remain some limitations. First of all, the series of studies that I presented do not clearly draw a line between in-group 'love' and out-group derogation, since in-group stimuli have typically been contrasted with a rival and, though neutral stimuli have also been used, it is difficult to

verify if items are truly neutral. Future work may attempt to assess these factors further – for example, by using priming to emphasise one factor over the other.

Another limitation of this programme of research was the low level of variability in the participants. Obviously, most of the participants who took part in the study strongly identified with their in-group. However, through a series of experiments I tried to have different groups to produce some variability and to test whether the effects were stable. For example, in Chapters 2, 5, 7 and 8 I recruited football fans and university students as control participants. In Chapters 3 and 6, I recruited rowers, and in Chapter 4 I recruited university students. However, if the time and resources had allowed, it would have been more beneficial to have larger groups of participants to produce more variability in the data. In tandem with this limitation, I would also have liked to test additional "*out-groups*" to see if they show similar biases against the groups that I assessed in my studies. This would have been potentially very interesting especially in the case of football fans to see whether the hierarchy of football teams also modulates the group biases. For example, would the fans who support a higher-ranked team also show similar effects to those who support a lower-ranked team?

Another limitation concerned the time course of the neural activity in the brain, which is a general issue for fMRI studies. The data that I presented for both resting state functional connectivity as well as the fMRI study failed to provide any information on the time course of neural activities with response to in and out-group stimuli. Future studies might start to combine a method with a finer time-course of analysis, such as electroencephalography (EEG), with resting state or task-based fMRI to help gain a better understanding of the time course of neural activities in the context of intergroup biases.

There still remain many interesting questions that were beyond the scope of this

thesis. For example, it will be important to examine whether the in-group biases established here can predict in- and out-group differences in attitude and other social behaviours. For example, if individuals perceive in-group related stimuli more accurately and faster than out-group related stimuli, then our sensitivity to variations and individuality within the out-group may be decreased. This line of research thus has important implications for broader areas of social behaviour including prejudice.

Another intriguing question that future studies might investigate is whether the in-group biases are liable to change? In line with this there is a growing body of research providing evidence for the notion that positive intergroup contact reduces prejudice against member of out-groups (see for example, Al Ramiah & Hewstone, 2013; Hewstone & Swart, 2011). Although there is ample behavioural evidence on the effect of intergroup contact on prejudice, relatively little is known about the potential underlying neural mechanisms of such effects. It would be very interesting for future studies to start shedding some light on this issue.

Another area deserving more investigation is the relationship between the self, emotion and in-group biases within the same context. It will be helpful for future studies to explore the neural correlates of in-group bias in visual perception to test the relations between the in-group effects and those of emotion and self-interest. Therefore, it will be helpful to test whether in-group biases can predict self- and emotion-related biases and vice versa.

Another rather odd but interesting area of research deserving more investigation is whether we can take advantage of social biases including self and in-group biases to help improve attentional disorders in neurological patients (see for example, Sui & Humphreys, 2013). This line of research is very interesting and has the potential to open up new doors into the rehabilitation of cognitive disorders. For example, using

socially salient stimuli (stimuli associated to self or an in-group) we might be able to enhance patients' attention to the contralesional side of their personal and extra-personal space. Sui and Humphreys (2013) have also shown that self-reference can improve memory in amnesia even when the patient failed to show any effects of deeper semantic encoding. The data suggest that self-reference can be harnessed to facilitate performance and it would be interesting to explore whether this is also the case if stimuli are associated with an in-group that the participant identifies with.

Despites its limitations, this thesis succeeded to bridge between the social psychology and cognitive neuroscience discipline and shed some new light on the perceptual foundations of prejudice.

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