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Neural network integration during the perception of in-group and out-group members

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ABSTRACT

Group biases guide social interactions by promoting in-group favouritism, but the neural mechanisms underpinning group biases remain unclear. While neuroscience research has shown that distributed brain circuits are associated with seeing in-group and out-group members as “us” and “them”, it is less clear how these networks exchange signals. This fMRI study uses functional connectivity analyses to investigate the contribution of functional integration to group bias modulation of person perception. Participants were assigned to an arbitrary group and during scanning they observed bodies of in-group or out-group members that cued the recall of positive or negative social knowledge. The results showed that functional coupling between perceptual and cognitive neural networks is tuned to particular combinations of group membership and social knowledge valence. Specifically, coupling between body perception and theory-of-mind networks is biased towards seeing a person that had previously been paired with information consistent with group bias (positive for in-group and negative for out-group). This demonstrates how brain regions associated with visual analysis of others and belief reasoning exchange and integrate signals when evaluating in-group and out-group members. The results update models of person perception by showing how and when interplay occurs between perceptual and extended systems when developing a representation of another person.

1. Introduction

Group biases are prevalent in daily social interactions and typically involve in-group favouritism and out-group dislike (Allport, 1954; Brewer, 1999). To date, neuroscience research has identified a set of brain circuits that control social interactions based on group membership, which span perceptual, affective and cognitive processes (Molenberghs, 2013; Amodio, 2014). However, it is currently unclear how signals from segregated patches of cortex are integrated during the perception of in-group and out-group members. The current fMRI experiment investigates the contribution of functional integration to group bias modulation of person perception.

Among the features used to categorize individuals as members of an in-group or out-group, race is commonly studied (Ito and Bartholow, 2009; Kubota et al., 2012; Azevedo et al., 2013; Molenberghs, 2013). For example, it has been demonstrated that the ability to recognise members of another race is impaired compared to own-race recognition (Malpass and Kravitz, 1969). Besides such pre-existing social categories, group biases can also be elicited by assigning individuals to a group based on arbitrary rules, such as the toss of a coin; a procedure known as minimal group assignment (Tajfel et al., 1971). Such an arbitrary categorisation also leads to better recognition of in-group members (Bernstein et al., 2007), as well as more favourable judgments of in-group compared to out-group members (Tajfel et al., 1971; Otten and Moskowitz, 2000; Hertel and Kerr, 2001). As such, even a temporary group assignment based on arbitrary criteria biases the way others are perceived and judged. In short, group membership has a powerful influence on the mental operations that underpin and guide social interactions.

Over the last 15 years, neuroscience research has started to investigate the neural correlates of group-bias. Consistent with the majority of human cognitive neuroscience research (Fox and Friston, 2012), investigations into the neural correlates of group bias have primarily focussed on measuring the response of functionally segregated brain circuits. These studies have shown that several brain circuits that span perceptual, affective, and cognitive systems are sensitive to group membership (Fig. 1; Molenberghs, 2013; Amodio, 2014). For example, patches of cortex along the ventral visual stream, which are involved in person perception (Kanwisher, 2010), show a response bias for in-group compared to out-group members based on racial and minimal group assignment (Golby et al., 2001; Van Bavel et al., 2008, 2011; Azevedo et al., 2013). Reduced activity for out-group compared

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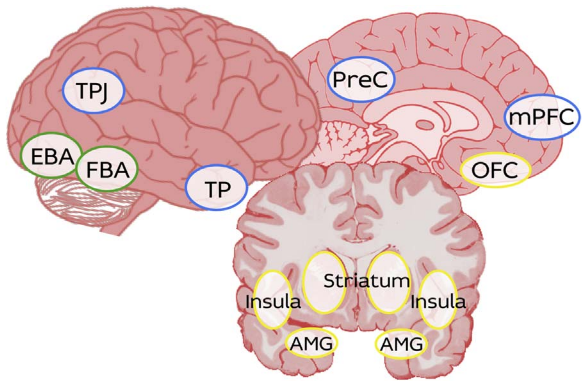

Fig. 1. Neural networks involved in body perception (green), Theory of Mind (blue), and affective processing (yellow). Abbreviations: Extrastriate Body Area (EBA), Fusiform Body Area (FBA), TemporoParietal Junction (TPJ), Temporal Pole (TP), Precuneus (PreC), medial PreFrontal Cortex (mPFC), Amygdala (AMG), OrbitoFrontal Cortex (OFC). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

to in-group members has been associated with diminished motivation to individuate out-group members (Malpass and Kravitz, 1969; Golby et al., 2001).

When categorising others we also “feel” differently about in-group compared to out-group members (Harris and Fiske, 2007; Mackie et al., 2008; Azevedo et al., 2013). An “affective network” of brain regions comprising amygdala, insula, striatum, and anterior frontal cortex, has been found to be underpin the ability to feel what someone else might feel (Keysers and Gazzola, 2009). This affective network also shows sensitivity to group biases (Golby et al., 2001; Wheeler and Fiske, 2005; Eres and Molenberghs, 2013; Molenberghs, 2013; Amodio, 2014; Azevedo et al., 2014; Molenberghs et al., 2016). For instance, left OFC was more active when participants saw an out-group member inflict harm to an in-group member compared to an out-group member (Molenberghs et al., 2016). Moreover, this area was functionally coupled with left insula and amygdala under these conditions, revealing a bias in the affective network to preferentially process in-group suffering.

A third neural network to show sensitivity to group membership is the Theory-of-Mind (ToM) network (Harris and Fiske, 2007; Volz et al., 2009; Contreras et al., 2012; Eres and Molenberghs, 2013; Molenberghs and Morrison, 2014). The ToM-network is engaged when making self-other distinctions, when reasoning about others' mental states (cognitive empathy), as well as when inferring traits about others (van Overwalle, 2009). The ToM-network includes mPFC, temporal poles, temporoparietal junction (TPJ), and precuneus (Frith and Frith, 1999; Saxe and Kanwisher, 2003; van Overwalle, 2009). When categorising individuals as in-group members, several ToM nodes are also involved (Volz et al., 2009; Molenberghs and Morrison, 2014). For example, when dividing money between in- and out-group members, participants gave more money to their in-group members and this decision was accompanied by greater activation of mPFC and left TPJ (Volz et al., 2009). Volz et al. (2009) suggest that ToM-network engagement reflects the different demands placed on self-other judgments when evaluating in-group compared to out-group members.

In sum, prior neuroimaging studies have shown how segregated patches of cortex are associated with seeing “us” and “them” during social interactions (Molenberghs, 2013). A key question from a neuroscience perspective, however, is how distributed neural circuits interact to support mental processes (Sporns et al., 2005; Sporns, 2014). Indeed, mental processes are likely to be an emergent property of network integration, rather that the sole work on segregated groups of neurons acting alone (Yuste, 2015). Network models of brain function that comprise interacting components have been proposed and supported in theoretical and systems biology (Bassett and Gazzaniga, 2011), but few empirical studies have directly tested how segregated circuits exchange information. For instance, with regard to group bias, it is currently unclear to what extent and in what ways neural circuits interact as a function of group membership. The current fMRI study uses functional connectivity analyses to investigate group bias modulation of person perception.

The design of the study was based on evidence that in-group members are viewed more positively than out-group members (Allport, 1954; Mullen et al., 1992; Brewer, 1999), as well as on research revealing that information consistent with stereotypes is remembered better than bias-inconsistent information (Fyock and Stangor, 1994). We hypothesised increased functional coupling between perceptual (Fusiform and Extrastriate Body Areas, FBA and EBA), affective, and cognitive (ToM) neural networks when seeing a person that had previously been paired with information consistent with their biases (positive for in-group and negative for out-group). Prior neuroimaging work has shown that body and ToM networks show increased coupling when forming links between body cues and social knowledge (Greven et al., 2016), as well as recalling social knowledge based on body cues (Greven and Ramsey, 2017). As such, the current study would extend prior work by understanding how neural network integration supports group bias modulation of person perception. Although more group bias research in person perception has focussed on faces, bodies convey a multitude of relevant social signals and offer cues that faces might hide (Slaughter et al., 2004; Aviezer et al., 2012), which makes bodies interesting to study in their own right. More generally, as integration between discrete brain circuits is a growing consideration for understanding brain function (Friston and Price, 2001; Sporns et al., 2005; Sporns, 2013), understanding how perceptual, cognitive and affective networks interact is a model problem that speaks to a fundamental question in human neuroscience.

2. Materials and methods

2.1. Participants

Twenty-four participants (15 females; mean ± SD age: 22.6 ± 4.7 years) were recruited from the Bangor community and received a monetary reimbursement of £15 for completing the fMRI experiment. All participants had normal or corrected-to-normal vision and reported no history of neurological damage and gave informed consent according to the local ethics guidelines. A behavioural pilot experiment was completed to validate the task and involved 31 participants (24 females; mean ± SD age: 20.8 ± 6 years). No participants completed both pilot and fMRI experiments. For 3 participants, 2 sessions from the main task had to be removed due to excessive head motion (displacement above 3 mm).

2.2. Overview of the experiment

The full experimental design comprised a 3 (Social knowledge: Positive, Negative, Neutral) × 2 (Group bias: in-group, out-group) factorial design. In order to study group bias modulation of person perception, the current study only analysed Positive and Negative social knowledge conditions. All analyses in the current experiment, therefore, focus on a 2 (Social knowledge: Positive, Negative) × 2 (Group bias: in-group, out-group) factorial design. Analyses investigating the recall of social knowledge compared to neutral knowledge have been reported elsewhere (Greven and Ramsey, 2017).

The experimental paradigm consisted of several phases (Fig. 2): 1) Group assignment to the yellow or blue team; 2) Encoding phase, where participants formed an impression of a person based on presentation of a body and a statement; 3) fMRI experiment, where participants observed all the bodies from the encoding phase and were asked to recall knowledge about each person; 4) Recognition phase, where participants had to judge which of the two bodies presented in each trial was