



Review

Distinct and common aspects of physical and psychological self-representation in the brain: A meta-analysis of self-bias in facial and self-referential judgements



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ABSTRACT

The neural representation of self is a fundamental question for brain research. Employing activation likelihood estimation (ALE) meta-analyses, we assessed the commonalities and distinctions between different components of the self by focusing on the ‘physical’ self and the ‘psychological’ self – assessed respectively through face processing and self-referential tasks. We first conducted ALE meta-analyses by computing the convergence of findings on brain activation in self-face recognition and self-referential studies respectively. Contrast and conjunction analyses of these two meta-analytic results were then applied to extract the distinctions and commonalities in self-face and self-reference tasks. Facial self processing was particularly associated with lateral brain regions with a right hemispheric dominance, while processing psychological self predominantly activated cortical midline structures, more specifically the anterior cingulate cortex/superior frontal cortex. In contrast, the conjunction analyses showed that the two aspects of self-processing recruit the dorsal anterior cingulate cortex and the left inferior frontal gyrus extending to the insula. A framework including both distinct and common neural representation of self is discussed.

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1. Introduction

What is the self and what is the neural representation of the self in the brain? In the last three decades, psychologists and neuroscientists have repeatedly attempted to localize the neural underpinnings of the self by assessing different components of the self, including studies focused on the facial self, self embodiment, self ownership, self-related personality traits and so on, with many studies using functional Magnetic Resonance Imaging (fMRI) to evaluate the functional localization of self-related processing in these tasks (e.g., Gusnard et al., 2001; Kelley et al., 2002; Kircher et al., 2000; Sugiura et al., 2000). However, inconsistent findings across studies have led to contradictory views – for example, about whether there are self-specific modules in the human brain (Gillihan and Farah, 2005; Legrand and Ruby, 2009), and whether there are brain regions associated with all components of the self reflecting a common self-representation or representations specific to particular tasks?

To address these issues Northhoff et al. (2006) conducted a meta-analysis of self-related neuroimaging studies and reported that self-relatedness was specifically processed in cortical midline structure (CMS), including the medial frontal cortex (MFC), anterior cingulate cortex (ACC), and posterior cingulate cortex (PCC). Several other meta-analyses have confirmed the role of CMS in processing self-related information (Araujo et al., 2013; Murray et al., 2012; Northhoff et al., 2011; Qin and Northhoff, 2011; van der Meer et al., 2010), with additional evidence suggesting the involvement of the anterior insula (AI, e.g., Northhoff et al., 2011). A common aspect of these meta-analyses is the focus on contrasts comparing processing of the self-relative to the processing of information related to other people (self > other). However, all of these meta-analyses have treated the self as a single psychological entity, either by pooling different components of self-related processes as a whole (Northhoff et al., 2011; Qin and Northhoff, 2011) or by focusing only on one component of the self (Araujo et al., 2013; Martinelli et al., 2013; Murray et al., 2012; Platek et al., 2008), e.g., visual self recognition (Apps and Tsakiris, 2013; Devue and Brédart, 2011; Knoblich, 2002; Suddendorf and Butler, 2013, 2014), autobiographical memory (Cabeza and St Jacques, 2007), or self-evaluation (Schmitz and Johnson, 2007). These meta-analyses are limited however because they do not directly compare different components of the self.

In contrast to the emphasis on a single aspect of the self in these meta-analyses, many psychologists have distinguished different aspects of the self. For example, James (1890) distinguished different categories of the “self” including physical/material self, psychological self, and spiritual self. Following these lines, some neuroimaging studies have reported the distinction in brain activity between the physical and the psychological selves (Gillihan and Farah, 2005; Uddin, 2011). In those studies, the physical self refers to dissociating one’s physical existence from the external environment and can be probed, for example, by tasks requiring a subject to discriminate his/her own face from the faces of strangers (Gillihan and Farah, 2005; Sugiura, 2013). In contrast, the psychological self is defined by personal attributes such as

personality traits as well as autobiographical memories and experiences (Gillihan and Farah, 2005; Murray et al., 2012; Northhoff, 2011). Given the different definitions of the physical and psychological selves and disparities in previous findings, it is interesting to examine if physical and psychological aspects of the self are represented differentially in the brain, or if these contrasting aspects of the self largely overlap in the brain to form a core self-representation (Northhoff and Bermpohl, 2004) (perhaps along also with some components specific to the different aspects of the self). Sui and Humphreys (2015) recently propose that there is an integrative self which can act as a glue to (i) bind information as a perceptual whole, (ii) link items to their context in memory, and (iii) integrate different levels of processing. This integrative capacity may be mediated by a core representation of the self, recruited in different tasks across. This is supported by neuropsychological evidence showing that selective brain lesions can modulate self-biases across a range of tasks (Sui et al., in press).

To address the above issues, we conducted meta-analyses by directly comparing the two key aspects of self-processing – reflecting the physical and psychological self, using activation likelihood estimation (ALE) meta-analyses of neuroimaging studies of self-biases in face recognition and referential judgements. ALE provides a quantitative measure of cross-study consistency that accommodates spatial uncertainty of activation data and allows statistically defensible conclusions to be formed (Fox et al., 2014; Laird et al., 2011). To take into account inconsistencies in the concept of the self (Legrand and Ruby, 2009), we first operationalized the physical and psychological selves, adopting relatively narrow definitions. The physical self was defined as the bodily-grounded self that dissociates one’s physical existence from the external environment and may be probed by three major types of experiment – self-face recognition, self-body recognition and self-agency (Gillihan and Farah, 2005). Here we focused on studies of self-face recognition as the face is not only the most distinctive physical feature of the individual (Gallup, 1970; Suddendorf and Collier-Baker, 2009; Tsakiris, 2008) but also the attribute most commonly investigated (Platek et al., 2006; Sugiura et al., 2000, 2005; Uddin et al., 2005). The psychological self was taken to comprise self-related traits, autobiographical memory and judgements based on a first person perspective (Gillihan and Farah, 2005). In practice, the psychological self is often associated with the self-reference effect (SRE), which can be measured in terms of better memory for the trait words that refer to self than the trait words referring to others (Rogers et al., 1977). Most studies of both self-related traits and autobiographical memory have employed self-reference tasks, as defined by previous meta-analyses (Araujo et al., 2013; Kim, 2012; Martinelli et al., 2013; Spreng et al., 2009; Svoboda et al., 2006). Accordingly we chose studies using the self-reference task as representative of the psychological self, both because it has been widely used and because of its relevance to self-related traits and autobiographical memory. In contrast, studies of first person perspective were excluded because their linkage to self-representation is more ambiguous (Gillihan and Farah, 2005).

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