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Neural correlates of reflection on actual versus ideal self-discrepancy

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ABSTRACT

Subjective feelings of actual/ideal self-discrepancy vary across individuals and influence one's own affective states. However, the neural correlates of actual/ideal self-discrepancy and their genetic individual differences remain unknown. We investigated neural correlates of actual/ideal self-discrepancy and their associations with the serotonin transporter promoter polymorphism (5-HTTLPR) that moderates human affective states during self-reflection. We scanned short/short and long/long allele carriers of 5-HTTLPR, using functional MRI, during reflection on the distance between actual and ideal self in personality traits. We found that larger actual/ideal self-discrepancy was associated with activations in the ventral/dorsal striatum and dorsal medial and lateral prefrontal cortices. Moreover, these brain activities were stronger in short/short than long/long allele carriers and predicted self-report of life satisfaction in short/short carriers but trait depression in long/long carriers. Our findings revealed neural substrates of actual/ideal self-discrepancy and their associations with affective states that are sensitive to individuals' genetic makeup.

Introduction

A key Buddhism doctrine is that the desire for a 'good' self deteriorates human happiness (Ñāṇamoli and Bodhi, 1995). Consistent with this traditional insight, modern psychologists posit that each person has beliefs of what attributes he/she actually possesses (actual self) and wishes to possess (ideal self) and the actual/ideal self-discrepancy induces negative emotion that is harmful to individuals' well-being (Rogers, 1961; Higgins, 1987; Carver et al., 1999). In support of this proposition, behavioral research found that a memory task that made self-structure dominated by actual/ideal self-discrepancy increased sensitivity to the presence and absence of positive outcomes of events (Higgins and Tykocinski, 1992). Questionnaire measures revealed that actual/ideal self-discrepancy was associated with negative affect such as shame/embarrassment (Higgins et al., 1985) and dissatisfaction/disappointment (Strauman and Higgins, 1987). In addition, self-report of actual/ideal self-discrepancy inversely predicted self-report of life satisfaction (Czaja, 1975).

Despite the significance of actual/ideal self-discrepancy for human well-being, the neural correlates of actual/ideal self-discrepancy and their relationships with affective states remain unknown. The current research addressed three questions regarding the neural correlates of actual/ideal self-discrepancy. First, since thinking about self-discrepancy engages evaluation of one's desire for good outcomes (Higgins, 1987), we investigated whether reflection on actual/ideal self-discrepancy on personality traits, which may automatically and implicitly inspire desire for a good self, recruits brain regions that overlap with the rewards neural network that mediates the desire for food or addictive substances. This rewards neural network, identified in functional magnetic resonance imaging (fMRI) studies, consists of the ventral striatum (VS), ventral tegmental area (VTA), amygdala, medial prefrontal cortex (MPFC), anterior cingulate cortex (ACC), and insula, which showed activations in drug users and smokers when perceiving drug/cigarette associated cues (Due et al., 2002; David et al., 2005; Wilson et al., 2005; Franklin et al., 2007; Kober et al., 2010). If reflection on actual/ideal self-discrepancy induces desire for positive attributes, reflection on actual/ideal self-discrepancy may activate brain regions in the neural circuit involved in desire for external rewards such as the VS and MPFC.

To test this hypothesis, we developed a paradigm to uncover the neural correlates of reflection on actual/ideal self-discrepancy. The previous fMRI studies of self-reflection usually asked participants to make judgments on whether a specific trait adjective can describe oneself or a celebrity and the neural correlates of self-reflection have been identified by calculating the contrast of judgments on the self vs. a celebrity. The studies have repeatedly shown that reflection on the self compared to a celebrity significantly activated the brain regions such the MPFC and precuneus (Kelley et al., 2002; Ma and Han, 2011; Northoff et al., 2006). In addition, trait words rated high versus low in self-relevance increased MPFC activity (Moran et al., 2006) and MPFC activity correlated with memory performances on recall of self-related trait words (Macrae et al., 2004; Ma and Han, 2011). Thus the MPFC has been suggested to be involved in encoding of self-relevance of stimuli (Northoff et al., 2006; Han and Northoff, 2009). The current study modified the previous paradigm by showing participants with trait adjectives and

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asking them to think over each trait word and to indicate how far the actual self is away from the ideal self in terms of a personality trait. Participants pressed one of four buttons to indicate the distance between the actual self and the ideal self (1 = "very close", 2 = "somewhat close", 3 = "somewhat far", 4 = "very far"). Such parametric behavioral response allowed us to identify the brain activations that were associated with one's own feelings of actual/ideal self-discrepancy.

The second question addressed in the current work is whether the neural activity underlying reflection on actual/ideal self-discrepancy differs between the two variants of the serotonin transporter promoter polymorphism (5-HTTLPR), a gene that affects neural responses to negative emotions (Hariri et al., 2002; Pezawas et al., 2005; Canli and Lesch, 2007; Ma et al., 2015) that dampen life satisfaction and are linked to depression. Early brain imaging studies found that, relative to homozygous long variant (l/l), the short variant of 5-HTTLPR exhibited stronger amygdala activity to negative environmental stimuli (Hariri et al., 2005, 2002; Canli et al., 2005; Heinz et al., 2005) and relative uncoupling of the amygdala and perigenual cingulate during the processing of negative emotion (Pezawas et al., 2005). Moreover, the degree of amygdala/perigenual cingulate uncoupling reversely predicted individuals' anxiety (Pezawas et al., 2005). Recent research further revealed that, relative to l/l carriers of 5-HTTLPR, the short homozygotes (s/s) showed stronger distressed feelings and greater activity in the ACC/MPFC and insula during reflection on their own negative traits (Ma et al., 2014a). Given that greater actual/ideal self-discrepancy reflects a larger gap between one's actual self and one's expectation, s/s relative to l/l carriers may show stronger neural responses to actual/ideal self-discrepancy that are sensitive to affective states. We tested these hypotheses by scanning s/s and l/l carriers of the 5-HTTLPR using fMRI during reflection on actual/ideal self-discrepancy in personality traits.

The third question addressed in the current study is whether the neural activity related to actual/ideal self-discrepancy can predict subjective feelings of life satisfaction and trait depression. Although the behavioral measures suggest that actual/ideal self-discrepancy is associated with life satisfaction (Czaja, 1975), negative affect (Higgins, 1987) and depression (Bibring, 1953), it remains unclear whether the association between self-discrepancy and subjective well-being as indicated by self-report of life satisfaction and depression varies across individuals with different genetic makeups. One possibility is that self-discrepancy is associated with subjective well-being in a similar vein in s/s and l/l carriers of the 5-HTTLPR. Alternatively, there may be stronger coupling of self-discrepancy and subjective well-being in those whose brain activity is more sensitive to actual/ideal self-discrepancy. These were clarified by investigating whether 5-HTTLPR moderates the relationships between neural correlates of self-discrepancy and self-report indicators of subjective well-being (e.g., life satisfaction and depression).

Materials and methods

Participants

Fifty Chinese students from Peking University (24 female; aged between 17 and 25 years, Mean ± SD = 21.00 ± 1.51) participated in this study as paid volunteers. There were 25 s/s homozygotes (13 female; 17 to 24 years, Mean ± SD = 20.88 ± 1.72) and 25 l/l homozygotes (11 female; 20 to 25 years, Mean ± SD = 21.12 ± 1.30). s/s and l/l carriers did not significantly differ in gender ($\chi^2(1) = 0.32$, $p = 0.57$) or age ($t(48) = -0.56$, $p = 0.58$). All participants were right-handed, had normal or corrected-to-normal vision, and reported no abnormal neurological or psychiatric history. Participants provided informed consent prior to fMRI scanning. This study was approved by a local ethics committee.

DNA isolation and analysis

We used a PCR method (Ota et al., 2007) to determine the genotypes of 5-HTTLPR. In a total volume of 50 μL, about 25 ng of genomic DNA was amplified in the presence of 1 × TransStart FastPfu DNA Polymerase (TransGen Biotech) reaction system and oligonucleotide primers (forward 5′-GCATCCCCCATTATCCCCCCCT-3′ and reverse 5′-AGGCTTGGAG GCCGGGATGC-3′) at final concentration of 200 nM. Thermal cycling consisted of a 15 min of initial denaturation at 95 °C followed by 35 cycles of 95 °C (20 s), 69 °C (20 s) and 72 °C (15 s) each with a final extension step of 10 min at 72 °C. Subsequently, the PCR product was loaded onto a 3% agarose gel (BioWest G-10) to perform electrophoresis to distinguish genotypes of s/s, s/l, and l/l. All genotyping was performed in duplicate. Blood samples of 901 university students (490 males and 411 females, 18–33 years, mean age ± SD = 19.99 ± 2.76 years) were collected for genotyping 5-HTTLPR, which identified 88 long allele homozygotes (l/l), 194 heterozygotes (l/s), and 619 short allele homozygotes (s/s).

Stimuli and procedure

Forty-eighty positive trait adjectives (each consisting of two Chinese characters) were selected from the established personality trait adjective pool (Liu, 1990). Each participant completed a task of rating how important it is to possess each trait before fMRI scanning. Participants rated each trait adjective on a four-point Likert scale (1 = "not important at all", 2 = "a little bit important", 3 = "moderately important", 4 = "very important") by a key press. They were informed that ratings indicate the importance of owning a trait rather than actually possessing it. The importance rating scores were used as implicit estimation of participants' desire for each personality trait. The rating task was self-paced during which trait words were presented at the center of a computer screen above a four-point scale and in a random order.

During fMRI scanning participants performed actual/ideal self-discrepancy judgments on these trait words. Trait words were presented at the center of a screen in a random order, with the four-point scale presented below. Each Chinese character subtended a visual angle of 1.7° × 2.3° (width × height) for the trait adjectives at a viewing distance of 80 cm. The fixation cross subtended a visual angle of 1.31° × 1.31°. Participants were instructed to think over each trait word and to indicate how far the actual self is away from the ideal self in terms of that trait. Participants responded on each trait word by pressing one of four buttons that were associated with a four-point Likert scale (1 = "very close", 2 = "somewhat close", 3 = "somewhat far", 4 = "very far"). Each trait word was presented for 2000 ms, with inter-stimulus-interval varying among 1 s, 2 s, 3 s, 4 s, or 5 s (mean = 3 s). The mapping of the scale to the four response keys was counterbalanced across participants.

After scanning, participants indicated their general life satisfaction on a seven-point Likert scale (1 = "very unsatisfied", 7 = "very satisfied") (Campbell, 1976) and their trait depression (subscale of the State-Trait Depression Inventory, Krohne et al., 2002). Participants also completed the Positive and Negative Affect scale (Watson et al., 1988), the Rosenberg Self-Esteem scale (Rosenberg, 1965), the neuroticism subscale of the short version of the Revised Eysenck Personality Questionnaire (Eysenck et al., 1985), and the Relationship Assessment scale (Hendrick, 1988) to control for the influences of affect, self-esteem, neuroticism, and family relationship. Participants were also asked to finish an ideal-self rating task during which participants were presented with each trait adjective used during scanning and had to answer "to what degree does this word describe your ideal self?" on each trait adjective on a four-point Likert scale (1 = "not at all", 4 = "very well"). This measure was used as explicit estimation of participants' desire for each personality trait.