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BRAIN RESPONSE TO MASKED AND UNMASKED FACIAL EMOTIONS AS A FUNCTION OF IMPLICIT AND EXPLICIT PERSONALITY SELF-CONCEPT OF EXTRAVERSION

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Abstract—Extraversion–introversion is a personality dimension referring to individual differences in social behavior. In the past, neurobiological research on extraversion was almost entirely based upon questionnaires which inform about the explicit self-concept. Today, indirect measures are available that tap into the implicit self-concept of extraversion which is assumed to result from automatic processing functions. In our study, brain activation while viewing facial expression of affiliation relevant (i.e., happiness, and disgust) and irrelevant (i.e., fear) emotions was examined as a function of the implicit and explicit self-concept of extraversion and processing mode (automatic vs. controlled). 40 healthy volunteers watched blocks of masked and unmasked emotional faces while undergoing functional magnetic resonance imaging. The Implicit Association Test and the NEO Five-Factor Inventory were applied as implicit and explicit measures of extraversion which were uncorrelated in our sample. Implicit extraversion was found to be positively associated with neural response to masked happy faces in the thalamus and temporo-parietal regions and to masked disgust faces in cerebellar areas. Moreover, it was positively correlated with brain response to unmasked disgust faces in the amygdala and cortical areas. Explicit extraversion was not related to brain response to facial emotions when controlling trait anxiety. The implicit compared to the explicit self-concept of extraversion seems to be more strongly associated with brain activation not only during automatic but also during controlled processing of affiliation relevant facial emotions. Enhanced neural response to facial disgust could reflect high sensitivity to signals of interpersonal rejection in extraverts (i.e., individuals with affiliative tendencies).

Key words: extraversion, emotional facial expression, Implicit Association Test, automatic processing, visual perception, functional magnetic resonance imaging.

INTRODUCTION

Extraversion–introversion is a core dimension of human personality (Costa and McCrae, 1995). Extraversion comprises traits such as sociability, talkativeness, excitement seeking, being energetic, assertive, and optimistic, whereas introversion is characterized by preferences for solitude, passivity, thoughtfulness, and reflection (Goldberg, 1990). Extraverted individuals report more positive affects in their everyday life than introverted ones (Costa and McCrae, 1980). They appear more responsive to the effects of positive mood induction (Larsen and Ketelaar, 1991). However, even though one might expect that extraverts are more exercised in social interactions they seem not to be more effective decoders of facial emotions or non-verbal signals than are introverts (Bastone and Wood, 1997; Lieberman and Rosenthal, 2001).

Typically, extraversion is assessed by self-report instruments such as the NEO Personality Inventory (Costa and McCrae, 1997). These direct measures assess individual differences in the conscious representations of the self. According to the *Behavioral Process Model of Personality* (Back et al., 2009) reflective processes form conscious self-representations such as "*I really enjoy talking to people*". The so-called *explicit self-concept* is the product of deliberate processes in perceiving and categorizing situations and realizing behavioral preferences. However, it is well-known that individuals process information about themselves and their environment not only in an explicit or controlled way but also an implicit or automatic mode (Bargh and

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Abbreviations: BA, Brodmann area; BDI, Beck Depression Inventory; EEG, electroencephalography; fMRI, functional magnetic resonance imaging; IAT, Implicit Association Test; KDEF, Karolinska Directed Emotional Faces database; MNI, Montreal Neurological Institute; MWT-B, multiple choice vocabulary test; NEO-FFI, NEO Five-Factor Inventory; ROI, region-of-interest; SPM, Statistical Parametric Mapping; STAI, State-Trait-Anxiety Inventory.

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Chartrand, 1999; Wilson et al., 2000). It has been recognized that, besides reflection, impulsive processes affect social behavior by interplay of automatic perception of situational cues with spontaneous motivational tendencies (Strack and Deutsch, 2004). The typical functioning of impulsive processes should lead to chronic associative links between associative network elements. Associative representations of the self, such as "*me*"–"*reserved*", are assumed to result from repeated activation of the self, as a concept in an associative network, together with patterns of impulsive behavioral inhibition and automatic avoidance motivation. Individual differences in associative representations of the self have been called the *implicit self-concept of personality* (Asendorpf et al., 2002). The latter can be measured by indirect tests, e.g., the Implicit Association Test (IAT; Greenwald et al., 1998; Schmukle et al. 2008). The IAT extraversion measure has been found to predict actual social behavior above and beyond explicit measures of extraversion (Steffens and Schulze König, 2006; Back et al., 2009). Personality can be understood as the result of the habitual functioning across time and multiple situations of implicit as well as explicit processes (Back et al., 2009). Consideration of both the implicit and the explicit self-concept of personality seems to be necessary for a comprehensive understanding of social behaviors and their neural substrates. The usefulness of the IAT in research on the biological foundations of extraversion has been shown in a recent genetic study suggesting a link between a polymorphism of the dopamine transporter gene and implicit extraversion (Osinsky et al., 2010).

Eysenck (1967, 1994) introduced the arousal/arousability hypothesis as an explanation of individual differences in extraversion. He assumed that extraverts are characterized by a low level of cortical arousal. Since this state is experienced as unpleasant, they seek situations that increase their arousal. Importantly, arousability in extraverts and introverts depends on the level of arousal: under low stimulation introverts should be more arousable than extraverts, but under high stimulation introverts may experience over-arousal, which is assumed to lead to lower increases in arousal. In contrast, extraverts should manifest low arousability under low stimulation, but under high stimulation they should exhibit higher increments in arousal than introverts (Eysenck, 1967). Individual differences in cortical arousal are thought to be the result of differences in the reactivity of the ascending reticular activation system (ARAS) which originates in the brainstem and exerts its effects on higher cortical centers via the thalamus, caudate nucleus, and limbic cortex. Findings from psychophysiological studies on perception and arousal have provided evidence supporting Eysenck's basic assumptions (e.g., Fowles et al., 1977; Bullock and Gilliland, 1993; Corr et al., 1995).

Even though sociability represents a defining feature of extraversion only few studies have examined the effect of extraversion on brain response to facial emotions or social gestures. In an early functional magnetic resonance imaging (fMRI) study using blocked presentations of emotional faces (Canli et al., 2002), extraversion as measured by self-report questionnaire was found to be positively related to (left) amygdala response to happy (but not fearful) facial expression. The authors argue that insofar as the left hemisphere is assumed to be associated with approach-related behavior and positive emotions (Davidson, 1992), enhanced left amygdala activation to happy facial expression may contribute to behaviors consistent with a sociable style of interaction and positive affectivity.

Cheung et al. (2010) investigated perception of neutral faces using event-related potentials. Participants scoring high on self-reported introversion or extraversion were presented upright and inverted face stimuli. Extraverts were comparable to introverts in terms of response to upright faces. An inversion effect in response to upside down faces, demonstrating a heightened N170 relative to upright faces, were only found for extraverts. The latter finding might result from higher levels of perceptual expertise with faces in extraverted individuals. In another electroencephalographic study, participants had to judge whether emotional facial expressions were equivalent (Fink, 2005). Extraverted individuals, as assessed by questionnaire, were more likely to display lower cortical activation than introverts during judgment of facial emotions, primarily in the left hemisphere. This finding is consistent with the idea that extraverts manifest lower arousability under low stimulation than introverts. Finally, Knyazev (2009) investigated cortical distribution of spectral power as a function of personality. During EEG registration, single faces with a happy, angry, or neutral expression had to be evaluated as hostile vs. friendly. In this experiment, trials were rather long (about 10 s) but facial stimuli evoked only minor changes in cortical spectral power distribution, implying that internal states were important for establishing cortical oscillatory patterns. It was found that self-reported extraversion was related to higher activity of posterior cortical regions.

In a recent fMRI study (Saggar et al., 2016), processing of gestures containing social intent was examined as a function of personality administering color video clips of live actors. Positive correlations were observed between self-reported extraversion and bilateral thalamic activation during viewing social gestures. It was concluded that more responsivity in a basic structure of the reticulothalamic-cortical arousal system could facilitate processing of social intent in extraverts.

In all of the above-mentioned neurobiological studies, the explicit self-concept of extraversion was investigated. Under conditions of high stimulation (blocked presentation or video clip) extraversion was observed to be positively associated with amygdala response to happy faces and thalamus activation to social gestures (Canli et al., 2002; Saggar et al., 2016). Under low stimulation, introverts showed higher left cortical activation than extraverts during comparison of facial emotions (Fink, 2005). Suslow et al. (2010a) investigated automatic brain reactivity to happy and sad facial expression as a function of both implicitly and explicitly measured extraversions. In this study, a slow event-related design was applied with a trial duration of 9 s so that stimulation intensity was rather low. Implicit extraversion and explicit extraversion (even though not significantly interrelated) were both found to