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Dissociations of subliminal and supraliminal self-face from other-face processing: Behavioral and ERP evidence

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ABSTRACT

Self-related information has been found to be processed more quickly and accurately in studies with supraliminal self-stimuli and traditional paradigms such as masked priming. We conducted two experiments to investigate whether subliminal self-face processing enjoys this advantage and the neural correlates of processing self-faces at both subliminal and supraliminal levels. We found that self-faces were quicker than famous-other faces to gain dominance against dynamic noise patterns during prolonged interocular suppression to enter awareness (Experiment 1). Meanwhile, subliminal contrast of self- and famous-other face processing was reflected in a reduced early vertex positive potential (VPP) component, whereas supraliminal self-other face differentiation was reflected in an enhanced N170, as well as a more positive late component (300–580 ms, Experiment 2) to the self-face. The clear dissociations of self- and other-face processing found across our two experiments validate the self advantage. Our findings also contribute to understandings of the mechanisms underlying self-face processing at different levels of awareness.

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1. Introduction

The self bears unique importance to humans' survival. For example, the capacity to recognize oneself, to distinguish 'me' from 'not me', is critical to many higher-order cognitive abilities, such as self-consciousness and the Theory of Mind (Turk et al., 2002). Correspondingly, self-related stimuli demonstrate an advantage in that they are processed faster and more accurately compared with other types of stimuli. This 'self advantage' or the specialty of the self has been observed in studies with various types of stimuli, such as one's own name (Wood & Cowan, 1995), voice (Rosa, Lassonde, Pinard, Keenan, & Belin, 2008), hands (Ferri, Frassinetti, Costantini, & Gallese, 2011), and handwriting (see Keenan, Gallup, and Falk (2003)). Recognizing one's own face contributes to maintaining the sense of self (Platek, Thomson, & Gallup, 2004), therefore its processing also enjoys the self advantage (e.g., Keenan et al., 2003; Keyes & Brady, 2010; Tong & Nakayama, 1999). Because of the unique characteristics of one's own face (such as containing more semantic information than names), processing the self-face may even show an advantage than that of other self-stimuli such as self-names (Tacikowski, Jednoróg, Marchewka, & Nowicka, 2011).

An important question to ask regarding this self advantage would be whether it exists when self-related information is processed without one's awareness. There has been evidence that even when self-belongingness of presented stimuli is not recognized (Huntley, 1940) or self-relatedness of a task is unrealized (e.g., an implicit association test measuring self-esteem, Greenwald, McGhee, & Schwartz, 1998), the self advantage still presents. Nevertheless, most studies on self-processing, including the ones on self-face processing, have used supraliminal presentations of self-stimuli (e.g., Keyes, Brady, Reilly, & Foxe, 2010; Sui, Zhu, & Han, 2006; Turk et al., 2002; Uddin, Kaplan, Molnar-Szakacs, Zaidel, & Iacoboni, 2005). The limited number of studies that did examine subliminal self-processing usually took an indirect approach to focus on how processing self-related information gave rise to performance differences in subsequent tasks. For example, traditional masked priming paradigm includes very brief presentations of self-related stimuli as primes (<30 ms) with backward-masking, and examines how these primes affect processing of subsequent probes (e.g., Ibáñez et al. 2011; Spalding & Hardin, 1999). The self advantage is implied by a facilitation effect, such as processing self-related word primes facilitated judgment of subsequent positive (vs. negative) words (Spalding & Hardin, 1999).

In addition to the behavioral evidence, important support for the self specialty comes from fMRI studies examining the cognitive neural network in the brain (e.g., Devue et al., 2007; Kircher et al., 2001; Sugiura, Watanabe, Matsue, Fukuda, & Kawashina, 2005; Uddin et al., 2005; for reviews see Sugiura, 2007; Devue &

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Brédart, 2011). For example, the perception of self-faces was accompanied by the enhanced activities in left inferior parietal, left prefrontal regions, the right middle temporal lobe, and right limbic areas (Kircher et al., 2000). Self-recognition was also found to selectively activate the right occipito–temporo–parietal junction and frontal operculum, as well as the left fusiform gyrus (Sugiura et al., 2005).

Self-face processing not only triggers activities in particular brain areas but also elicits distinct electrophysiological responses. For example, the N170, a component previously considered to reflect structural encoding of faces as oppose to non-faces (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Rossion et al., 2000), has also been found distinguishable between self- and other face processing (Keyes et al., 2010; Zeman, Till, Livingston, Tanaka, & Driessen, 2007), indicating the involvement of the N170 in person-identity nodes (PIN) in face recognition (Burton, Bruce, & Johnston, 1990; Gainotti, Ferraccioli, & Marra, 2010). Particularly, recent findings based on improved, more sensitive measures of the event-related potentials (ERPs), such as the independent component analysis (ICA) and *k*-means clustering, revealed larger N170 to self-faces compared with non-self faces of varied familiarity (Zeman et al., 2007).

Similarly, some ERP research showed increased positivity in response to self-faces relative to faces of a familiar other at 220–700 ms (Sui et al., 2006) or beyond 350 ms over fronto-central sites (specifically at FCz, Keyes et al., 2010). These self-specific activities are different from those related to familiarity effects in the similar time window. For example, the magnitude of N250 at inferior temporal sites was affected by both pre-experimental familiarity of faces (famous > unknown), and repeated exposures of famous or unknown faces (Tacikowski et al., 2011), patterns that were not found for self-faces (Tanaka, Curran, Porterfield, & Collins, 2006). ERP differences between familiar and unfamiliar faces have also been reported on the 'face-N400' (or 'N400f') at a later post-stimulus onset in the parietocentral area (Eimer, 2000), or at across all sites (Bentin & Deouell, 2000). Consistently, an event-related synchronization (ERS) study demonstrated that familiarity and self-recognition processing were represented by different frequency bands (Sakihara, Gunji, Furushima, & Inagaki, 2011): the delta ERS over parietal and left temporal areas within 0–800 ms showed greater responses to familiar faces relative to unfamiliar faces, whereas the beta ERS over prefrontal areas within 400–800 ms was enhanced to self than familiar faces.

Despite the accumulating evidence on the neuroscientific characteristics of self-face processing, almost all of these investigations were pursued at a supraliminal level. We conducted two experiments to examine the self advantage, with a particular focus on the subliminal self-face processing, and our study differs from previous research in several important ways.

First, instead of studying how subliminal presentations of the self-face influence processing of subsequent targets, Experiment 1 tried to demonstrate the advantage of subliminal self-face processing more directly. Specifically, we subliminally presented participants with their own face or a famous other's face based on an adapted paradigm of continuous flash suppression (CFS). The CFS is a powerful paradigm that creates a reliable suppression of a low-contrast image presented to one eye, by flashing distinct noise images to the corresponding location of the other eye, and the suppression can last ten times or even longer than generated by other techniques such as binocular rivalry (Tsuchiya & Koch, 2005). Therefore it allows us to observe and compare the possible time difference between self- and other faces to break the dynamic interocular suppression. The rationale is that since the self-face is a characteristic of the 'self', even when suppressed and invisible, it should still have a processing advantage over another person's face, which would be reflected in the shorter time needed for self-faces to break suppression during the interocular rivalry.

Previous findings on self-face processing are often based on contrasting self-faces and famous-other faces such as TV stars and politicians (e.g., Keenan, Nelson, O'Connor, & Pascual-Leone, 2001; Miyakoshi, Kanayama, Nomura, Iidaka, & Ohira, 2008), or faces of close others such as friends and family members (Bentin & Deouell, 2000; Eimer, 2000; Keyes et al., 2010; Sui et al., 2006; Zhu, Zhang, Fan, & Han, 2007). Given that Chinese participants may include close others in their self construal (Markus & Kitayama, 1991; Zhu et al., 2007), we decided to use the facial picture of a famous other person (the current Chinese Prime Minister) to minimize the familiarity effect and the possibility of inducing confounds to the self-relatedness of the faces in comparison.

Second, Experiment 2 extended previous research by exploring the ERP characteristics of self-face processing at a subliminal level with a CFS paradigm. As pointed out earlier, although existing ERP studies (e.g., Keyes et al., 2010; Sakihara et al., 2011; Sui et al., 2006) consistently showed increased activation to self-faces than other faces, particularly at fronto-central sites, almost all of these studies have been limited to supraliminal presentations of face stimuli; whether subliminal self-face processing evokes the same electrophysiological patterns is largely untested. An exception is Ibáñez et al. 2011's study that explored the different effects of subliminal self- and other faces on subsequent pain judgment. However, this study applied the traditional priming paradigm and focused on the ERPs evoked by targets (pain stimuli), but not the face stimuli themselves. Meanwhile, the short exposure to primes may limit the sustained periods of perceptual invisibility (Kim & Blake, 2005), resulting in difficulties in capturing the transient processing of the primes (Henson, Mouchlianitis, Matthews & Kouider, 2008).

Our study, however, was designed to assess the time course of the electrophysiological activities directly elicited by face primes with the CFS paradigm. The effectiveness of the CFS paradigm in obtaining recordable neural correlates has been reported in Jiang et al. (2009), in which the researchers used this paradigm to study the subliminal processing of facial expressions, and proposed separate pathways for processing the fine details and crude emotional information of faces. In our study, we explored a different but equally important research question in subliminal face processing: processing the self-face itself. Furthermore, this paradigm would not only help with the recording of the ERPs that are directly triggered by subliminal self-face stimuli, but also allow comparisons of these signals generated under different conditions of awareness. In fact, Experiment 2 was the first study to compare the neural correlates between subliminal and supraliminal self- vs. other face conditions, offering a more complete picture of self-face processing.

In summary, our present study was designed to examine subliminal self-face processing at both behavioral and electrophysiological levels with prolonged suppression, and explore the (dis)associations of subliminal and supraliminal self-processing.

2. Experiment 1

At a behavioral level, Experiment 1 examined whether the self-face has an advantage in subliminal processing to overcome the interocular suppression and enter awareness in a computer task programmed with Microsoft Foundation Classes (MFC, Microsoft Corp., Redmond, Washington, US).

The time for a stimulus to remain in suppression usually decreases as the meaningfulness and familiarity of that stimulus increases (Jiang, Costello, & He, 2007). For example, upright faces, recognizable characters from unknown language, and textures with a possible meaningful pattern can break suppression much faster than inverted faces, unrecognizable characters (Jiang et al., 2007) and texture stimuli that have no meaningful pattern (Yu & Blake, 1992).

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