Biological Psychology 87 (2011) 290–295

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Temporal features of the degree effect in self-relevance: Neural correlates

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ARTICLE INFO

Article history:
Received 5 March 2010
Accepted 28 March 2011
Available online 9 April 2011

Keywords:
Event-related potential
Self-relevance
Degree effect
P3

ABSTRACT

The present study investigated neural correlates underlying the psychological processing of the extent of self-relevance. Event-related potentials were recorded for distracting names different in extent of self-relevance while subjects performed a three-stimulus oddball task. The results showed larger amplitudes and prolonged latencies for high self-relevant than for moderate self-relevant, low self-relevant and non-self-relevant names at P2 component. Furthermore, N2 amplitudes were decreased for the high self-relevant and moderate self-relevant names than for the low self-relevant and non-self-relevant names. Moreover, the high self-relevant names elicited larger positive deflections than the moderate self-relevant names which, in turn, elicited larger positive deflections than the low self-relevant and non-self-relevant names at both P3 and 440–540 ms intervals. Additionally, the peak latencies of P3 were prolonged during the high self-relevant and moderate self-relevant than during the low self-relevant and non-self-relevant conditions. Therefore, in addition to replicating the classic self-relevant effect, the present study extended previous studies by showing a clear self-relevant degree effect, with high self-relevant stimuli processed more preferentially in the brain relative to those low in self-relevance.

1. Introduction

A growing body of research has shown a processing bias of the human brain for self-relevant information compared to self-irrelevant information (Berlad and Pratt, 1995; Perrin et al., 2005; Ninonfiya et al., 1998; Michel et al., 2002; Gray et al., 2004; Makoto et al., 2007). For example, early studies found that people detect their own names rapidly even in the absence of attention (i.e. cocktail party effect, Moray, 1959), and information encoded with reference to self was remembered better than that encoded with reference to structural, phonemic and semantic properties (Rogers et al., 1977). These findings suggested that the self had special mnemonic properties and superior organizational properties that facilitate the processing of self-relevant information (Rogers et al., 1977, 1979). Later, many studies found event-related potential correlates of preferential processing of self-relevant stimuli. A frontal P2 component, which peaks around 200 ms post stimulus, was reported larger in amplitudes during processing self compared to other-related information (Meixner and Rosenfeld, 2010; Hu et al., 2010), suggesting that self-related information elicited enhanced recruitment of attention in early time points. In addition, there was evidence showing a self-relevant effect in the following N2 stage, with self-relevant stimuli, such as one's own handwriting, or own face, eliciting smaller N2 amplitudes than self-irrelevant stimuli (Chen et al., 2008; Keyes et al., 2010).In addition to these early components, numerous studies found an important role of P3 in reflecting cognitive processing of self-relevant information (Berlad and Pratt, 1995; Gray et al., 2004; Makoto et al., 2007; Su et al., 2010). In an early study, people's own names were found to elicit larger P3 compared to other words during a passive oddball task (Berlad and Pratt, 1995). In addition, Perrin et al. (2005) found that P3 amplitude was larger, and the right medial prefrontal cortex (MPFC) was more activated, when hearing the subject's own first name than when hearing other first names (Perrin et al., 2005). In addition to names, P3 and Late positive potential response were also more intense to the subject's own face (Ninonfiya et al., 1998), and other materials related to self (Michel et al., 2002). Recently, Gray and coworkers showed larger P3 amplitudes for autobiographical self-relevant stimuli compared to control stimuli, and they interpreted this effect as heightened emotional responding induced by self-relevant stimuli (Gray et al., 2004). Noticeably, P3 effect of self-relevance was observed even for self-related objects, with own objects (e.g. self-used objects or self hand) eliciting enhanced P3 or late positive component (LPC) than other objects (Makoto et al., 2007; Su et al., 2010). This suggests that the self-relevant effect is robust and self-relevant processing involves higher-order cognitive brain function (Makoto et al., 2007).Therefore, numerous studies have reported a self-relevant effect in both early and late ERP components, irrespective of what materials were used (Berlad and Pratt, 1995; Perrin et al., 2005;

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0301-0511/$ – see front matter © 2011 Published by Elsevier B.V.
doi:10.1016/j.biopsycho.2011.03.012

Ninonfiya et al., 1998; Michel et al., 2002; Gray et al., 2004; Makoto et al., 2007; Su et al., 2010). However, all these studies considered self-relevant effect as the behavioral or neural activation differences between self-relevant and non-self-relevant stimuli, failing to take into account the degree of self-relevance. In life settings, stimuli distinct in closeness to self are often different in adaptive significance, with high self-relevant stimuli possessing greater biological and social significance to individuals than low self-relevant stimuli. This is why hearing one's own name elicits enhanced alerting than hearing a friend's name, although both names may elicit increased attention than self-irrelevant names. This resembles previous findings in our lab that highly emotional stimuli elicit enhanced brain activation than mildly emotional stimuli, though both sets of emotional stimuli elicited enhanced attention than the emotion-irrelevant stimuli (Yuan et al., 2007, 2009). In fact, self-relevant stimuli and emotionally arousing stimuli shared some similarities, particularly in terms of biological significance (Gray et al., 2004; Phan et al., 2004). In fact, the processing of self-relevant stimuli and emotional stimuli was indicated underlain by overlapping neural substrates such as nucleus acumbens and insula (Phan et al., 2004). Based on these evidence, it is likely that self-related stimuli distinct in closeness to self may receive different depth of processing, with the human brain more responsive to high (e.g. own name) to low (e.g. friend's name) self-relevant stimuli.

Nevertheless, the degree effect in self-relevant processing has yet to be directly investigated. In particular, whether high and low self-relevant stimuli are processed differently in the brain, and spatiotemporal features of the degree effect, remain undetermined and deserve clarification. Based on these considerations, the present study used ERP technique, which is known for high temporal resolution, to investigate the degree effect in self-relevant processing and its neural correlates.Because P3 component was established as a valid index for self-relevant processing (Berlad and Pratt, 1995; Perrin et al., 2005; Ninonfiya et al., 1998; Michel et al., 2002; Gray et al., 2004), the present study hypothesized that P3 waves would be a most noticeable marker of the degree effect in self-relevance. Specifically, because self-relevant processing was indicated to result in enhanced P3 amplitudes, we hypothesized that P3 amplitudes may increase linearly with the degree of self-relevance in the present study.

In order to build an experimental setting similar to natural situation, where the happening of self-relevant stimuli is often task-irrelevant and unpredictable (e.g. detecting one's own name in a noisy cocktail party), the present study used a three-stimulus oddball task, in which subjects were engaged in detecting a rare target in a train of standard stimulus. Names different in degree of self-relevance were interspersed unpredictably in the stream of standard and target trials as novel stimuli (for a review, see Polich, 2007). On the other hand, though self-relevant stimuli are often more familiar to individuals than non-self relevant stimuli in natural settings, familiarity, however, is another attribute distinct from self-relevance. Therefore, in studies of self-relevant processing, it is usually necessary to consider and exclude possible influence of familiarity on brain activity specific to self-representation (e.g. Zhu et al., 2007; Kelley et al., 2002). With this consideration, the present study used self-relevant and non-self-relevant stimuli equally familiar to Chinese subjects, consequently to exclude this potential contamination.

2. Materials and methods

2.1. Participants

As paid volunteers, 14 Chinese undergraduate students (8 females, 6 males) aged 18–26 years (mean age: 20.9-year-old) participated in the experiment. All subjects were healthy, right-handed, with normal or corrected to normal vision, and reported no history of affective disorder. In addition, all subjects were members of their Clansmen Associations. This association was founded by students from the same province. Each subject signed an informed consent form for the experiment.

2.2. Stimuli

Seven categories of stimuli were used in a three-stimulus oddball paradigm. A small circle was used as the target stimulus, and a big circle was used as the standard stimulus. Three sets of self-relevant stimuli, the non-self-relevant stimulus and the filler stimuli were used as distracters. Participant's own name (e.g. 万永凤) was used as the high self-relevant stimulus, the name of participant's own province (e.g. Shandong People, 山东人) as the moderate self-relevant stimulus, the name of Chinese (中国人) as the low self-relevant stimulus, while the name of American (美国人), which is equally familiar to Chinese subjects, as the non-self-relevant stimulus. In addition, some pseudo names were used as filler stimuli. All name stimuli were made into images by PC with Microsoft Office Picture Manager, with the image size, word length and complexity matched across the three self-relevant, the non-self-relevant and the pseudo name conditions.

2.3. Task design and procedures

In this study, the big circle was presented for 640 times (64%), the small circle was presented for 60 times (6%). Moreover, the non-self-relevant stimulus was presented for 60 times (6%), the filler stimuli for 60 times (6%), and each set of self-relevant stimuli was presented for 60 times (6%), respectively. The entire experiment was divided into nine blocks, and the onset sequence of the stimuli was randomized across conditions in each block.

Subjects were seated in a quiet room at approximately 120 cm from a computer screen with the horizontal and vertical visual angles below 5°. In order to familiarize participants with the task, experiment started with 30 practice trials. Each trial was initiated by a 500 ms presentation of a small white cross on the black computer screen. Afterwards, a blank screen was presented for a duration ranging from 500 to 1000 ms which, then, was followed by the presentation of one of the seven types of stimuli for 300 ms. The task of the participant was to detect the small circle interspersed in a train of big circles. Subjects were instructed to press "J" key with their right index finger if the stimulus is the small circle, and no response was required for other stimuli. Each stimulus was followed by a 1200 ms of a blank screen. Between blocks, several minutes of rest were taken appropriately.

In order to measure the familiarity and to test the validity of the stimulus in reflecting the corresponding extent of self-relevance, subjects were required to rate the high self-relevant, moderate self-relevant, low self-relevant and non-self-relevant stimuli using a self-report 9-point scale in terms of the self relevance (1 = 'not self-related at all' to 9 = 'extremely self-related') and the familiarity (1 = 'not familiar at all' to 9 = 'extremely familiar'). The order of two ratings was counterbalanced across subjects.

2.4. ERP recording and analysis

Electroencephalography (EEG) was recorded from 64 scalp sites using tin electrodes mounted in an elastic cap (brain products), with the references on the left and right mastoids (average mastoiod reference, Luck, 2005) and a ground electrode on the medial frontal aspect. Vertical electrooculograms (EOGs) were recorded supra- and infra-orbitally at the left eye. Horizontal EOG was recorded as the left versus right orbital rim. Electrode impedance was maintained below 5 kΩ. EEG and EOG activity was amplified with a dc ~100 Hz bandpass and continuously sampled at 500 Hz/channel. EEG data were corrected to a 200 ms baseline prior to the onset of the target. Artifact-free EEG segments to trials with correct responses were averaged separately for each name condition. ERP averages were computed off-line; trials with EOG artifacts (mean EOG voltage exceeding ±80 V), amplifier clipping artifacts, or peak-to-peak deflection exceeding ±80 V was excluded from averaging.

ERP waveforms were time-locked to the onset of stimuli and the average epoch was 1200 ms, including a 200 ms pre-stimulus baseline. The following 15 electrode sites (F3, FZ, F4, FC3, FCZ, FC4, C3, CZ, C4, CP3, CPZ, CP4, P3, PZ, P4) were selected for statistical analysis. As shown by Fig. 2, prominent N1 (70–110 ms), P2 (130–190 ms), N2 (270–320 ms), P3 (370–430 ms) components were elicited during the four conditions. Moreover, the amplitude differences during the four conditions started at about 170 ms, and these differences were pronounced and lasted until 540 ms afterwards (Fig. 2). Therefore, the amplitudes (from baseline to peak) and peak latencies (from stimulus onset to the peak of each component) of N1, P2, N2, P3 components as well as the average amplitudes at 440–540 ms were measured and analyzed at corresponding intervals. A two-way repeated measures analysis of variance (ANOVA) was conducted for the amplitudes and the peak latencies of each component. ANOVA factors were stimulus type (4 levels: high self-relevant, moderate self-relevant, low self-relevant and non-self-relevant conditions) and electrode sites (15 sites). The degrees of freedom of the *F*-ratio were corrected according to the Greenhouse–Geisser method.

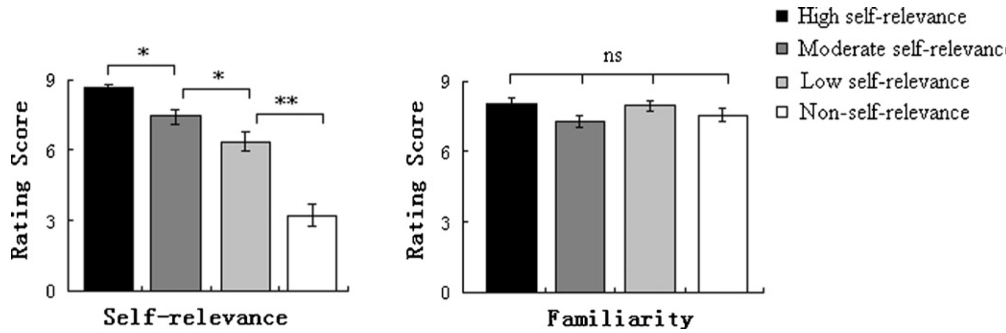

Fig. 1. The results of self-relevance and familiarity ratings during the high self-relevant, moderate self-relevant, low self-relevant and non-self-relevant stimulus conditions. Error bars plot *SEM*. "*" means the difference is significant at .05 level, "**" means the difference is significant at .01 level, and "ns" means no significant difference.

3. Result

3.1. Behavioral result

The post-experiment assessment showed a significant main effect of stimulus type in self-relevance [$F(3, 39) = 74.05$, $p < 0.001$]. The self-relevance scores for high self-relevant, moderate self-relevant, low self-relevant and non-self-relevant stimuli were 8.64, 7.43, 6.36 and 3.21, respectively. The subsequent Post hoc test revealed that the self-relevance score for high self-relevant names was significantly higher than for moderate self-relevant names [$t(13) = 2.36$, $p < 0.05$] which, in turn, were rated more self-relevant than low self-relevant [$t(13) = 2.08$, $p < 0.05$] and non-self-relevant [$t(13) = 8.2$, $p < 0.01$] names. In addition, the self-relevance score for the low self-relevant name were higher than for the non-self-relevant [$t(13) = 6.11$, $p < 0.001$] name (see Fig. 1). In contrast, the analysis of the familiarity scores showed no significant differences across the four conditions [$F(3, 39) = 2.07$, $p = 0.14$]. The familiarity scores for the high self-relevant, moderate self-relevant, low self-relevant and non-self-relevant conditions were 8.07, 7.29, 7.93 and 7.57, respectively.

3.2. ERP analysis

As shown in Fig. 2, N1, P2, N2 and P3 components were elicited during each of the four conditions. A two-way repeated measure ANOVA on N1 amplitudes and latencies demonstrated no any significant effects. In P2 component, the repeated measures ANOVA on

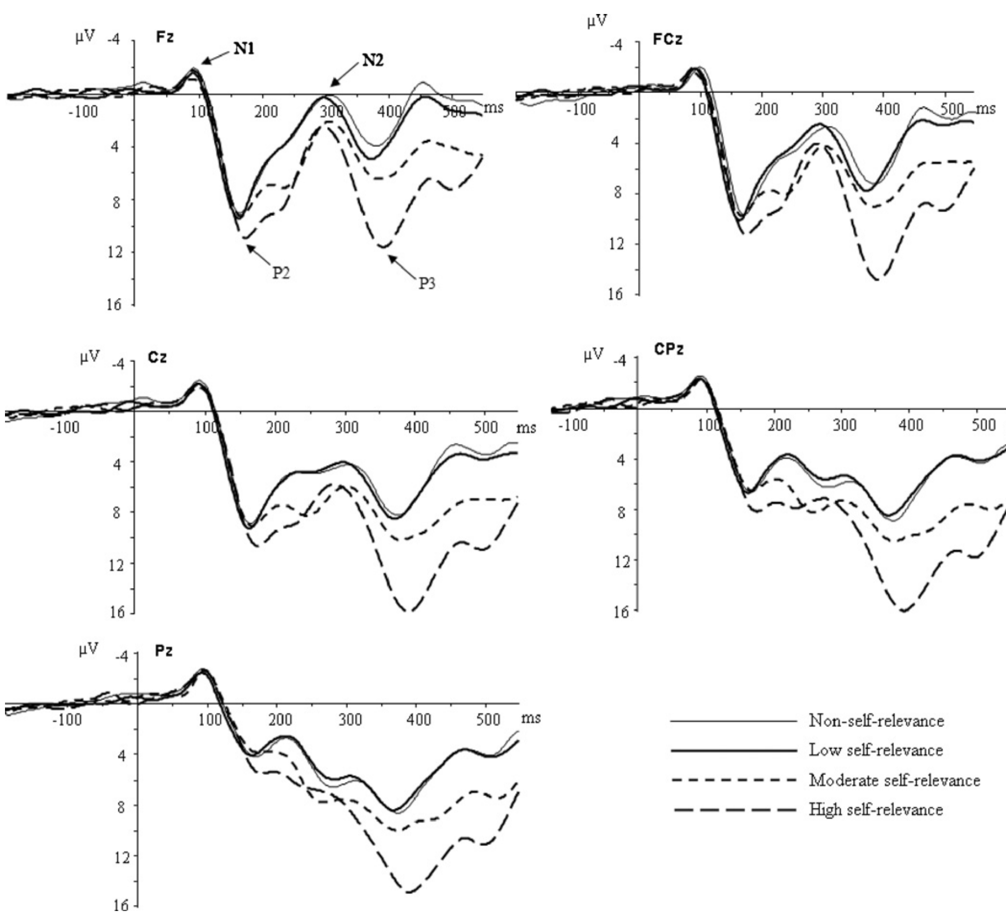

Fig. 2. Averaged ERPs at FZ, FCZ, CZ, CPZ nd PZ for high self-relevant (long dashed lines), moderate self-relevant (short dashed lines), low self-relevant (thick solid lines) and non-self-relevant (thin solid lines) stimulus conditions.

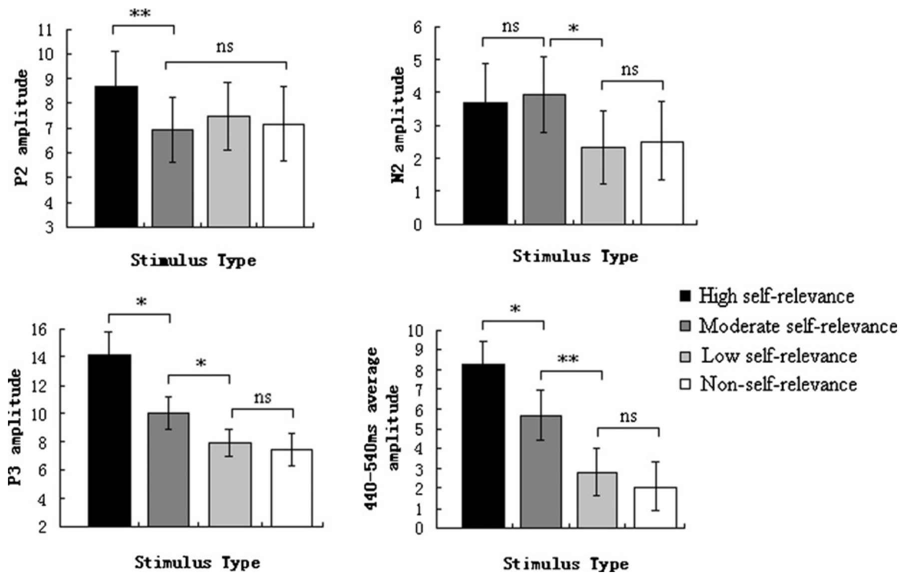

Fig. 3. Bar graphs of P2, N2, P3 and 440–540 ms average amplitudes during high self-relevant, moderate self-relevant, low self-relevant and non-self-relevant stimulus conditions. Error bars plot *SEM*. "*" means the difference is significant at .05 level, "**" means the difference is significant at .01 level, and "ns" means no significant difference.

the amplitudes demonstrated significant main effects of stimulus type [$F(3, 39) = 5.8$, $p = 0.005$] and electrode sites [$F(14, 182) = 29.1$, $p < 0.001$]. P2 amplitudes were largest at frontal sites, and decreased from central to parietal sites (Fig. 2). Post hoc test revealed that high self-relevant names elicited larger P2 amplitudes than the moderate self-relevant [$t(13) = 3.51$, $p = 0.004$], low self-relevant [$t(13) = 2.26$, $p = 0.042$] and non-self-relevant [$t(13) = 4.7$, $p < 0.001$] names. In addition, there were no significant differences among moderate self-relevant, low self-relevant and non-self-relevant names (Fig. 3). Moreover, there was a significant main effect of stimulus type on P2 latencies [$F(3, 39) = 8.45$, $p = 0.001$]. High self-relevant names elicited longer peak latencies than the other name conditions (see Fig. 2). NO other main or interaction effects were observed at P2 components.

In N2 component, the repeated measures ANOVA conducted on the amplitudes demonstrated significant main effects of stimulus type [$F(3, 39) = 5.50$, $p = 0.006$] and electrode sites [$F(14, 182) = 10.07$, $p < 0.001$], while there were no any significant effects on N2 latencies. Frontal and frontal–central sites recorded larger N2 amplitudes than central, centro-parietal and parietal sites (Fig. 2). Post hoc multiple comparison revealed that N2 amplitudes elicited by the non-self-relevant name was larger than those elicited by high self-relevant [$t(13) = 2.86$, $p = 0.013$] and moderate self-relevant names [$t(13) = 3.30$, $p = 0.006$]. Similarly, the low self-relevant name elicited lager amplitudes than high self-relevant [$t(13) = 2.34$, $p = 0.036$] and moderate self-relevant [$t(13) = 2.67$, $p = 0.019$] names. In contrast, there were no significant differences between low self-relevant and non-self-relevant conditions, or between high self-relevant and moderate self- relevant conditions (Fig. 3).

The repeated measures ANOVA on P3 amplitudes showed significant main effects of stimulus type [$F(3, 39) = 18.56$, $p < 0.001$] and electrode sites [$F(14, 182) = 7.32$, $p = 0.002$], and also a significant electrode by stimulus type interaction effect [$F(42,546) = 2.76$, $p = 0.015$]. Central–parietal and parietal sites recorded larger P3 amplitudes than central and frontal sites, and the amplitude differences across name conditions were more pronounced at central and frontal sites than at parietal sites. Post hoc multiple comparison revealed that the P3 amplitudes were larger during the high self-relevant than during the moderate self-relevant [$t(13) = 2.97$, $p = 0.011$], the low self-relevant [$t(13) = 5.23$, $p < 0.001$], and the non-self-relevant [$t(13) = 6.35$, $p < 0.001$] conditions. Moreover, the moderate self-relevant names elicited larger P3 amplitudes than the low self-relevant [$t(13) = 2.95$, $p = 0.011$] and non-self-relevant [$t(13) = 2.97$, $p = 0.011$] names, while the latter two conditions showed no significant differences [$t(13) = 0.89$, $p = 0.562$] (Fig. 3). There was a significant main effect of stimulus type at P3 latencies [$F(3, 39) = 8.30$, $p < 0.001$]. The Post hoc multiple comparison showed that the high self-relevant names (396.2 ms) elicited longer latencies than the low self-relevant [380.4 ms; $t(13) = 4.11$, $p = 0.001$] and non-self-relevant names [385.7 ms, $t(13) = 2.93$, $p = 0.019$]. In addition, the moderate self-relevant names (396.4 ms) elicited longer P3 latencies than the low self-relevant [$t(13) = 3.79$, $p = 0.002$] and non-self-relevant names [$t(13) = 2.55$, $p = 0.024$]. However, the differences between high and moderate self-relevant names, and those between low self-relevant and non-self-relevant conditions, were both not significant (all $p > 0.1$). No other main or interaction effects were observed at P3 latencies.

Furthermore, a two-way repeated measure ANOVA showed significant main effects of stimulus type [$F(3, 39) = 33.05$, $p < 0.001$] and electrode sites [$F(14, 182) = 7.12$, $p = 0.001$] on the average amplitudes of the 440–540 ms time interval. Post hoc multiple comparison revealed that the high self-relevant names elicited enhanced positive deflection than moderate self-relevant names [$t(13) = 2.97$, $p = 0.011$] which, in turn, elicited larger amplitudes than did low self-relevant [$t(13) = 4.34$, $p = 0.001$] and non-self-relevant [$t(13) = 5.07$, $p < 0.001$] conditions. Moreover, the differences between low self-relevant and non-self-relevant conditions were not significant [$t(13) = 1.44$, $p = 0.17$] (Fig. 3).

Therefore, the self-relevant degree effect in brain potentials was embodied in the P3 and the 440–540 ms components. To test whether these components were valid indexes for the degree effect of self-relevance, we ran zero-order correlation analysis between the behavioral self-rating scores and P3 (or 440–540 ms) amplitudes, after collapsing across the four experimental conditions. The results demonstrated a significant positive correlation between the self-relevant rating scores and P3 amplitudes [$r = 0.68$, $p < 0.01$, $df = 12$], whereas the correlation between rating scores and the 440–540 ms amplitudes failed statistical significance ($r = 0.45$, $p > 0.05$, $df = 12$). To exclude a possible influence of the preceding N2 on the P3 correlation with the self rating scores, we further ran a partial correlation analysis between P3 amplitudes and the self-rating scores, with the preceding N2 as a controlling variable. The correlation, however, remained significant even after excluding this possible influence ($r = 0.49$, $p < 0.05$, $df = 11$). These data indicated that P3 is a most likely candidate component embodying the degree effect of self-relevance in the present study.

4. Discussion

In the present study, we found that early visual processing, as reflected by N1 activity, was similar in the four conditions; probably because four types of names are Chinese characters equal in size, word length and complexity. At approximately 170 ms after name onset, obvious frontal P2 activity was elicited in the four conditions, and high self-relevant names elicited larger P2 amplitudes than moderate self-relevant, low self-relevant and non-self-relevant names. It has been indicated that frontal P2 activity is indicative of rapid detection of typical stimulus features that is sensitive to attention recruitment (Karayanidis and Michie, 1996; Thorpe et al., 1996). In addition, P2 amplitudes were shown larger in response to emotion-relevant than to neutral stimuli, probably due to enhanced attention alerting to biologically important stimuli (Carretie et al., 2001). Evidently, one's own name represents him or her-self directly and thus is motivationally important to an individual (Perrin et al., 2005). Therefore, in the present study, high self-relevant name elicited enhanced early attention and was differentiated from other names rapidly in the brain, in the absence of top-bottom cognitive and controlled resources (Hu et al., 2010; Del Cul et al., 2007). This probably accounts for the largest P2 amplitudes for the high self-relevant names before 200 ms. Moreover, high self-relevant names elicited longer latencies than other names, suggesting that high self-relevant names, due to biological importance, required prolonged attention engagement. However, the attention effect for moderate self-relevant and low self-relevant names were not significant at this component, most likely because these names, despite relevance to self, are not as salient and motivationally important as one's own name. Therefore, the self-relevant effect for moderate self-relevant and low self-relevant names, as well as the degree effect, may occur at later processing stages.

A frontocentral N2 was observed under the four conditions in the 270–320 ms interval, and N2 waves elicited by non-self-relevant and low self-relevant names were more negative than moderate and high self-relevant names. Recently, an ERP study in our lab investigated the self-referential processing evoked by handwriting. The results found that N2 waves elicited by other handwriting were more negative than that of subject's own handwriting (Chen et al., 2008). This suggests that the recognition of subjects' own handwriting is easier, with less top-down cognitive resources consumption than that of other handwriting (Campanella et al., 2002). Similar to these findings, the smaller N2 during high self-relevant and moderate self-relevant conditions in the present study may be associated with the self-relevant effect induced by high self-relevant and moderate self-relevant names. Specifically, the high and moderate self-relevant names, due to their important adaptive values to individuals, were processed preferentially and their self-relevant information was retrieved more easily, with less top-down cognitive resources consumption relative to low and non-self-relevant names. In contrast to the absence of the self-relevant effect for the moderate names in P2, N2 component manifested self-relevant effect for both high and moderate self-relevant names, probably because self-relevance in moderate self-relevant stimuli was processed by the brain at N2, a temporal stage where information processing lies between automatic and controlled phases (Carretié et al., 2004). Therefore, with access to a portion of top-bottom resources, self-relevant information in moderate self-relevant names, whose self-relevance is smaller than that of high self-relevant names, was processed differently from self-irrelevant names. Apparently, self-relevant information was detected faster during high self-relevant (P2, before 200 ms) than during moderate self-relevant (N2, after 200 ms) conditions. Nevertheless, high self-relevant and moderate self-relevant names elicited similar N2 amplitudes, suggesting that self-relevant information was processed roughly and the extent of self-relevance was not clearly differentiated by the brain at these early stages. Therefore, we expect that more elaborative processing of self-relevance may be observed at later cognitive processing stages.

As expected, a clear P3 component was elicited by all the four name conditions, and the amplitude differences across conditions were most pronounced at central and frontal sites. In the present study, we used a three-stimulus oddball task and participants were required to detect the target by making a buttonpress response to the small circle. Therefore, all names served as distracters whose presentation entails novelty processing. Accordingly, the P3 observed in this study was in fact a novelty P3 component. It has been accepted that the novelty P3 is an index of the late phase of orienting response that is sensitive to central controlled processes (Carretié et al., 2004; Campanella et al., 2002; Yuan et al., 2008). Specifically, Novelty P3 was associated with the controlled-processing phenomena triggered by previous automatic processes (Carretié et al., 2004), and its generation requires top-down attentional mechanisms initiated by frontal lobe functions (Knight and Nakada, 1998). With more cognitive and controlled processing resources, the brain processed not only the self-relevance of high and moderate self-relevant names, but also the differences in the extent of self-relevance in these stimuli. Consequently, the high self-relevant names elicited larger P3 amplitudes than the moderate self-relevant names which, in turn, elicited larger P3 amplitudes than the low self-relevant and non-self-relevant names. Therefore, apart from significant self-relevant effects for both high self-relevant and moderate self-relevant names, our result demonstrated a significant self-relevant degree effect, with high self-relevant stimuli eliciting increased processing compared to stimuli of lower self-relevance. This suggested that P3 component, different from earlier P2 and N2 which reflect a general processing of self information, was an effective ERP index of the self-relevant degree effect central to the present study.

Subject's own name is an exclusive symbol of one's identity and is closest to the core self (Shapiro and Caldwell, 1997). Numerous studies have demonstrated a processing bias for subject' own name (Wolford and Morrison, 1980; Berlad and Pratt, 1995; Shapiro and Caldwell, 1997). In the present study, subject's own name recruited greatest amount of attention and cognitive resources and may have evoked most intense emotional/motivational responses, indexed by the largest P2 and P3 amplitudes induced by high self-relevant names. In addition, as reported by the subjects, there were many Clansmen Associations in their campus, and they were all the members of these Clansmen Associations. Therefore, the name of one's own province (e.g. Shandong People) is also an important symbol of his/her identity, which most likely accounted for the larger P3 amplitudes during moderate self-relevant than during low self-relevant and non-self-relevant conditions. Nevertheless, the self-relevance of province names was not as intense as that of people's own names. Also, one's own name, but not province name, is directly indicative of someone him/herself. Therefore, high self-relevant names elicited enhanced cognitive processing than did moderate self-relevant names across both P3 and 440–540 ms intervals, though the self-relevant effects elicited by high self-relevant and moderate self-relevant names were significant at both intervals.

However, there were no amplitude differences between low self-relevant and non-self-relevant conditions at P3 and 440–540 ms intervals. The lack of self-relevant effect in the low self-relevant condition may result from the possibility that the low and non-self relevant stimuli were not different enough to induce differences in ERP amplitudes (i.e. floor effect). Consistent with this hypothesis, we observed longer P3 latencies for the high and moderate self-relevant names than for low and non-self-relevant names, while the latter two conditions displayed no significant differences. The longer latencies and larger amplitudes for high self-relevant and moderate self-relevant names suggest that these names, due to their close relation to self, elicited prolonged cognitive processing and stronger motivational response relative to other names, probably because self-relevant names were psychologically salient and biologically important.

However, prior studies reported that familiar materials were associated with enhanced P3 amplitudes than unfamiliar materials (Bobes et al., 2000; Beauchemin et al., 2006), which would form a contamination if familiarity were not equated in self-relevant studies. However, our behavioral rating data excluded this possibility as all self and non-self stimuli were rated equally familiar. Therefore, our ERP effects at P3 were most likely specific to the degree of self relevance without familiarity influences. Nevertheless, it is also likely that P3 amplitudes are modulated by the specific-general continuum of experimental stimuli. Because one's own name is the most specific descriptor of the self, one's province is more general but still more specific than the name of Chinese or American, which may be equal in the level of generality. This possibility should be considered in future studies of self-relevant processing, particularly when P3 is taken as the key component for analysis. However, our correlation analysis demonstrated a significantly positive correlation between self-relevance rating and the P3 amplitudes, and this correlation remained significant even after we excluded the influence of the preceding N2 component. This, to some extent, suggested that the observed P3 effect should be ascribed to the extent of self-relevance instead of specific-general attributes.

Taken together, using high temporal resolution ERPs, the present study not only replicated the classic self-relevant effect, but extended previous studies by revealing a degree effect of self-relevance at both behavioral and neurophysiologic levels. Stimuli different in the extent of self-relevance are processed differently at both early attentional and late cognitive processing stages. High self-relevant stimuli elicited attention faster than moderate self-relevant stimuli at early time points, while high and moderate self-relevant stimuli received different processing depths in the brain at late cognitive stages. Future study should adopt other materials, experimental tasks and methods to replicate the present findings, particularly to unravel neural substrates mediating the self-relevant degree effect.

Acknowledgements

This study was supported by National Natural Science Foundation of China (30770727; 30970897) and by the Fundamental Research Funds for the Central Universities (Grant No. XDJK2009B038).

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