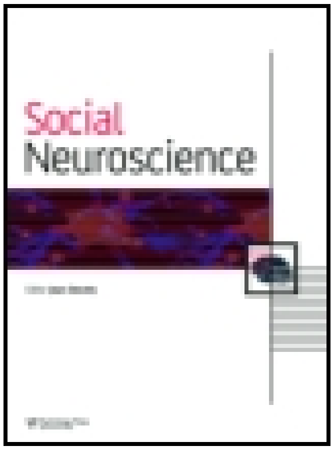

Social Neuroscience
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/psns20

Conflict monitoring and stimulus categorization processes involved in the prosocial attitude implicit association test: Evidence from event-related potentials

Fengqiu Xiao[a], Zhiwei Zheng[b], Ya Wang[c], Jifang Cui[d] & Yinghe Chen[a]

[a] Institute of Developmental Psychology, School of Psychology, Beijing Normal University, Beijing, China

[b] Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Beijing, China

[c] Neuropsychology and Applied Cognitive Neuroscience Laboratory, Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Beijing, China

[d] Information Center, National Institute of Education Sciences, Beijing, China

Published online: 27 Jan 2015.

SOCIAL NEUROSCIENCE, 2015
http://dx.doi.org/10.1080/17470919.2014.1003598

Conflict monitoring and stimulus categorization processes involved in the prosocial attitude implicit association test: Evidence from event-related potentials

Fengqiu Xiao[1], Zhiwei Zheng[2], Ya Wang[3], Jifang Cui[4], and Yinghe Chen[1]

[1]Institute of Developmental Psychology, School of Psychology, Beijing Normal University, Beijing, China
[2]Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Beijing, China
[3]Neuropsychology and Applied Cognitive Neuroscience Laboratory, Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Beijing, China
[4]Information Center, National Institute of Education Sciences, Beijing, China

The implicit association test (IAT) is a promising method used to assess individual implicit attitudes by indirectly measuring the strengths of associations between target and attribute categories. To date, the cognitive processes involved in the prosocial attitude IAT task have received little attention. The present study examined the temporal dynamics of the IAT that measures prosocial attitude using event-related potentials (ERPs). ERP results revealed enhanced N2 amplitudes for incongruent trials when compared with congruent trials and enhanced P300 amplitudes for congruent trials when compared with incongruent trials. In addition, the N2 amplitude differences were significantly correlated with individual prosocial behavior (the amount of donation). Our findings suggest that conflict monitoring and stimulus categorization processes are involved in the prosocial attitude IAT task and that the ERP indices of IATs that measure prosocial attitude may predict individual prosocial behavior.

Keywords: Prosocial attitude; Implicit association test; Event-related potentials; N2; P300.

Prosocial attitude is regarded as an orientation that can guide prosocial behavior that benefits other people or society, such as helping, sharing, and cooperation (Batson & Powell, 2003; Cheung, Ma, & Shek, 1998; Penner, Dovidio, Piliavin, & Schroeder, 2005). Previous studies explored prosocial attitude and behavior based primarily on self-reported measures (Balconi & Canavesio, 2013, 2014; Colzato, Hommel, Van Den Wildenberg, & Hsieh, 2010), which are the methods usually used to examine explicit attitude and behavior. However, the validity of explicit attitude measures has been challenged because these measures have proven to be sensitive to social desirability (Greenwald, Poehlman, Uhlmann, & Banaji, 2009). This issue prompted researchers to investigate implicit prosocial attitude using indirect methods, such as the implicit association test (IAT; Greenwald, McGhee, & Schwartz, 1998; Greenwald et al., 2009).

The IAT is a method used to measure implicit attitude by measuring the strengths of associations between target and attribute categories (Greenwald et al., 1998). The underlying assumption of the IAT is that subjects should be able to press the same key more quickly for target and attribute categories that

Correspondence should be addressed to: Yinghe Chen, Institute of Developmental Psychology, Beijing Normal University, No. 19 Xinjiekouwai Street, Haidian District, Beijing 100875, China. E-mail: chenyinghe@bnu.edu.cn
This work was supported by the twelfth 5-year-plan project of philosophy and social science, Beijing, China [No. 12JYA003] and the Humanity and Social Science Key Project Foundation, Ministry of Education, China [No. 12JJD190001].

are strongly associated in congruent trials than for those that are weakly associated in incongruent trials. This assumption has been validated in various domains (Arcuri, Castelli, Galdi, Zogmaister, & Amadori, 2008; Maison, Greenwald, & Bruin, 2004; Wilson & Scior, 2014). A considerable body of evidence supports proposals that implicit measures are better than explicit measures as predictors of behavior (Greenwald et al., 2009; Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005; Huntjens, Rijkeboer, Krakau, & De Jong, 2014; Nosek, Hawkins, & Frazier, 2011).

As social variables, prosocial attitude and behavior may be driven by reflective and impulsive systems: "The reflective system generates behavioral decisions that are based on knowledge about facts and values, whereas the impulsive system elicits behavior through associative links and motivational orientations" (Strack & Deutsch, 2004, p. 220). From the perspective of this model, explicit processes may occur in the reflective system, and implicit processes likely occur in the impulsive system. Self-reported prosocial attitude and behavior may be sourced from the reflective system, and implicit attitudes measured by IAT may be explained by the impulsive system.

Previous investigations of prosocial attitude and behavior have frequently relied on explicit measures that are sensitive to social desirability (Carpenter, Uebel, & Tomasello, 2013; Fehr & Fischbacher, 2003; Paciello, Fida, Cerniglia, Tramontano, & Cole, 2013). However, to date, implicit prosocial attitude and behavior are rarely considered. In particular, very little work has investigated the cognitive processes involved in the prosocial attitude IAT. One methodology that can be considered to assess the cognitive processes involved in implicit prosocial attitude is the event-related potentials (ERPs) technique. This technique provides an effective method for recording the time course of cognitive processes with excellent temporal resolution. It also helps us answer questions about and when specific cognitive processes occur by recording changes in electrophysiological responses. In the present study, we primarily sought to examine the time dynamics of the prosocial attitude IAT using ERPs. Moreover, we were also interested in whether the ERP effects were associated with the behavioral IAT effect and individual prosociality (e.g., prosocial personality and prosocial behavior).

The present study adopted a standard IAT task in which participants were required to discriminate between the stimuli of target and attribute categories by pressing one of two response keys. Previous research has provided evidence that people are prosocial. For example, Rand, Greene, and Nowak (2012) demonstrated that people are intuitively cooperative and reflections decrease cooperation across a board of experiments. Thus, in the congruent condition, the combined target-attribute pairs (e.g., self- and prosocial-related words; others- and non-prosocial-related words) were assigned to the same keys. In the incongruent condition, the combined target-reversed attribute pairs (e.g., self- and non-prosocial-related words; others- and prosocial-related words) were assigned to the same keys. The electroencephalograms (EEGs) were recorded during the execution of the prosocial attitude IAT task. In addition, corresponding scales measured individual prosocial personality and prosocial behavior after the IAT task.

Evidence has documented that several ERP indices related to different cognitive processes were sensitive to the IAT task. For example, the early ERPs components related to selective attentional and perceptual processes, such as N1 and P1 (Doyle, Rugg, & Wells, 1996; Luck, Woodman, & Vogel, 2000; Vogel & Luck, 2000), and conflict monitoring-related ERPs modulations, such as N2 (Folstein & Van Petten, 2008; Yeung, Botvinick, & Cohen, 2004), were found to be sensitive to the congruency between targets and attributes (Coates & Campbell, 2010; Fleischhauer, Strobel, Diers, & Enge, 2014). In addition, researchers have revealed that P300-like deflection, an index of attentional resource allocation during decision-related stimulus evaluation and categorization (Polich, 2007), is also sensitive to IAT tasks (e.g., Coates & Campbell, 2010; Fleischhauer et al., 2014; O'Toole & Barnes-Holmes, 2009; Williams & Themanson, 2011). However, the specific ERP modulations associated with the prosocial attitude IAT remain relatively unclear.

In the present study, in terms of behavior, we expected a significant IAT effect to be reflected in shorter response times for congruent trials when compared with incongruent trials. For the ERP results, we first expected that early perceptual processes were involved in the prosocial attitude IAT task, characterized by the amplitude differences between the early ERP components of congruent and incongruent conditions. In addition, we further expected that conflict monitoring and stimulus categorization would support the prosocial attitude IAT task, which was primarily displayed by significant N2 and P3 amplitude differences across conditions. Finally, we speculated that ERP amplitude differences across conditions would be related to the behavioral IAT effect as well as individuals' prosocial personality and prosocial behavior.

METHODS

Participants

Twenty-one right-handed undergraduates (11 females; ages ranging from 19 to 25; mean age of 21.90) participated in the study. All participants were native Chinese speakers with normal or corrected-to-normal vision and were free of neurological and psychiatric disorders. Each participant signed an informed consent form and received 50 ¥ as monetary compensation for participating in the study. The Institutional Review Board (IRB) at Beijing Normal University approved the study.

Materials

There were a total of 20 two-character Chinese words in the prosocial attitude IAT task. The target categories consisted of ten items, five for "self" (e.g., 自己, meaning *self*) and five for "others" (e.g., 他人, meaning *others*). The attribute categories also consisted of ten items, five for "prosocial" (e.g., 帮助, meaning *helping)* and five for "non-prosocial" (e.g., 拒绝, meaning *refusing*). All of these words were selected from the materials used by Jiang, Wang, Fu, and Zhou (2008).

Procedures

The IAT experiment program was designed using E-Prime (Psychology Software Tools Inc., Pittsburgh, PA, USA). In this task, participants were instructed to discriminate between the stimuli of two target categories and two attribute categories by pressing one of two response keys. The IAT consisted of seven blocks. The block design and number of trials are illustrated in Table 1. Stimuli discriminations for target and attribute categories were practiced in the first and second blocks, respectively. In the third block, a combined practice block, discrimination of the stimuli for targets and attributes were combined. The fourth block (i.e., the congruent condition) was a combined test block in which the task demand was similar to that of the third block. In the fifth block, participants practiced identifying the attribute categories by the changed response key assignment. The sixth block was a combined practice block to discriminate between the stimuli of targets and reversed attributes. Finally, the seventh block (i.e., the incongruent condition) was a combined test block that was similar to the sixth block. In all of the practiced trials, a red "×" would appear in the middle of the screen if participants responded incorrectly.

The participants were asked to respond as quickly and accurately as possible. The order of the congruent and incongruent blocks and response key mapping

TABLE 1
Task Sequence of prosocial attitude IAT

Block	*Task*	*Stimulus*	*Response key*	*No. of trials*
1	Target categorization	Self-related words	F	20
		Other-related words	J	
2	Attribute categorization	Prosocial-related words	F	20
		Nonprosocial-related words	J	
3	Combined target and attribute categorization (practice)	Self-related words	F	20
		Other-related words	J	
		Prosocial-related words	F	
		Nonprosocial-related words	J	
4	Combined target and attribute categorization (test)	Self-related words	F	40
		Other-related words	J	
		Prosocial-related words	F	
		Nonprosocial-related words	J	
5	Reversed attribute categorization	Prosocial-related words	J	20
		Nonprosocial-related words	F	
6	Combined target and reversed attribute categorization (practice)	Self-related words	F	20
		Other-related words	J	
		Prosocial-related words	J	
		Nonprosocial-related words	F	
7	Combined target and reversed attribute categorization (test)	Self-related words	F	40
		Other-related words	J	
		Prosocial-related words	J	
		Nonprosocial-related words	F	

were counterbalanced across participants. EEGs were recorded during the combined test blocks. To reduce eye movements in the test phases, the labels that were presented in the upper left and right corners of the screen in previous behavioral IAT studies were removed for the present experiment. Instead, participants were shown the instructions before each block. To minimize EEG artifacts, they were also instructed to maintain fixation and to avoid body or eye movements as much as possible when words and fixation crosses appeared on the screen.

All words were displayed in black in the middle of a white computer screen at a viewing distance of approximately 50 cm, and the words subtended a visual angle of 5° × 2°. The trial procedure during the congruent and incongruent blocks is as follows. Each trial began with a fixation cross presented for 800 ms, followed by a target word displayed in the center of the screen with a maximum presenting time of 2000 ms. Once the subject responded or the time limit was exceeded, a blank screen was presented for a random period of 1500 to 1700 ms, followed by the next trial.

After the IAT task, participants were asked to complete some scales, which were used to measure prosocial personality and prosocial behavior.

Scales

Prosocial personality

Participants' prosocial personality was assessed using the prosocial personality battery (PSB, Penner, 2002); a Chinese version was used in this study. The 30-item PSB measures seven dimensions of prosocial personality: social responsibility (SR), empathic concern (EC), perspective taking (PT), personal distress (PD), mutual moral reasoning (MMR), other-oriented reasoning (OOR), and self-reported altruism (SRA). The five-point rating scales had alternatives ranging from 1 ("strongly disagree" or "never") to 5 ("strongly agree" or "very often"). The alpha coefficients for the seven PSB subscales are .65, .67, .66, .77, .64, .77, .73, respectively (Penner, 2002).

Prosocial behavior

Participants' prosocial behavior was measured by asking participants to voluntarily write down how much they would like to donate from their monetary compensation for participating in the study. The number was used as an index of prosocial behavior (Van Lange, Bekkers, Schuyt, & Vugt, 2007).

ERP recordings and analysis

EEGs with a band-pass filter of 0.05–100 Hz and a sampling rate of 500 Hz were recorded continuously via NeuroScan 4.3 software (Compumedics Neuroscan, Abbotsford, VIC, Australia). Using an electrode cap with Ag/AgCl inserts, 62 scalp electrodes were arranged in an international 10–20 system. The left mastoid was used as the online reference and re-referenced offline to left and the right mastoid averages. The vertical electrooculogram (VEOG) was recorded with two electrodes placed above and below the left eye, and the horizontal electrooculogram (HEOG) was recorded with two electrodes placed at the outer canthus of each eye. Electrode impedance was maintained below 5 kΩ. Ocular artifacts with eye blinks were removed through ocular reduction in Scan 4.3. EEG signals were digitally filtered with a 0.05–40 Hz (24 dB/oct) band-pass offline filter. Stimulus-locked data were segmented into epochs from 100 ms before stimulus onset to 1000 ms after stimulus onset. A period of 100 ms before stimulus onset was used for baseline correction. Incorrect response trials or trials with artifacts larger than ±75 μV were excluded from ERP averages. The mean trials contributing to the grand average ERPs were 37 for the congruent condition and 35 for the incongruent condition.

Based on visual inspection of the grand average waveforms and previous studies, the ERP differences between congruent and incongruent trials were quantified by calculating the mean amplitude in four consecutive time windows of 80–150 ms, 150–250 ms, 250–400 ms, and 400–650 ms. These time windows were used to characterize the N1, P2, N2, and P300, respectively. The following nine electrodes were selected for the statistical analysis: F3, Fz, and F4 for the frontal region; C3, Cz, and C4 for the central region; and P3, Pz, and P4 for the parietal region. The mean amplitude for each time window was subjected to a three-way repeated-measures analysis of variance (ANOVA) with condition (i.e., congruent, incongruent), region (i.e., frontal, central, parietal), and laterality (i.e., left, middle, right) as factors. In addition, for the time window during which the condition differences were statistically significant, correlation analyses were conducted between ERP amplitude differences (incongruent minus congruent condition) at the three scalp regions (each representing the mean amplitude over the three electrodes described above) and the behavioral IAT effect (response time differences between incongruent and congruent conditions) and individual performance on prosocial personality and the amount of donation ($p < .05$, Bonferroni corrected).

For the ANOVA analyses, the Greenhouse-Geisser correction for non-sphericity of the data was applied as necessary. The uncorrected degrees of freedom and corrected p-values were reported. The significance level was set at 0.05.

RESULTS

Behavioral results

The amount of donation

The mean number that participants wanted to donate was 24.62 ¥ (SD = 15.70, range from 0 to 50 ¥), and 50 ¥ was the monetary compensation for participating in the study.

Behavioral results of IAT effect

The paired t-test for accuracy showed a significant difference between conditions (t (20) = 5.59, $p < .001$), revealing that participants performed better in the congruent condition (M = 98.57%, SD = 1.69) than in the incongruent condition (M = 94.76%, SD = 2.95) (Figure 1).

The mean response times of correct responses were computed. The paired t-test also revealed a significant condition difference (t (20) = 6.68, $p < .001$), with longer response times for incongruent trials (M = 746.00 ms, SD = 125.13) than for congruent trials (M = 586.02 ms, SD = 74.72) (Figure 1). These results provided evidence of the expected IAT effect.

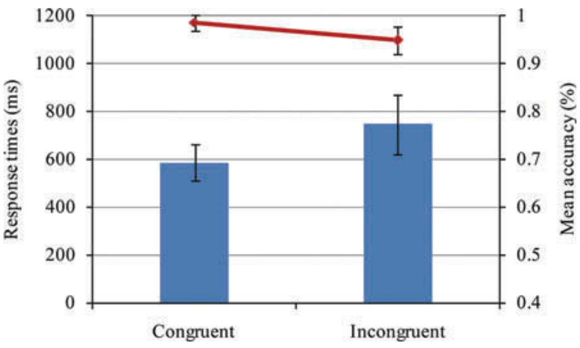

Figure 1. Behavioral performance. Mean (and standard deviation) response times (blue bars) and mean (and standard deviation) accuracy (red lines) shown for congruent and incongruent trials.

ERP results

The grand average ERPs of nine selected electrodes elicited by correct congruent and incongruent trials are depicted in Figure 2. Visual inspection of the ERP responses showed that, approximately 250 ms after stimulus onset, the ERPs for the incongruent trials were more negative than those for the congruent trials. This effect continued to approximately 400 ms, which was visibly maximal over frontalcentral regions. Beginning at approximately 400 ms and continuing until approximately 650 ms, the ERP waveforms became more positive, which was reflected in more positive ERPs for congruent trials than for incongruent trials. There was

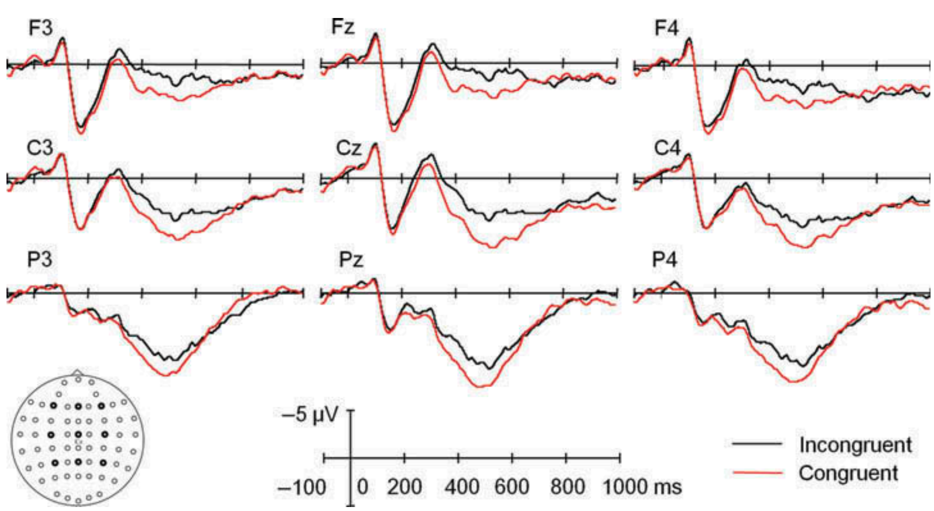

Figure 2. Grand average ERP waveforms evoked by congruent and incongruent trials at selected electrodes, which are indicated by the insert.

no obvious ERP difference between the congruent and incongruent conditions during the late time window.

N1 (80–150 ms)

ANOVA analyses of the data from 80 to 150 ms revealed a main effect of region ($F(2, 40) = 4.58$, $p = .039$, partial $\eta^2 = .19$). Pairwise comparisons revealed a more negative N1 component at the frontal and central regions than at the parietal region (ps < .05, Figure 2). No other significant main effects or interactions involving condition were found.

P2 (150–250 ms)

ANOVA analyses of the data from 150 to 250 ms also revealed a main effect of region ($F(2, 40) = 13.97$, $p < .001$, partial $\eta^2 = .41$). Pairwise comparisons revealed larger P2 amplitudes at the frontal and central regions than at the parietal region (ps < .01, Figure 2). No other significant main effects or interactions involving condition were found.

N2 (250–400 ms)

ANOVA analyses of this time window revealed a main effect of condition ($F(1, 20) = 4.91$, $p = .038$, partial $\eta^2 = .20$), as seen in Figure 2, indicating more negative N2 components for the incongruent condition than for the congruent condition. The main effect of region was significant ($F(2, 40) = 17.32$, $p < .001$, partial $\eta^2 = .46$). Pairwise comparisons revealed more negative N2 components at the frontal and central regions than at the parietal region (ps < .001). No other significant main effects or interactions involving condition were found. Figure 3A illustrates the topographic distribution of the N2 effects during this time window.

P300 (400–650 ms)

ANOVA analyses of the data from 400 to 650 ms revealed a main effect of condition ($F(1, 20) = 16.62$, $p = .001$, partial $\eta^2 = .45$), as seen in Figure 2, verifying that the congruent trials evoked a more positive P300 component than did the incongruent trials. The main effect of region was significant ($F(2, 40) = 24.19$, $p < .001$, partial $\eta^2 = .55$). Pairwise comparisons revealed larger P300 amplitudes for the parietal and central regions than for the frontal region (ps < .001). No other significant main effects or interactions involving condition were found. Figure 3B illustrates the topographic distribution of the P300 effects during this time window.

Correlation analyses

First, the correlations between the behavioral IAT effect (response time differences across conditions) and prosocial personality and prosocial behavior were calculated. No significant correlation between these variables was found.

Second, we conducted the correlation analyses between ERP effects (amplitude differences across conditions) during the N2 and P300 time windows at three scalp regions and the behavioral IAT effect. Unfortunately, we found no significant correlations for any ERP effects at any scalp regions.

Lastly, the relationships between N2 effect and prosocial personality and the amount of donation

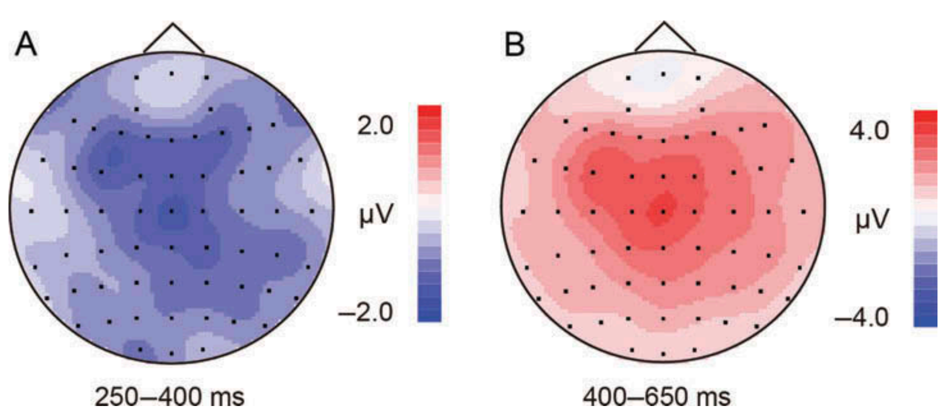

Figure 3. Topographical maps. Panel A shows the topographic distribution of N2 effects during the 250–400 ms time window, which were formed by subtracting the ERPs of correct congruent trials from the ERPs of correct incongruent trials. Panel B shows the topographic distribution of P300 effects during the 400–650 ms time window, which were formed by subtracting the ERPs of correct incongruent trials from the ERPs of correct congruent trials. The scale bar shows the amplitude range.

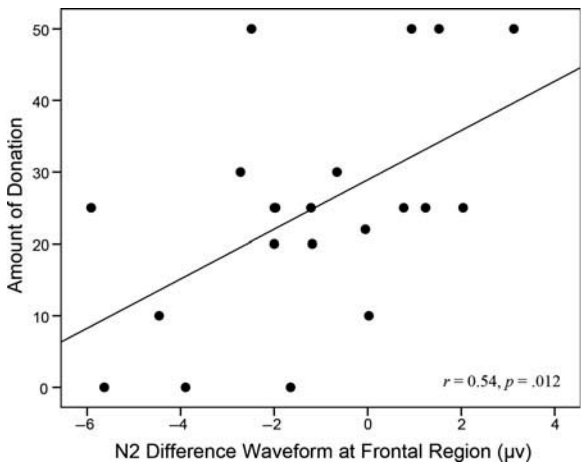

Figure 4. Scatterplot shows the relationship between N2 difference waveforms (incongruent minus congruent condition) at the frontal region and the amount of donation.

were examined. During the time window of 250 to 400 ms, correlation analyses showed significantly positive correlations between N2 amplitude differences at the frontal region and the amount of donation ($r = 0.54$, $p = .012$ at a Bonferroni corrected threshold of .017 (.05/3)) (See Figure 4 for the scatterplot). The correlations between P300 effect and prosocial personality and the amount of donation were also calculated. During the time window of 400 to 650 ms, correlation analyses revealed that P300 amplitude differences were neither significantly related to prosocial personality nor to the amount of donation at any scalp region.

DISSCUSSION

In the present study, we examined the neural correlates of implicit prosocial attitude by analyzing the ERPs correlates of the prosocial attitude IAT. Behaviorally, we observed the typical IAT effect, characterized by faster responses for congruent trials than for incongruent trials. The ERP results revealed a more negative N2 component for the incongruent condition than for the congruent condition and a more positive P300 component for the congruent condition than for the incongruent condition. Moreover, significant correlation between N2 amplitude differences and the amount of donation was observed. These findings will in turn be discussed.

In line with previous work using other types of IAT paradigms (Fleischhauer et al., 2014; Maison et al., 2004; van Nunspeet, Ellemers, Derks, & Nieuwenhuis, 2014; Wilson & Scior, 2014), we obtained a typical IAT effect. As noted above, the IAT effect hypothesis is that the stronger the association between target and attribute categories, the more quickly task switching occurs (Greenwald et al., 2009); in our study, the faster responses for categorizing self-related words and prosocial-related words into the same key suggested that individuals had a positive attitude toward their prosociality. Unfortunately, we did not find a significant correlation between the behavioral performance of the prosocial IAT and the amount of donation. Although the meta-analysis studies suggest that the IAT is a valid method and has been used in many areas including prosocial domain (Greenwald et al., 2009; Jiang et al., 2008; Nosek et al., 2011; Rezaei, 2011; Wilson & Scior, 2014), with respect to the exact relationship between IAT measure and actual behavior, up to now, a consistent conclusion could not be made (Azar, 2008; Karpinski, Steinman, & Hilton, 2005; Nosek & Smyth, 2007). Therefore, further studies are needed in the future.

Interestingly, with respect to ERP results, we did not observe early ERP modulations in the present study (Figure 2). Early ERP amplitude differences across conditions were found in the only preceding study of the personality IAT measuring neuroticism (Fleischhauer et al., 2014). The differences between the present findings and those of Fleischhauer et al. -(2014) potentially may derive in part from differences in materials. Previous ERP studies have demonstrated that early ERPs' components exhibited larger amplitudes for emotional stimuli than for neutral stimuli, indicating that emotional stimuli involve more early attentional processing than neutral stimuli due to their high arousal levels (Eimer & Holmes, 2007; Olofsson, Nordin, Sequeira, & Polich, 2008). In the present study, the prosocial-related stimuli may have lower arousal levels than the stimuli of the attribute categories associated with emotional states in the IAT measuring neuroticism, which thus did not induce the early ERP effects. The present findings suggest that congruent trials did not trigger an enhanced early selective attentional and perceptual facilitation when compared with incongruent trials in the prosocial attitude IAT.

ERP amplitude differences initially emerged between 250 and 400 ms post-stimulus onset, corresponding with the N2 component distributed mainly at the frontalcentral regions, which was characterized by increased amplitudes for incongruent condition when compared with those for congruent condition. The N2 component has been thought to reflect response-conflict monitoring and executive cognitive control, and its neural source is located in the anterior cingulate cortex (ACC, Folstein & Van

Petten, 2008; Nieuwenhuis, Yeung, Wildenberg, & Ridderinkhof, 2003; Yeung et al., 2004). In social neuroscience research, the N2 is a widely observed component (Ibanez et al., 2012) and is sensitive to the detection and monitoring of social stimulus conflict (Nieuwenhuis, Holroyd, Mol, & Coles, 2004). For example, N2 effects were observed when stimuli conflicted with personal expectations (Folstein & Van Petten, 2008; Yeung et al., 2004). In ERP studies of IAT task, the effects of congruency on the N2 component were also observed. Coates and Campbell (2010) reported the effects of congruency on the N2 component for the parietal and occipital electrode sites between 350 and 400 ms. In contrast with these findings, the present study provided evidence of the effects of congruency on typical N2 deflection at the frontalcentral regions. The enhanced N2 amplitude for the incongruent trials may suggest greater response conflict in the incongruent condition, indicating that individuals consider themselves prosocial in their implicit self-evaluation.

ERP amplitude differences across conditions were also observed for the centralparietal P300 component between 400 and 650 ms. These findings agree with previous IAT studies that reported an increased P300 amplitude for congruent trials when compared with incongruent trials (Coates & Campbell, 2010; O'Toole & Barnes-Holmes, 2009; Williams & Themanson, 2011). The amplitude of the P300 component was shown to be associated with the extent of attentional resource allocation during stimuli evaluation and categorization processes, with more positive P300 components observed for task-relevant stimuli (Polich, 2007). In addition, the P300 showed amplitude modulation by the motivational significance of the stimuli; for instance, emotional stimuli evoked larger P300 amplitudes than neutral stimuli (Ferrari, Codispoti, Cardinale, & Bradley, 2008; Nieuwenhuis, Aston-Jones, & Cohen, 2005; Schupp, Flaisch, Stockburger, & Junghofer, 2006). Most importantly, the P300 can also be used as an index of attentional resource allocation for self-relevant stimuli, reflected by the augmented P300 for self-relevant stimuli relative to control stimuli (Gray, Ambady, Lowenthal, & Deldin, 2004). Our finding of enhanced P300 amplitude for the congruent condition may suggest that the self- and prosocial-related word pairings are closely associated with each other. In other words, the finding of enhanced P300 may indicate that the prosocial-related words are more likely deemed to be self-related characteristics. According to the reflective-impulsive model, if two aspects of a procedure are activated repeatedly in the impulsive system, the joint activation will establish an associative link between these two aspects. The link will then be stored in memory and retrieved in an automatic way (Strack & Deutsch, 2004). This model may help explain why the self- and prosocial-related word pairings are closely associated with each other.

Moreover, with respect to why more attentional resources were allocated to the congruent condition, the following aspects might be considered. On the one hand, stimuli that are closely related to the self are associated with greater degree of emotionality (Gray et al., 2004); on the other hand, the self- and prosocial-related word pairings may have more important social significance because of the social attributes of human beings. Both of these aspects may make the self- and prosocial-related word pairings motivationally significant stimuli and thus induce more attentional resource allocation to congruent trials. In brief, the P300 effects in the present study provide further evidence that people have implicit prosocial attitude.

The correlation analysis results showed that N2 amplitude differences between the incongruent and congruent conditions were positively correlated with the amount of donation. The positive correlation suggests that people who behave more prosocially exhibit higher-level conflict monitoring during stimuli categorization. Previous studies have assessed the predictive validity of implicit attitudes in relation to behavior (Arcuri et al., 2008; Greenwald et al., 2009; Huntjens et al., 2014); however, to our knowledge, the present findings are the first to show a direct link between the ERP correlates of the prosocial attitude IAT task and the actual prosocial behavior. These findings suggest the role of the ERP effects of implicit prosocial attitude in predicting individual prosocial behavior.

Another issue that should be noted is that, we did not find significant correlations between the ERPs results and behavioral performance (i.e., the response time differences). The underlying reasons for these findings are not clear. Because of the limited trials, we cannot closely examine the ERP-behavior relationships on a single level, for example, the "self-prosocial" versus "self-non-prosocial" level or "others-non-prosocial" versus "others-prosocial" level. From this perspective, inadequate trials for each level in both conditions indeed limit the present study. Future research should increase the number of trials in each condition to allow closer examination of the ERP effects of the prosocial attitude IAT, for example, ERP differences among four types of pairings in congruent and incongruent conditions, and then examine the relationships between ERP amplitude differences and behavioral IAT effects in detail.

In summary, the present study examined the neural correlates of the prosocial attitude IAT with ERPs. Our findings show that individuals have implicit prosocial attitude and that the IAT task involves conflict monitoring and stimulus categorization processes. In addition, ERP amplitude differences are associated with individual actual prosocial behavior. These findings provide detailed information about the temporal dynamics of the prosocial attitude IAT task and have important implications for understanding the relationships between implicit prosocial attitude and prosocial behavior.

Original manuscript received 27 June 2014
Revised manuscript accepted 27 December 2014
First published online 26 January 2015

REFERENCES

Arcuri, L., Castelli, L., Galdi, S., Zogmaister, C., & Amadori, A. (2008). Predicting the vote: Implicit attitudes as predictors of the future behavior of decided and undecided voters. *Political Psychology*, *29*(3), 369–387. doi:10.1111/j.1467-9221.2008.00635.x

Azar, B. (2008). IAT: Fad or fabulous? *Monitor in Psychology*, *39*(7), 44.

Balconi, M., & Canavesio, Y. (2013). Prosocial attitudes and empathic behavior in emotional positive versus negative situations: Brain response (ERPs) and source localization (LORETA) analysis. *Cognitive Processing*, *14*(1), 63–72. doi:10.1007/s10339-012-0525-1

Balconi, M., & Canavesio, Y. (2014). High-frequency rTMS on DLPFC increases prosocial attitude in case of decision to support people. *Social Neuroscience*, *9*(1), 82–93. doi:10.1080/17470919.2013.861361

Batson, C. D., & Powell, A. A. (2003). Altruism and prosocial behavior. In I. B. Weiner (Series Ed.), T. Millon & M. J. Lerner (Vol. Eds.), *Handbook of psychology: Personality and social psychology* (Vol. 5, pp. 463–484). Hoboken, NJ: Wiley.

Carpenter, M., Uebel, J., & Tomasello, M. (2013). Being mimicked increases prosocial behavior in 18-month-old infants. *Child Development*, *84*(5), 1511–1518. doi:10.1111/cdev.12083

Cheung, P. C., Ma, H. K., & Shek, D. T. L. (1998). Conceptions of success: Their correlates with prosocial orientation and behaviour in Chinese adolescents. *Journal of Adolescence*, *21*(1), 31–42. doi:10.1006/jado.1997.0127

Coates, M. A., & Campbell, K. B. (2010). Event-related potential measures of processing during an implicit association test. *Neuroreport*, *21*(16), 1029–1033. doi:10.1097/WNR.0b013e32833f5e7d

Colzato, L. S., Hommel, B., Van Den Wildenberg, W., & Hsieh, S. (2010). Buddha as an eye opener: A link between prosocial attitude and attentional control. *Frontiers in Psychology*, *1*. doi:10.3389/fpsyg.2010.00156

Doyle, M. C., Rugg, M. D., & Wells, T. (1996). A comparison of the electrophysiological effects of formal and repetition priming. *Psychophysiology*, *33*(2), 132–147. doi:10.1111/j.1469-8986.1996.tb02117.x

Eimer, M., & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia*, *45*(1), 15–31. doi:10.1016/j.neuropsychologia.2006.04.022

Fehr, E., & Fischbacher, U. (2003). The nature of human altruism. *Nature*, *425*(6960), 785–791.

Ferrari, V., Codispoti, M., Cardinale, R., & Bradley, M. M. (2008). Directed and motivated attention during processing of natural scenes. *Journal of Cognitive Neuroscience*, *20*(10), 1753–1761. doi:10.1162/jocn.2008.20121

Fleischhauer, M., Strobel, A., Diers, K., & Enge, S. (2014). Electrophysiological evidence for early perceptual facilitation and efficient categorization of self-related stimuli during an implicit association test measuring neuroticism. *Psychophysiology*, *51*(2), 142–151. doi:10.1111/psyp.12162

Folstein, J. R., & Van Petten, C. (2008). Influence of cognitive control and mismatch on the N2 component of the ERP: A review. *Psychophysiology*, *45*(1), 152–170. doi:10.1111/j.1469-8986.2007.00602.x

Gray, H. M., Ambady, N., Lowenthal, W. T., & Deldin, P. (2004). P300 as an index of attention to self-relevant stimuli. *Journal of Experimental Social Psychology*, *40*(2), 216–224. doi:10.1016/S0022-1031(03)00092-1

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The implicit association test. *Journal of Personality and Social Psychology*, *74*(6), 1464–1480. doi:10.1037/0022-3514.74.6.1464

Greenwald, A. G., Poehlman, T. A., Uhlmann, E. L., & Banaji, M. R. (2009). Supplemental material for understanding and using the implicit association test: III. Meta-analysis of predictive validity. *Journal of Personality and Social Psychology*, *97*, 17–41. doi:10.1037/a0015575

Hofmann, W., Gawronski, B., Gschwendner, T., Le, H., & Schmitt, M. (2005). A meta-analysis on the correlation between the implicit association test and explicit self-report measures. *Personality and Social Psychology Bulletin*, *31*(10), 1369–1385. doi:10.1177/0146167205275613

Huntjens, R. J., Rijkeboer, M. M., Krakau, A., & De Jong, P. J. (2014). Implicit versus explicit measures of self-concept of self-control and their differential predictive power for spontaneous trait-relevant behaviors. *Journal of Behavior Therapy and Experimental Psychiatry*, *45*(1), 1–7. doi:10.1016/j.jbtep.2013.07.001

Ibanez, A., Melloni, M., Huepe, D., Helgiu, E., Rivera-Rei, A., Canales-Johnson, A., & Moya, A. (2012). What event-related potentials (ERPs) bring to social neuroscience? *Social Neuroscience*, *7*(6), 632–649. doi:10.1080/17470919.2012.691078

Jiang, D., Wang, X. R., Fu, L., & Zhou, R. L. (2008). A study on implicit altruistic behavior. *Psychological Science (In Chinese)*, *5*, 79–82.

Karpinski, A., Steinman, R. B., & Hilton, J. L. (2005). Attitude importance as a moderator of the relationship between implicit and explicit attitude measures. *Personality and Social Psychology Bulletin*, *31*(7), 949–962. doi:10.1177/0146167204273007

Luck, S. J., Woodman, G. F., & Vogel, E. K. (2000). Event-related potential studies of attention. *Trends in Cognitive Sciences*, *4*(11), 432–440. doi:10.1016/S1364-6613(00)01545-X

Maison, D., Greenwald, A. G., & Bruin, R. H. (2004). Predictive validity of the implicit association test in studies of brands, consumer attitudes, and behavior. *Journal of Consumer Psychology*, *14*(4), 405–415. doi:10.1207/s15327663jcp1404_9

Nieuwenhuis, S., Aston-Jones, G., & Cohen, J. D. (2005). Decision making, the P3, and the locus coeruleus–norepinephrine system. *Psychological Bulletin*, *131*(4), 510–532. doi:10.1037/0033-2909.131.4.510

Nieuwenhuis, S., Holroyd, C. B., Mol, N., & Coles, M. G. H. (2004). Reinforcement-related brain potentials from medial frontal cortex: Origins and functional significance. *Neuroscience and Biobehavioral Reviews*, *28*(4), 441–448. doi:10.1016/j.neubiorev.2004.05.003

Nieuwenhuis, S., Yeung, N., Wildenberg, W., & Ridderinkhof, K. R. (2003). Electrophysiological correlates of anterior cingulate function in a go/no-go task: Effects of response conflict and trial type frequency. *Cognitive, Affective, and Behavioral Neuroscience*, *3*(1), 17–26. doi:10.3758/CABN.3.1.17

Nosek, B. A., Hawkins, C. B., & Frazier, R. S. (2011). Implicit social cognition: From measures to mechanisms. *Trends in Cognitive Sciences*, *15*(4), 152–159. doi:10.1016/j.tics.2011.01.005

Nosek, B. A., & Smyth, F. L. (2007). A multitrait-multimethod validation of the implicit association test: Implicit and explicit attitudes are related but distinct constructs. *Experimental Psychology (Formerly "Zeitschrift Für Experimentelle Psychologie")*, *54*(1), 14–29. doi:10.1027/1618-3169.54.1.14

O'Toole, C., & Barnes-Holmes, D. (2009). Electrophysiological activity generated during the implicit association test: A study using event-related potentials. *Psychological Record*, *59*(2), 207–219.

Olofsson, J. K., Nordin, S., Sequeira, H., & Polich, J. (2008). Affective picture processing: An integrative review of ERP findings. *Biological Psychology*, *77*(3), 247–265. doi:10.1016/j.biopsycho.2007.11.006

Paciello, M., Fida, R., Cerniglia, L., Tramontano, C., & Cole, E. (2013). High cost helping scenario: The role of empathy, prosocial reasoning and moral disengagement on helping behavior. *Personality and Individual Differences*, *55*(1), 3–7. doi:10.1016/j.paid.2012.11.004

Penner, L. A. (2002). Dispositional and organizational influences on sustained volunteerism: An interactionist perspective. *Journal of Social Issues*, *58*(3), 447–467. doi:10.1111/1540-4560.00270

Penner, L. A., Dovidio, J. F., Piliavin, J. A., & Schroeder, D. A. (2005). Prosocial behavior: Multilevel perspectives. *Annual Review of Psychology*, *56*, 365–392. doi:10.1146/annurev.psych.56.091103.070141

Polich, J. (2007). Updating P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology*, *118*(10), 2128–2148. doi:10.1016/j.clinph.2007.04.019

Rand, D. G., Greene, J. D., & Nowak, M. A. (2012). Spontaneous giving and calculated greed. *Nature*, *489*(7416), 427–430. Retrieved from http://www.nature.com/nature/journal/v489/n7416/abs/nature11467.html#supplementary-information

Rezaei, A. R. (2011). Validity and reliability of the IAT: Measuring gender and ethnic stereotypes. *Computers in Human Behavior*, *27*(5), 1937–1941. doi:10.1016/j.chb.2011.04.018

Schupp, H. T., Flaisch, T., Stockburger, J., & Junghofer, M. (2006). Emotion and attention: Event-related brain potential studies. *Progress in Brain Research*, *156*, 31–51. doi:10.1016/s0079-6123(06)56002-9

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review*, *8*(3), 220–247. doi:10.1207/s15327957pspr0803_1

Van Lange, P. A. M., Bekkers, R., Schuyt, T. N. M., & Vugt, M. V. (2007). From games to giving: Social value orientation predicts donations to noble causes. *Basic and Applied Social Psychology*, *29*(4), 375–384. doi:10.1080/01973530701665223

van Nunspeet, F., Ellemers, N., Derks, B., & Nieuwenhuis, S. (2014). Moral concerns increase attention and response monitoring during IAT performance: ERP evidence. *Social Cognitive and Affective Neuroscience*, *9*(2), 141–149. doi:10.1093/scan/nss118

Vogel, E. K., & Luck, S. J. (2000). The visual N1 component as an index of a discrimination process. *Psychophysiology*, *37*(2), 190–203. doi:10.1111/1469-8986.3720190

Williams, J. K., & Themanson, J. R. (2011). Neural correlates of the implicit association test: Evidence for semantic and emotional processing. *Social Cognitive and Affective Neuroscience*, *6*(4), 468–476. doi:10.1093/scan/nsq065

Wilson, M. C., & Scior, K. (2014). Attitudes towards individuals with disabilities as measured by the implicit association test: A literature review. *Research in Developmental Disabilities*, *35*(2), 294–321. doi:10.1016/j.ridd.2013.11.003

Yeung, N., Botvinick, M. M., & Cohen, J. D. (2004). The neural basis of error detection: Conflict monitoring and the error-related negativity. *Psychological Review*, *111*(4), 931–959. doi:10.1037/0033-295x. 111.4.931