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Social value orientation modulates behavioral and neural responses to social influence

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Abstract

Substantial studies have investigated the social influence effect; however, how individuals with different social value orientations (SVOs), prosocials and proselfs, respond to different social influences remains unknown. This study examines the impact of positive and negative social information on the responses of people with different SVOs. A face-attractiveness assessment task was employed to investigate the relationships between influence probability, memory, and event-related potentials of social influence. A significant interactional effect suggested that prosocials and proselfs reacted differently to positive (group rating was more attractive) and negative (group rating was less attractive) social influences. Specifically, proselfs demonstrated significantly higher influence probability, marginally better recall performance, smaller N400, and larger late positive potential on receiving negative influence information than on receiving positive influence information, while prosocials showed no significant differences. Overall, correlations between N400/LPP, influence probability, and recall performance were significant. The above results indicate the modulating role of SVO when responding to social influence. These findings have important implications for understanding how people conform and how prosocial behavior occurs.

KEYWORDS
conformity, event-related potential, recall bias, social influence, social value orientation

1 | INTRODUCTION

People are constantly influenced by the social environment in which they live. The phenomenon of being influenced by others to change one's attitude or behavior and conform to that of others is called social conformity (Cialdini & Goldstein, 2004). In ambiguous situations, conformity can, on the one hand, increase the correctness of decisions; on the other hand, remaining consistent with others can result in social acceptance, thus maintaining good social relations and improving the sense of belonging (Cialdini & Goldstein, 2004; Mahmoodi et al., 2022; Panizza et al., 2021; Toelch & Dolan, 2015). However, the social influence information received by individuals may be positive or negative. Laboratory studies have found that generous or stingy donations from others can increase or reduce the number of individual donations, respectively (Chierchia et al., 2020; Nook et al., 2016; Wei et al., 2017), proving that positive and negative information influence people differently.

Related studies have shown that individual conformity may be influenced by personal preferences, and that individuals are more susceptible to behaviors that are consistent with their preferences (Chung et al., 2015; Feng et al., 2018). Individuals with high-risk preferences engage in more conformity behaviors under the influence of others' risk-taking behaviors. In contrast, those with low-risk preferences show more engagement in more conformity behaviors under the influence of others' risk-adverse behaviors (Chung et al., 2015). Until now, few studies have explored whether conformity preference for positive/negative information is moderated by individual personality traits.

Social value orientation (SVO) is often used to describe individuals' prosocial preferences during social interactions (Pletzer et al., 2018; Qi, Wu, et al., 2017). As a stable personality trait, SVO is often divided into two types: prosocial and proself (Cornelissen et al., 2011; Murphy et al., 2011; Van Lange, 1999). Individuals with prosocial SVO (prosocials) prefer to maximize collective interests, whereas individuals with proself SVO (proselfs) pay more attention to their own interests (Pletzer et al., 2018; Sul et al., 2015; Van Lange, 1999). This inherent motivational difference may further influence their conformity to positive or negative social information, the former encouraging helpfulness and mutual benefit, while the latter is characterized by selfishness and self-benefit (Nook et al., 2016; Van Assche et al., 2018).

The underlying mechanism of conformity behavior is associated with a learning process of other's behaviors or attitudes (Toelch & Dolan, 2015). It follows that the amount of learning is reflected in how much individuals remember about other's behaviors (Korn et al., 2012; Rouhani & Niv, 2019; Vijayalakshmi & Patchainayagi, 2020). While most studies limited their attention to behavioral changes (conformity or not) when inconsistency between self and others exists (Feng et al., 2018; Huang et al., 2014), few studies have focused on how information retention is subjected to social influence. Previous researchers have found that people are more likely to remember events related to their own states, exhibiting self-referent recall bias (Klein, 2012; Symons & Johnson, 1997). For example, depressed individuals exhibit better memory for negative memories than for positive memories (Gaddy & Ingram, 2014; Matt et al., 1992). These findings suggest that prosocials may memorize positive information or norms more readily, while proselfs tend to memorize negative information or norms. Thus, SVO may influence both the conformity to social information and the recall performance of such information.

The neural mechanisms of social influence have been identified in the past (Do et al., 2020; Feng et al., 2018; Wu et al., 2016). For instance, on the one hand, greater activation in the reward system (such as the striatum) was found when one's behavior was consistent with that of a group (Campbell-Meiklejohn et al., 2010; Do et al., 2020; Mahmoodi et al., 2022). On the other hand, brain regions involved in conflict processing, such as the anterior cingulate cortex and insula, showed activation when one's behavior deviated from that of the group (Klucharev et al., 2009; Mahmoodi et al., 2022; Wu et al., 2016; Zhang & Gläscher, 2020). Besides, corresponding electroencephalography (EEG) studies have also found that event-related potentials (ERPs) show greater amplitude when one's behavior is inconsistent with that of others (Chen et al., 2012; Feng et al., 2018; Huang et al., 2014; Kim et al., 2012; Shestakova et al., 2012). N400 is a prominent component of ERPs, specifically a negative-going deflection (the absolute value needs not be negative) that peaks around 400 ms post-stimulus onset and occurs across a variety of semantic tasks when unexpected linguistic stimuli are detected (Hagoort, 2003; Kutas & Federmeier, 2011; Kutas & Hillyard, 1980). Several studies have shown that N400 is also observed in social tasks involving unexpected or incongruent social information (Feng et al., 2018; Huang et al., 2014; Mu et al., 2015; Salvador et al., 2020; White et al., 2009), reflecting a deviation from expectations (Kutas & Federmeier, 2011). Furthermore, the late positive potential (LPP) is a positive wave distributed in the parietal lobe and related to motivational salience (Glazer et al., 2018; Hajcak & Foti, 2020). Greater LPP is induced when there is little or no conflict between one's views or behaviors and those of the group (Zheng et al., 2021), representing an integration of others' views into one's value coding (i.e., informational conformity) (Thiruchselvam et al., 2017). Taken together, if prosocials and proselfs have different preferences for social information, the presentation of positive versus negative social information should induce distinct impacts on N400 and LPP in the two groups.

To put it in a nutshell, this study examined how people with different SVOs respond to positive and negative social influence information. Specifically, we measured conformity, recall performance, and EEG responses. Our experiment first asked participants to rate facial attractiveness before they were presented with the average ratings of most people in their group (group rating). After seeing the group rating, participants rated the face again (Klucharev et al., 2009). Face-attractiveness assessment is highly subjective and easily influenced by others (Klucharev et al., 2009; Zaki et al., 2011), which makes it suitable for examining conformity behavior in the laboratory. Moreover, face attractiveness is an important part of self-evaluation or self-esteem (Bale & Archer, 2013; Oikawa et al., 2012). Thus, a higher attractiveness rating of majority represents the intention of maintenance and improvement of others' self-esteem with a more friendly and positive attitude, whereby it is defined as positive information/social influence. In contrast, a lower attractiveness rating of majority indicates a debasement of others' self-esteem, signaling a more negative attitude, which we defined as negative information/social influence.

We hypothesized that prosocials may show more conformity behavior and better recall performance of others' more positive ratings, whereas proselfs demonstrate similar patterns in regard to more negative ratings. Regarding ERP indicators, group-rating type and SVO may interact on N400 and LPP. For proselfs, more positive group ratings should induce larger N400 and smaller LPP than more negative group ratings. In contrast, for prosocials, more negative group ratings should induce larger N400 and smaller LPP. We also expected overall correlations between conformity behavior, recall performance, and ERP indicators, conveying the associations between behavioral, cognitive, and neurobiological processing.

2 | METHODS

2.1 | Participants

Three to 5 days before the formal experiment, participants were screened using the online SVO slider measure (Murphy et al., 2011).

The measure comprised six items involving monetary allocation between the self and others. Participants were asked to choose their preferred split (e.g., 50–40, 40–60) from a list of nine consecutive options (Figure 1a). Following Murphy et al. (2011), participants with scores >22.45° were classified as prosocials, and those with scores ≤22.45° were classified as proselfs. The chosen measure has been validated in a Chinese sample as an SVO quantifier with high reliability and excellent convergent validity (Qi et al., 2018; Zhang et al., 2015). The sample size was determined by G*Power 3.1 with a medium effect size ($f = 0.25$), and statistical power $= 0.95$ was fulfilled by recruiting 54 participants with 27 participants in each group (Cohen, 1992; Faul et al., 2007). In total, 58 participants were recruited for the experiment. Two participant's data was excluded. One was for the inconsistency of the SVO type measured at the initial screening and tested on the day of the experiment. Another participant, whose SVO score was near the cut-off value, was also out of analysis. Eventually, 56 participants (20.75 ± 1.99 years old, 29 males) were left. In the behavioral data, two participants' data were accidently covered, and the final dataset had 26 prosocials (19.88 ± 1.42 years old, 14 males), and 28 proselfs (21.57 ± 2.19 years old, 15 males). As for the recall performance, one participant's data was overwritten unintendedly, explaining a slight difference in the degree of freedom for the corresponding data analysis. In the EEG data, 3 participants were excluded because of the electrode cap failure, and there were 26 prosocials (20.00 ± 1.37 years old, 13 males) and 27 proselfs (21.52 ± 2.14 years old, 14 males) in the final analysis. All participants were right-handed, with normal or corrected-to-normal vision and no history of neurological or psychological disorders. All participants signed the informed consent form before the experiment began and received the corresponding fee for the participation. The experiment procedure was approved by the Academic Ethics Committee of Zhengzhou University.

2.2 | Stimuli

We first selected 200 faces (100 females, 100 males) with neutral expressions from the Chinese Facial Affective Picture System (CFAPS) (Gong et al., 2011) and standardized the faces by removing significant facial features (e.g., moles, birthmarks) (Qi, Gu, et al., 2017). An additional 26 undergraduate students (15 males) were recruited to rate the faces on a scale of "1" (unattractive) to "7" (attractive). Finally, 120 faces with moderate attractiveness ($M = 3.55$, $SD = 0.48$) were selected as experimental materials.

2.3 | Procedure

Participants first completed the SVO Slider Measure (Murphy et al., 2011; Zhang et al., 2015), State–Trait Anxiety Inventory (STAI)

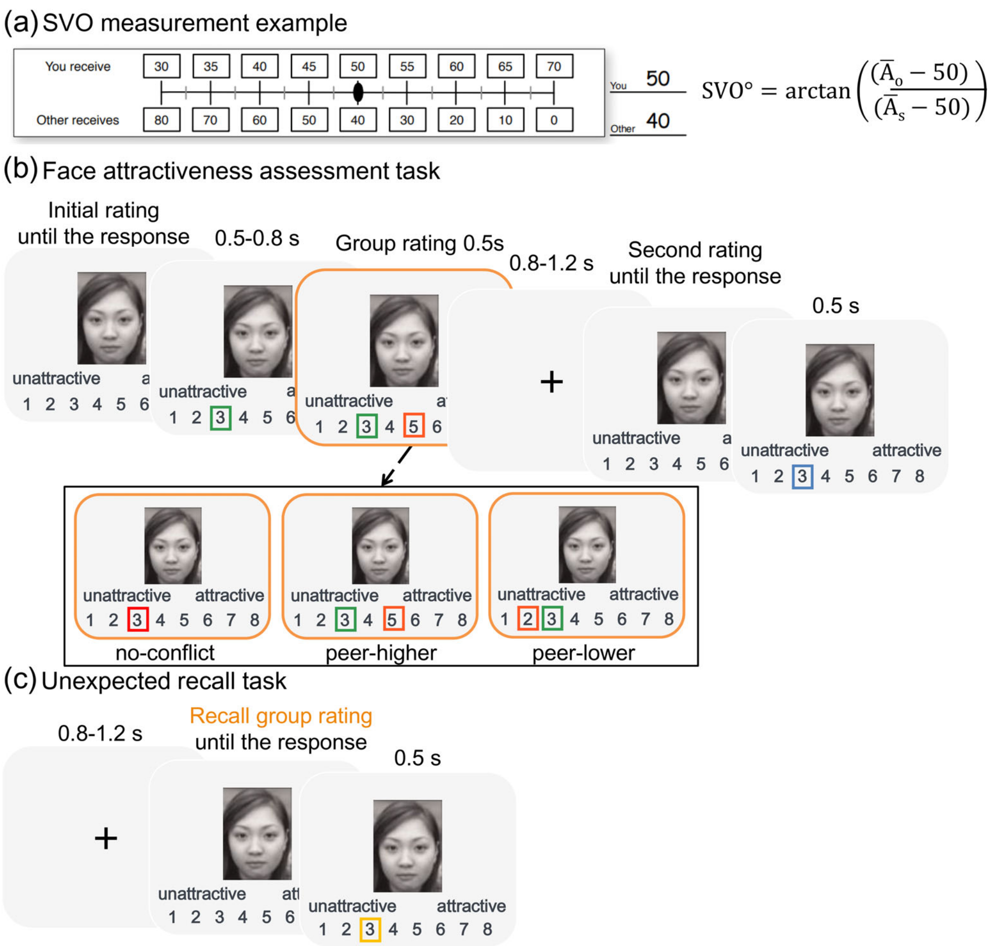

FIGURE 1 (a) An example of the SVO slider measurement and its calculation formula. (b) Example of a single trial in face-attractiveness assessment task. The green box and blue box are the initial and second ratings of the participants respectively, and the red box is group rating. The difference between group rating and participants' rating is between ±3, resulting in three conditions: no-conflict, peer-higher, and peer-lower. The face-attractiveness assessment task was completed in ERP recording, and the orange box interface was the stimulus interface where we focused on the EEG component changes. (c) Example of a single trial in unexpected recall task. The orange box is the group rating recalled by participant.

(Spielberger, 1983), Patient Health Questionnaire-9 (PHQ-9) (Kurt Kroenke et al., 2002), Liebowitz social anxiety scale (LSAS) (Liebowitz, 1987), and self-esteem scale (SES) (Rosenberg, 2015). These questionnaires were adopted to ensure that the trait anxiety, state anxiety, depression, social anxiety, and self-esteem scores of prosocials and proselfs matched, as well as their differences in SVO. Thereafter, they completed the face-attractiveness assessment task (Klucharev et al., 2009), which comprised 120 trials. Before the face attractiveness assessment, the participants were informed that they would participate in a large sample study of facial attractiveness that had already been done by many students. Participants were required to rate the attractiveness of faces on a scale of 1–8 (initial rating, *R1*), with "1" being unattractive and "8" being attractive. At 0.5–0.8 s after participant reaction, the group rating was presented as the average rating from other students, and participants rated the same face again (*R2*) (Figure 1b). In fact, the group rating was generated through an experimental procedure, with a difference of ±3 from the participants' initial score. In the experiment, there was approximately a 33% probability that the group rating was the same as the participants' rating (*no conflict*), a 33% probability that the group rating was higher than the participants' rating (*peer-higher*), and a 33% probability that the group rating was lower than the participants' rating (*peer-lower*). Five to 10 min after completing the first phase of the experiment, the participants were asked to perform an unexpected recall task to recall the group ratings of faces in the first session (Figure 1c).

2.4 | Data recording and analysis

Stimulus presentation and recording of behavioral data were performed using E-Prime software (Version 2.0, Psychology Software Tools, Inc.). EEG data were collected during the face-attractiveness assessment task, using the Neuroscan Synamps2 EEG recording and analysis system. The EEG was recorded using 64 Ag/AgCl electrodes in an elastic cap, using the International Standard 10–20 system. Vertical and horizontal EEG were recorded during data acquisition, using the Neuroscan electrode cap and with its own reference electrode as the online reference electrode. EEG data were sampled at 1000 Hz/channel, with impedances lower than 5 kΩ, and the recording bandwidth was from 0.05 to 100 Hz.

Curry 7 was used for offline analysis of EEG data, and the EEG signals were re-referenced to the average bilateral mastoids offline, then low-pass filtered at 30 Hz. In this experiment, we focused on the EEG responses of participants when the group rating was presented. Therefore, the time when the group rating appeared was used as the starting time, 0 ms. The epoch was −200 to 1000 ms, where the first 200 ms before the stimulus was used as baseline correction. Although the epoch during which the participant's original ratings were highlighted was used for baseline correction, the visual inspection of baseline waveforms indicated that they were similar across different experimental conditions. The threshold method was used to remove EOG artifacts from EEG signals (±200 μV as the threshold). Trials exceeding a threshold of ±100 μV were excluded from further analysis. To ensure minimal interference, EOGs were also visually detected. Finally, the average number of valid trials was 35.21 ± 5.87 for the "peer-higher" condition, 27.75 ± 7.71 for the "peer-lower" condition, and 41.08 ± 8.52 for the "no-conflict" condition. Electrodes and time windows were determined by combining previous studies (Feng et al., 2018; Huang et al., 2014; Lau et al., 2008; Zheng et al., 2021) with the averaged EEG diagram obtained here. The topography in present study showed the N400 was more left-oriented, so we selected electrodes in the center and left: FC3, FC1, FCz, C3, C1, Cz, CP3, CP1, and CPz. The average of the mean amplitude in the 390–500 ms across these electrodes was calculated as the indicator of N400. For the LPP, electrodes P1, Pz, and P2 were selected to calculate the mean amplitude in the time window of 550–1000 ms, and the average value of these three electrodes was considered as the indicator of LPP component.

2.5 | Statistical analysis

All behavioral and ERP data were statistically analyzed in the IBM SPSS Statistics version 18. A mixed 2 (SVO: prosocial vs. proself) × 2 (group rating: peer-higher vs. peer-lower) analysis of variance (ANOVA) was used to investigate whether there were differences in conformity and recall performance across SVOs under the influence of different information. The Greenhouse–Geisser correction was conducted to account for sphericity violations whenever appropriate. Pearson's correlation was used to calculate the overall relationship between conformity, recall performance, and ERP indicators of all participants across peer-higher and peer-lower conditions. The partial η^2 and Cohen *d* were used as effect sizes for ANOVA and *t*-test, respectively, and the correlation coefficients were reported with 95% confidence intervals (Cohen, 1992). As previous studies have found that anxiety levels influence individual conformity (Feng et al., 2018; Howell et al., 2010), we included both individual trait and state anxiety scores as covariates in all ANOVAs.

3 | RESULTS

3.1 | Behavioral results

An independent sample *t*-test was performed on the total scores of SVO, STAI, PHQ-9, LSAS, and SES. The results showed no significant difference between prosocials and proselfs in trait anxiety, state anxiety, depression, social anxiety, and self-esteem, except in SVO (Table 1).

3.1.1 | Conformity behavior

To test whether different types of information have affected people's conformity behavior differently, we calculated the change ($R2 - R1$) in individual attractiveness ratings in the presentation of peer-higher, peer-lower, and no-conflict conditions. The one-way repeated measure ANOVA revealed a significant difference between the three conditions, $F(1.18, 62.56) = 98.15$, $p < .001$, $\eta_p^2 = 0.65$. Post-hoc pairwise contrasts revealed that the absolute change in the no-conflict condition ($M = 0.02$, $SD = 0.08$) was significantly smaller than that in the peer-lower condition ($M = -0.29$, $SD = 0.23$) and peer-higher condition ($M = 0.23$, $SD = 0.20$), *ps* <0.001. These results suggest an effect of social influence for both positive and negative information. In the next section, we focused on whether there was a modulation effect of SVO on conformity under different social norms.

We calculated the influence probability as a conformity index (Chen et al., 2012; Chierchia et al., 2020), which is the probability that participants would change their ratings (*R2*) in the direction of the observed group ratings. To do so, we marked the trials with no change between the two ratings, or changes in the opposite direction of the group rating, as 0 and the trials with the same direction of the group rating as 1. Thus, the larger the value, the higher the probability of changing the rating in the same direction with group ratings. A 2 (SVO: prosocial vs. proself) × 2 (group rating: peer-higher vs. peer-lower) ANOVA was conducted on the influence probability. The results revealed a significant interaction of group rating and SVO, $F(1, 50) = 4.39$, $p = .041$, $\eta_p^2 = 0.08$ (Figure 2a), and no main effects of group rating, $F(1, 50) = 0.29$, $p = .592$, $\eta_p^2 = 0.01$, and SVO, $F(1, 50) = 0.05$, $p = .832$, $\eta_p^2 = 0.001$. Simple effect analysis revealed that, for proselfs, the influence probability under peer-lower condition ($M = 0.30$, $SD = 0.19$) was significantly higher than that under peer-higher condition ($M = 0.20$, $SD = 0.14$), $p < .001$, whereas prosocials showed no significant difference under the two conditions, peer-lower: $M = 0.27$, $SD = 0.17$, peer-higher: $M = 0.24$, $SD = 0.16$, $p = .546$.

TABLE 1 Characteristics of the participants with different SVOs (prosocials vs. proselfs).

	Prosocials (*M* ± *SD*)	Proselfs (*M* ± *SD*)	*t*
SVO	34.12 ± 4.24	3.85 ± 8.40	−17.19***
S-AI	37.52 ± 10.73	42.69 ± 10.33	1.84
T-AI	43.19 ± 8.35	45.00 ± 9.17	0.77
PHQ-9	7.00 ± 4.16	6.38 ± 4.47	−0.54
LSAS	52.56 ± 19.97	46.79 ± 17.47	−1.15
SES	27.89 ± 4.29	27.86 ± 3.72	−0.03

Abbreviations: LSAS, Liebowitz social anxiety scale; PHQ-9, Patient Health Questionnaire-9; S-AI, state anxiety; SES: self-esteem scale; SVO, social value orientation; T-AI, trait anxiety.
***$p < .001$.

3.1.2 | Recall performance

We then calculated the correlation of *Recall-R1* and *Group rating-R1* under more positive and more negative norms (correlation [*Recall -R1*, *Group rating-R1*]) and converted it into fisher *z* score, as the recall coefficient: The larger the recall coefficient, the better the memory level. A 2 (group rating: peer-higher vs. peer-lower) × 2 (SVO: prosocial vs. proself) ANOVA of the recall coefficient revealed a significant interaction between group rating and SVO, $F(1, 49) = 6.68$, $p = .013$, $\eta_p^2 = 0.12$ (Figure 2b), and the main effects of SVO, $F(1, 49) = 0.09$, $p = .770$, $\eta_p^2 = 0.002$, and group rating, $F(1, 49) = 0.01$, $p = .920$, $\eta_p^2 < 0.001$, were not significant. Simple effects analysis revealed that the recall coefficient of proselfs in peer-lower condition ($M = 0.23$, $SD = 1.00$) was marginally significantly higher than that in peer-higher condition ($M = -0.21$, $SD = 0.88$), $p = .055$. However, the recall coefficient of prosocials in peer-higher condition ($M = 0.18$, $SD = 1.10$) was marginally significantly higher than that in peer-lower condition ($M = -0.22$, $SD = 0.98$), $p = .080$. As there was no significant difference in recall rating between prosocials ($M = 3.73$, $SD = 0.79$) and proselfs ($M = 3.29$, $SD = 1.35$), $t(1, 42.24) = -1.43$, $p = .160$, Cohen $d = 0.39$, here the memory performance of different SVOs should not only reflect the response preferences of different SVOs, which rules out the possibility that memory preferences originate from response preferences.

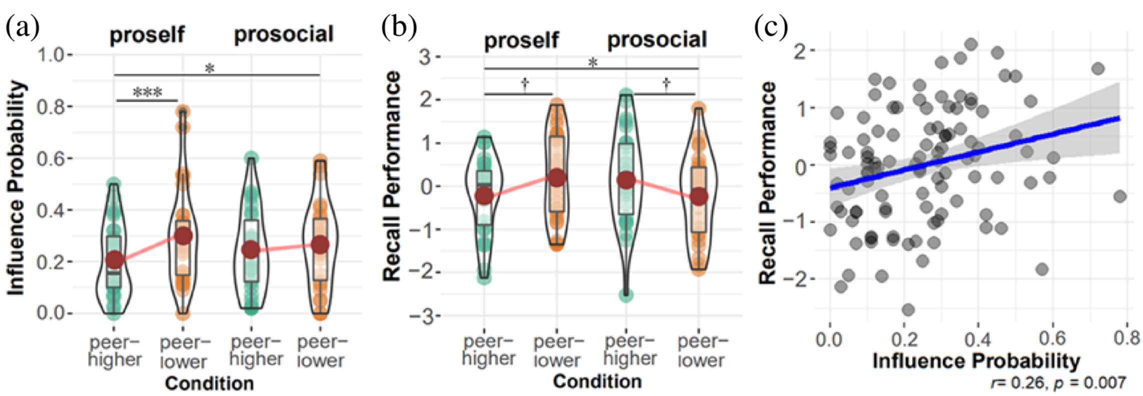

FIGURE 2 Plots of the interaction between SVO and group-rating type on influence probability (a) and recall performance (b). The overall correlation of all participants between influence probability and recall performance across peer-higher and peer-lower conditions (c). †$p < .1$, *$p < .05$, ***$p < .001$, gray shading depicts the 95% confidence interval.

3.2 | ERP results

3.2.1 | N400

To examine whether there are differences in N400 between different SVOs for different types of group ratings, a 2 (SVO: prosocial vs. proself) × 2 (group rating: peer-–higher vs. peer-lower) ANOVA was conducted on N400 amplitude. The main effects of group rating, $F(1, 49) = 0.26$, $p = 0.614$, $\eta_p^2 = 0.005$, and SVO type, $F(1, 49) = 0.17$, $p = 0.683$, $\eta_p^2 = 0.003$, were not significant, while the interaction effect of group rating and SVO was significant, $F(1, 49) = 4.06$, $p = 0.049$, $\eta_p^2 = 0.077$ (Figure 3b). Simple effects analysis showed that for proselfs, significantly negative N400 was induced in peer-higher condition ($M = 3.48$ μV, $SD = 6.61$) than it was in peer-lower condition ($M = 5.29$ μV, $SD = 7.02$), $p = 0.029$. However, for prosocials, there was no significant difference between peer-higher condition ($M = 4.78$ μV, $SD = 4.54$) and peer-lower condition ($M = 4.44$ μV, $SD = 4.77$), $p = 0.492$ (Figure 3b).

3.2.2 | LPP

To examine whether different types of group ratings induce different LPP amplitudes in prosocials and proselfs, an ANOVA of 2 (SVO: prosocial vs. proself) × 2 (group rating: peer-higher vs. peer-lower) was conducted on LPP amplitudes. The results showed that the main effects of group rating, $F(1, 49) = 0.35$, $p = .554$, $\eta_p^2 = 0.007$, and SVO type, $F(1, 49) = 0.25$, $p = .617$, $\eta_p^2 = 0.005$, were not significant; however, the interaction effect of group rating and SVO was significant, $F(1, 49) = 4.15$, $p = .047$, $\eta_p^2 = 0.078$ (Figure 4b). Further analysis revealed that for proselfs, significantly larger LPP was induced in peer-lower condition ($M = 6.21$ μV, $SD = 6.82$) than it was in peer-higher condition ($M = 4.88$ μV, $SD = 6.90$), $p = .025$. However, for prosocials, there was no significant difference between peer-lower condition ($M = 5.93$ μV, $SD = 5.35$) and peer-higher condition ($M = 5.99$ μV, $SD = 5.16$), $p = .503$.

3.3 | Correlations between conformity, recall performance, and ERPs

Influence probability and recall coefficient were significantly correlated across all participants and conditions ($r = 0.26$, $p = .007$, 95% CI = [0.08, 0.44]; Figure 2c). To test the association between behavioral performance and neurobiology, we examined correlations between N400/LPP, influence probability, and recall performance. We determined neurological differences between the conflict (i.e., peer-higher and peer-lower) and no-conflict conditions by substracting mean amplitudes of the latter from those of the former, yielding dN400 and dLPP. Across all conditions, dN400 was significantly correlated with influence probability ($r = 0.29$, $p = .003$, 95% CI = [0.12, 0.45]; Figure 5a) and with recall performance ($r = 0.40$, $p < .001$, 95% CI = [0.19, 0.58]; Figure 5b). Likewise, dLPP was significantly correlated with influence probability ($r = 0.19$, $p = .052$, 95% CI = [−0.01, 0.38]; Figure 5c) and recall performance ($r = 0.34$, $p = .001$, 95% CI = [0.15, 0.50]; Figure 5d).

4 | DISCUSSION

In this study, we used a face-attractiveness rating task to investigate how individuals with different SVOs respond to positive and negative social influences, by indicators of conformity, memory, and neural activities. The results demonstrated that SVO had a modulating effect, partly supporting our hypothesis. Proselfs showed more conformity and better recall performance (marginal significance) to negative information, while prosocials showed no significant differences. Furthermore, both N400 and LPP differed between groups, with proselfs

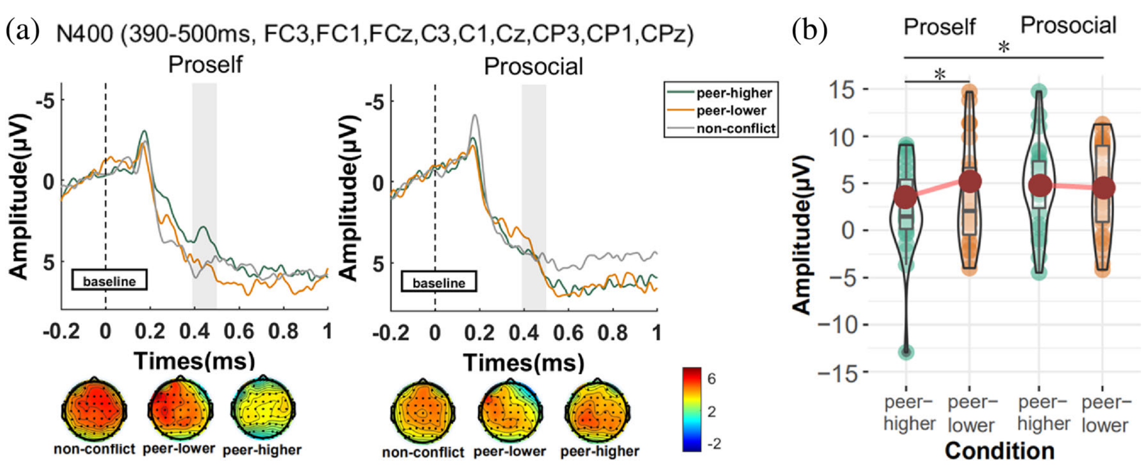

FIGURE 3 (a) Grand average ERP of the N400 component; the time window was 390–500 ms. The corresponding scalp topography for each condition of group-rating type is provided below. (b) The interaction between SVO and group-rating type on N400. For proselfs, more negative N400 was induced in peer-higher condition than peer-lower condition, whereas for prosocials, there was no significant difference. *$p < .05$.

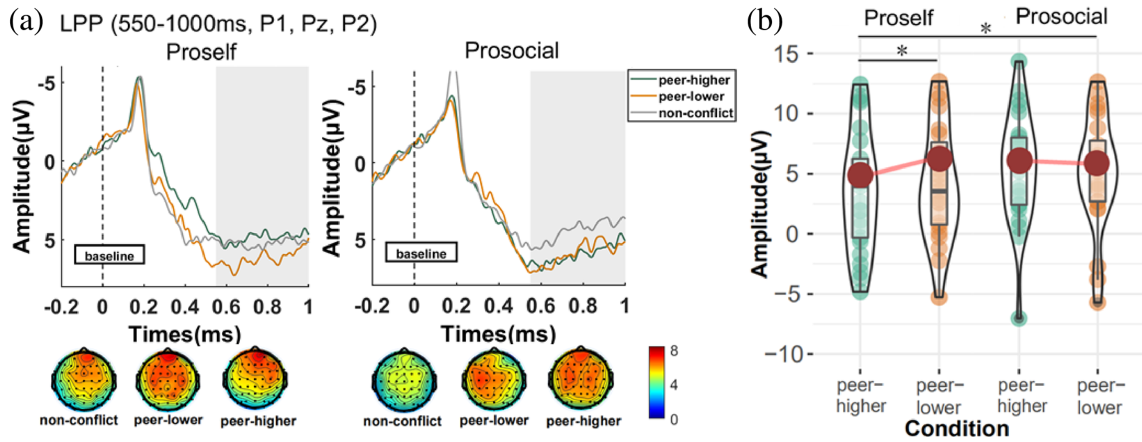

FIGURE 4 (a) Grand average ERP of the LPP component; the time window was 550–1000 ms. The corresponding scalp topography for each condition of group-rating type is provided below. (b) The interaction between SVO and group-rating type on LPP amplitude. For proselfs, significantly larger LPP was induced in peer-lower condition than peer-higher condition, whereas for prosocials, there was no significant difference. *p < .05.

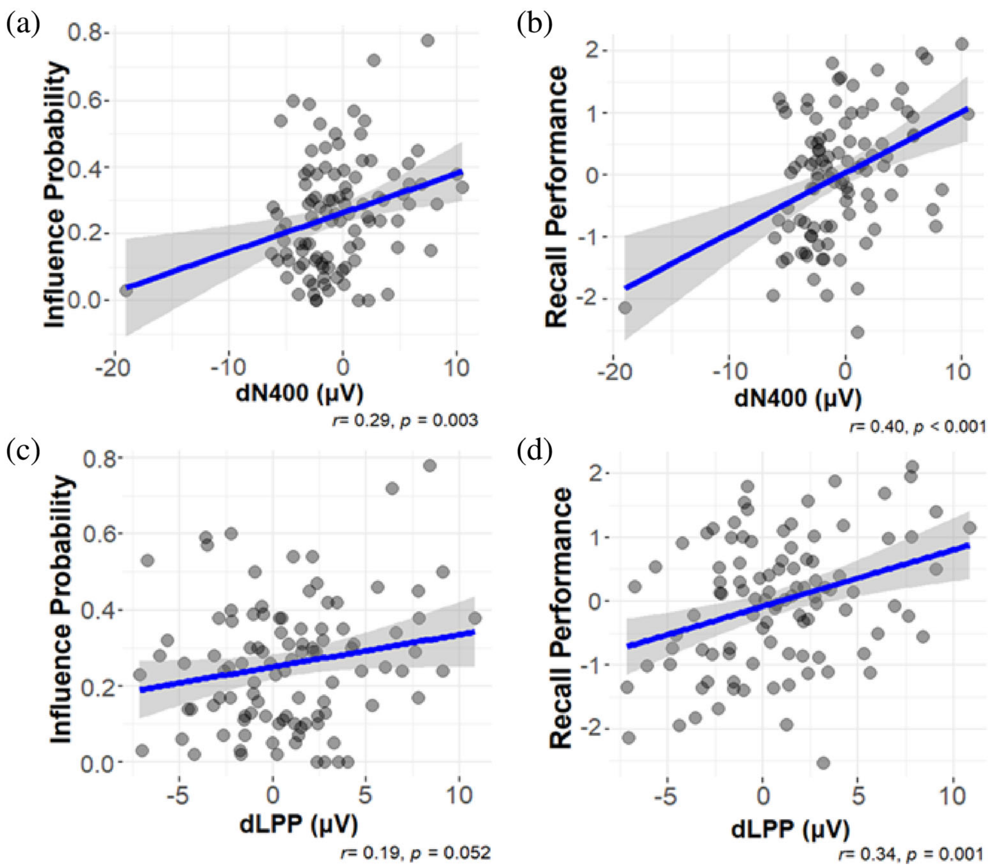

FIGURE 5 The overall correlation of all participants between conformity, recall performance and ERPs across peer-higher and peer-lower conditions. (a) The correlation between dN400 and influence probability. (b) The correlation between dN400 and recall performance. (c) The correlation between dLPP and influence probability. (d) The correlation between dLPP and recall performance. Gray shading depicts the 95% confidence interval. dN400/dLPP: The mean amplitude of N400/LPP under conflict conditions (i.e., peer-higher and peer-lower) minus the mean amplitude of N400/LPP under no-conflict conditions.

having smaller N400 and larger LPP with negative information than positive information, while prosocials showed no significant difference in the two conditions. Finally, conformity, recall performance, and ERP indicators were significantly correlated.

Face attractiveness constitutes an important part of self-esteem (Bale & Archer, 2013; Oikawa et al., 2012); thus, more positive attractiveness ratings on others could be positive social influence, while more negative attractiveness ratings on others could be viewed as negative social influence (Feng et al., 2018; Zhang et al., 2021). Although previous studies using a similar paradigm have already identified the social conformity effect (Feng et al., 2018; Huang et al., 2014), our findings provided evidence of SVO modulation, extending current understanding of the underlying mechanisms. More importantly, we showed that people do not conform to all social norms, but instead selectively conform to norms consistent with their prosocial preferences, which was especially exhibited in proselfs who were more susceptible to negative social norms than to positive norms. This biased conformity is partially consistent with previous findings on risk decision-making. Risk-seeking individuals have been found to conform more to others' risky decisions, while risk-aversive individuals conform more to others' safe decisions (Chung et al., 2015). As such, the assertion that people incorporate social information depending on the extent to which social information and one's own opinions are matched is substantiated (Chung et al., 2015; Feng et al., 2018).

Our study further expanded the existing research on conformity under social influence through examining variation in individual memories when faced with positive or negative social influence. We identified an SVO × group-rating-type interaction effect on recall performance (Figure 2b) that implied individuals with different SVOs treat positive and negative social norms differently. Further, we did not find significant differences in the recalled attractiveness ratings between prosocials and proselfs, ruling out the possibility that the memory preference originated from response preference. This finding corroborates the self-reference effect, in which people are more likely to remember information related to themselves or their states (Gaddy & Ingram, 2014; Klein, 2012; Rouhani & Niv, 2019; Symons & Johnson, 1997). Moreover, influence probability was positively correlated with memory performance, suggesting that behavioral responses to social norms are consistent with the cognitive processing of this social information. Conformity behavior may deepen the memory consolidation of information, resulting in better recall performance.

Regarding neural mechanism, we found a significant interaction between SVO and group-rating type on N400. In addition to interpreting N400 as reflecting semantic violation, substantial studies have observed N400 in a variety of social tasks and considered it as perceived conflict due to the deviance from expectation or social norm (Bartholow et al., 2001; Feng et al., 2018; Goto et al., 2010; Mu et al., 2015; White et al., 2009). Guided by this interpretation, a larger N400 in proselfs to positive social norm implies that the more the positive evaluation of others, the more the perceived conflict in proselfs. LPP further illustrates this in the late time-course processing; it reflects the significance of the motivation and attention allocation (Glazer et al., 2018; Hajcak & Foti, 2020). Studies on social influence found that larger LPP is usually induced when there is little or no conflict between one's opinion or behavior and group opinion or behavior (Zheng et al., 2021). Here, we observed that proselfs had significantly greater LPP when group ratings were negative, suggesting that this negative evaluation from others was consistent with the intrinsic motivation of proselfs.

The positive correlations between neurobiological processes and behavioral responses indicate that conformity and memory encoding improve as perceived conflict (reflected in N400) decreases (Feng et al., 2018; Mu et al., 2015) and attention (reflected in LPP) increases (Thiruchselvam et al., 2017). These findings are consistent with our hypothesis, and provide EEG evidence of the behavioral performance.

Notably, against our prediction, for both influence probability and neural mechanisms (N400 and LPP), prosocials showed no significant differences in terms of positive and negative influences, indicating no processing bias. These findings may suggest that prosocials equally adhere to established group norms. The underlying motivation may be that they would prefer remaining consistent with group behavior or opinion to show cooperation, thereby demonstrating belongingness and reducing social tension.

In sum, the present study extends existing studies by introducing individual differences in how individuals respond to social influence. This study used a commonly used face-attractiveness rating task, in which more attractive and more unattractive group ratings correspond to the positive and negative influence. Under such minimal manipulation of social influence, we found that SVO modulated the processing of social influence through influence probability, memory, and neural mechanisms, reflected by significant interactions of SVO and group-rating type. These findings have potential implications for understanding how social norms influence conformity behavior and further how prosocial behavior occurs. Simultaneously, the findings of this study are significant as they may provide guidance for the use of social norms to promote prosocial behavior. Follow-up studies could further examine whether increasing exposure to positive norms could increase prosocial behavior in proselfs, and whether the present findings can hold in issues that are more closely related to one's interests, such as donation.

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CONFLICT OF INTEREST STATEMENT

There is no conflict of interest in relation to the subject of this study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

Bale, C., & Archer, J. (2013). Self-perceived attractiveness, romantic desirability and self-esteem: A mating sociometer perspective. *Evolutionary Psychology*, *11*(1), 68–84. https://doi.org/10.1177/147470491301100107

Bartholow, B. D., Fabiani, M., Gratton, G., & Bettencourt, B. A. (2001). A psychophysiological examination of cognitive processing of and affective responses to social expectancy violations. *Psychological Science*, *12*(3), 197–204.

Campbell-Meiklejohn, D. K., Bach, D. R., Roepstorff, A., Dolan, R. J., & Frith, C. D. (2010). How the opinion of others affects our valuation of objects. *Current Biology*, *20*(13), 1165–1170.

Chen, J., Wu, Y., Tong, G., Guan, X., & Zhou, X. (2012). ERP correlates of social conformity in a line judgment task. *BMC Neuroscience*, *13*(1), 43.

Chierchia, G., Piera Pi-Sunyer, B., & Blakemore, S.-J. (2020). Prosocial influence and opportunistic conformity in adolescents and young adults. *Psychological Science*, *31*(12), 1585–1601.

Chung, D., Christopoulos, G. I., King-Casas, B., Ball, S. B., & Chiu, P. H. (2015). Social signals of safety and risk confer utility and have asymmetric effects on observers' choices. *Nature Neuroscience*, *18*(6), 912–916.

Cialdini, R. B., & Goldstein, N. J. (2004). Social influence: Compliance and conformity. *Annual Review of Psychology*, *55*, 591–621.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, *112*(1), 155–159.

Cornelissen, G., Dewitte, S., & Warlop, L. (2011). Are social value orientations expressed automatically? Decision making in the dictator game. *Personality and Social Psychology Bulletin*, *37*(8), 0146167211405996.

Do, K. T., McCormick, E. M., & Telzer, E. H. (2020). Neural sensitivity to conflicting attitudes supports greater conformity toward positive over negative influence in early adolescence. *Developmental Cognitive Neuroscience*, *45*, 100837.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191.

Feng, C., Cao, J., Li, Y., Wu, H., & Mobbs, D. (2018). The pursuit of social acceptance: Aberrant conformity in social anxiety disorder. *Social Cognitive and Affective Neuroscience*, *13*(8), 809–817.

Gaddy, M. A., & Ingram, R. E. (2014). A meta-analytic review of mood-congruent implicit memory in depressed mood. *Clinical Psychology Review*, *34*(5), 402–416. https://doi.org/10.1016/j.cpr.2014.06.001

Glazer, J. E., Kelley, N. J., Pornpattananangkul, N., Mittal, V. A., & Nusslock, R. (2018). Beyond the FRN: Broadening the time-course of EEG and ERP components implicated in reward processing. *International Journal of Psychophysiology*, *132*, 184–202. https://doi.org/10.1016/j.ijpsycho.2018.02.002

Gong, X., Huang, Y., Wang, Y., & Luo, Y. (2011). Revision of the Chinese facial affective picture system. *Chinese Mental Health Journal*, *25*(1), 40–46.

Goto, S. G., Ando, Y., Huang, C., Yee, A., & Lewis, R. S. (2010). Cultural differences in the visual processing of meaning: Detecting incongruities between background and foreground objects using the N400. *Social Cognitive and Affective Neuroscience*, *5*(2–3), 242–253. https://doi.org/10.1093/scan/nsp038

Hagoort, P. (2003). How the brain solves the binding problem for language: A neurocomputational model of syntactic processing. *NeuroImage*, *20*, S18–S29.

Hajcak, G., & Foti, D. (2020). Significance? … Significance! Empirical, methodological, and theoretical connections between the late positive potential and P300 as neural responses to stimulus significance: An integrative review. *Psychophysiology*, *57*(7), e13570.

Howell, A. N., Leyro, T. M., Hogan, J., Buckner, J. D., & Zvolensky, M. (2010). Anxiety sensitivity, distress tolerance, and discomfort intolerance in relation to coping and conformity motives for alcohol use and alcohol use problems among young adult drinkers. *Addictive Behaviors*, *35*(12), 1144–1147.

Huang, Y., Kendrick, K. M., & Yu, R. (2014). Social conflicts elicit an N400-like component. *Neuropsychologia*, *65*, 211–220.

Kim, B. R., Liss, A., Rao, M., Singer, Z., & Compton, R. J. (2012). Social deviance activates the brain's error-monitoring system. *Cognitive, Affective, & Behavioral Neuroscience*, *12*(1), 65–73. https://doi.org/10.3758/s13415-011-0067-5

Klein, S. B. (2012). Self, memory, and the self-reference effect: An examination of conceptual and methodological issues. *Personality and Social Psychology Review*, *16*(3), 283–300.

Klucharev, V., Hytönen, K., Rijpkema, M., Smidts, A., & Fernández, G. (2009). Reinforcement learning signal predicts social conformity. *Neuron*, *61*(1), 140–151.

Korn, C. W., Prehn, K., Park, S. Q., Walter, H., & Heekeren, H. R. (2012). Positively biased processing of self-relevant social feedback. *The Journal of Neuroscience*, *32*(47), 16832–16844. https://doi.org/10.1523/JNEUROSCI.3016-12.2012

Kurt Kroenke, M., Robert, L., & Spitzer, M. (2002). The PHQ-9: A new depression diagnostic and severity measure. *Psychiatric Annals*, *32*(9), 509–515.

Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: Finding meaning in the N400 component of the event related brain potential (ERP). *Annual Review of Psychology*, *62*, 621–647.

Kutas, M., & Hillyard, S. A. (1980). Event-related brain potentials to semantically inappropriate and surprisingly large words. *Biological Psychology*, *11*(2), 99–116.

Lau, E. F., Phillips, C., & Poeppel, D. (2008). A cortical network for semantics: (de)constructing the N400. *Nature Reviews Neuroscience*, *9*(12), 920–933.

Liebowitz, M. R. (1987). Social phobia. *Modern Problems of Pharmacopsychiatry*, *22*, 141–173.

Mahmoodi, A., Nili, H., Bang, D., Mehring, C., & Bahrami, B. (2022). Distinct neurocomputational mechanisms support informational and socially normative conformity. *PLoS Biology*, *20*(3), e3001565.

Matt, G. E., Vázquez, C., & Campbell, W. K. (1992). Mood-congruent recall of affectively toned stimuli: A meta-analytic review. *Clinical Psychology Review*, *12*(2), 227–255.

Mu, Y., Kitayama, S., Han, S., & Gelfand, M. J. (2015). How culture gets embrained: Cultural differences in event-related potentials of social norm violations. *Proceedings of the National Academy of Sciences*, *112*(50), 15348–15353.

Murphy, R. O., Ackermann, K. A., & Handgraaf, M. (2011). Measuring social value orientation. *Judgment and Decision Making*, *6*(8), 771–781.

Nook, E. C., Ong, D. C., Morelli, S. A., Mitchell, J. P., & Zaki, J. (2016). Prosocial conformity: Prosocial norms generalize across behavior and empathy. *Personality and Social Psychology Bulletin*, *42*(8), 1045–1062.

Oikawa, H., Sugiura, M., Sekiguchi, A., Tsukiura, T., Miyauchi, C. M., Hashimoto, T., Takano-Yamamoto, T., & Kawashima, R. (2012). Self-face evaluation and self-esteem in young females: An fMRI study using contrast effect. *NeuroImage*, *59*(4), 3668–3676.

Panizza, F., Vostroknutov, A., & Coricelli, G. (2021). How conformity can lead to polarised social behaviour. *PLoS Computational Biology*, *17*(10), e1009530.

Pletzer, J. L., Balliet, D., Joireman, J., Kuhlman, D. M., Voelpel, S. C., & Van Lange, P. A. (2018). Social value orientation, expectations, and cooperation in social dilemmas: A meta-analysis. *European Journal of Personality*, *32*(1), 62–83.

Qi, Y., Gu, R., Cao, J., Bi, X., Wu, H., & Liu, X. (2017). Response bias-related impairment of early subjective face discrimination in social anxiety disorders: An event-related potential study. *Journal of Anxiety Disorders*, *47*, 10–20.

Qi, Y., Wu, H., & Liu, X. (2017). The influences of social value orientation on prosocial behaviors: The evidences from behavioral and neuroimaging studies. *Chinese Science Bulletin*, *62*(11), 1136–1144. https://doi.org/10.1360/n972016-00631

Qi, Y., Wu, H., Raiha, S., & Liu, X. (2018). Social value orientation modulates context-based social comparison preference in the outcome evaluation: An ERP study. *Neuropsychologia*, *112*, 135–144.

Rosenberg, M. (2015). *Society and the adolescent self-image*. Princeton University Press.

Rouhani, N., & Niv, Y. (2019). Depressive symptoms bias the prediction-error enhancement of memory towards negative events in reinforcement learning. *Psychopharmacology*, *236*(8), 2425–2435. https://doi.org/10.1007/s00213-019-05322-z

Salvador, C. E., Mu, Y., Gelfand, M. J., & Kitayama, S. (2020). When norm violations are spontaneously detected: An electrocortical investigation. *Social Cognitive and Affective Neuroscience*, *15*(3), 319–327.

Shestakova, A., Rieskamp, J., Tugin, S., Ossadtchi, A., Krutitskaya, J., & Klucharev, V. (2012). Electrophysiological precursors of social conformity. *Social Cognitive and Affective Neuroscience*, *8*(7), 756–763.

Spielberger, C. D. (1983). *State-trait anxiety inventory munual*. Mind Garden, SPSS, Redwood City, CA.

Sul, S., Tobler, P. N., Hein, G., Leiberg, S., Jung, D., Fehr, E., & Kim, H. (2015). Spatial gradient in value representation along the medial prefrontal cortex reflects individual differences in prosociality. *Proceedings of the National Academy of Sciences*, *112*(25), 7851–7856.

Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: A meta-analysis. *Psychological Bulletin*, *121*(3), 371–394.

Thiruchselvam, R., Gopi, Y., Kilekwang, L., Harper, J., & Gross, J. J. (2017). In God we trust? Neural measures reveal lower social conformity among non-religious individuals. *Social Cognitive and Affective Neuroscience*, *12*(6), 956–964. https://doi.org/10.1093/scan/nsx023

Toelch, U., & Dolan, R. J. (2015). Informational and normative influences in conformity from a neurocomputational perspective. *Trends in Cognitive Sciences*, *19*(10), 579–589. https://doi.org/10.1016/j.tics.2015.07.007

Van Assche, J., Asbrock, F., Roets, A., & Kauff, M. (2018). Positive neighborhood norms buffer ethnic diversity effects on neighborhood dissatisfaction, perceived neighborhood disadvantage, and moving intentions. *Personality and Social Psychology Bulletin*, *44*(5), 700–716.

Van Lange, P. A. (1999). The pursuit of joint outcomes and equality in outcomes: An integrative model of social value orientation. *Journal of Personality and Social Psychology*, *77*(2), 337–349.

Vijayalakshmi, D. V., & Patchainayagi, D. S. (2020). Role of memory in language learning – A review. *International Journal of Early Childhood Special Education*, *12*(2), 68–76. https://doi.org/10.9756/int-jecse/v12i2.201057

Wei, Z., Zhao, Z., & Zheng, Y. (2017). The neural basis of social influence in a dictator decision. *Frontiers in Psychology*, *8*, 2134. https://doi.org/10.3389/fpsyg.2017.02134

White, K. R., Crites, S. L., Jr., Taylor, J. H., & Corral, G. (2009). Wait, what? Assessing stereotype incongruities using the N400 ERP component. *Social Cognitive and Affective Neuroscience*, *4*(2), 191–198.

Wu, H., Luo, Y., & Feng, C. (2016). Neural signatures of social conformity: A coordinate-based activation likelihood estimation meta-analysis of functional brain imaging studies. *Neuroscience & Biobehavioral Reviews*, *71*, 101–111.

Zaki, J., Schirmer, J., & Mitchell, J. P. (2011). Social influence modulates the neural computation of value. *Psychological Science*, *22*(7), 894–900.

Zhang, H., Zhang, K., Zhang, Z., Zhao, M., Liu, Q., Luo, W., & Wu, H. (2021). Inter-trial variations in EEG predict the individual differences in social tasks. *bioRxiv*, 2021–10.

Zhang, L., & Gläscher, J. (2020). A brain network supporting social influences in human decision-making. *Science Advances*, *6*(34), eabb4159.

Zhang, Z., Zhang, F., Yuan, S., Guo, F., & Wang, Y. (2015). Psychometric analysis of the SVO slider measure in Chinese cultural context. *Studies of Psychology and Behavior*, *13*(3), 404–409.

Zheng, J., Hu, L., Li, L., Shen, Q., & Wang, L. (2021). Confidence modulates the conformity behavior of the investors and neural responses of social influence in crowdfunding. *Frontiers in Human Neuroscience*, *15*, 766908. https://doi.org/10.3389/fnhum.2021.766908

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