Self-prioritization is modulated by arousal

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* Z. Wang's involvement in this project was supported by a grant from the National Natural Science Foundation of China (grant # 31371133).

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Abstract

Stimuli related to the self are processed more efficiently in a variety of cognitive tasks. Recent studies have shown that this self-referential bias is modulated by one's emotional states; however, it remains unclear whether the impact of emotion is primarily attributable to valence or arousal. Experiment 1 measured the self-prioritization effect with a label-shape matching task under four mood states. The results revealed a stronger self-prioritization effect in moods of higher arousal level, and a significant correlation between the arousal ratings and the self-prioritization effect. Experiment 2 further showed that alerting cues, which have been known to elevate the arousal level, boosted the self-prioritization effect measured in a similar label-shape matching task. These results provide clear evidence that arousal modulates self-referential processing.

Key words: self-referential bias, mood, valence, arousal, self-prioritization effect, mood

Introduction

Items associated with the self are prioritized in a range of cognitive operations. For instance, materials related to the self are better memorized (e.g., Symons & Johnson, 1997) and one's own face is processed much faster than a stranger's face (e.g., Tong & Nakayama, 1999; Ma & Han, 2010; Guan, Qi, Zhang, & Yang, 2014). Using a label-shape matching task, Sui, He, and Humphreys (2012) observed faster and more accurate responses to geometric shapes paired with the participant's own name (self-label), compared to those paired with friends' and strangers' names (other-label). This matching task effectively eliminates the contribution of familiarity, provides strong evidence for a self-prioritization effect (see also Sui, Rotshtein, & Humphreys, 2013). Using a drift-diffusion modelling approach, Golubickis and colleagues (2017) showed that the self-prioritization effect in matching tasks is underpinned by a perceptual bias (i.e., rate of information uptake; but see Fuentes, Sui, Estevez, & Humphreys, 2016, for evidence suggesting a learning bias). This observation is in line with the finding that items associated to the self through short-term learning could increase the percentage of BOLD signal change in the left intra-parietal sulcus, an area linked to perceptual salience (e.g. Sui, Liu, Mevorach, & Humphreys, 2015).

The self-prioritization effect is influenced by a multitude of factors (e.g.,Golubickis et al., 2017; Fuentes et al., 2015; Stein et al., 2016). Pertinent to the current investigation is the finding that moods modulate the self-prioritization effect. For instance, Ma and Han (2010) showed that associating oneself to negative personal traits resulted in depressive feelings and reduced the processing bias towards one's own face. Sui and colleagues (2016) found that instructing the participants to read a list of self-related depressive statements (i.e., mood induction) disrupted the faster responses to self-associated shapes in a label-shape matching task. Consistent with these behavioural findings, a recent ERP study (Fan et al., 2016) also showed that negative moods (low valence and low arousal) reduced the amplitude of P3, an ERP component that reflects self-referential processing (Knyazev, 2013).

Self-referential processing is implicitly associated with positive feelings (Greenwald & Farnham, 2000) and stimuli of positive valence typically have higher attentional priority (e.g., Leppanen & Hietanen, 2004). Some researchers reasoned that the positive emotional responses associated with self-referential processing facilitate the processing of self-related stimuli and speed up motor responses (Ma & Han, 2010; 2012). Being in a negative mood, on the other hand, may impair the positive emotional responses to self-related stimuli, which in turn reduces the self-prioritization effect. Recent finding that mood of negative valence can eliminate the self-prioritization effect (e.g. Ma & Han, 2010) is generally in agreement with this theory, which emphasizes the importance of valence. In addition to valence, the other dimension of emotion (i.e., arousal; Bradley, Codispoti, Cuthbert, & Lang, 2001) may also modulate the self-prioritization effect. The arousal-related noradrenalin system is known to mediate attention to salient external stimuli (see Robbins, 1997, for a review). Functional MRI studies have shown that disrupting the interaction between the ventral regions of the parietal cortex, which have been implicated in arousal processing, and the dorsal regions, which are associated with salience processing, will lead to a failure in orienting attention to salient stimuli (e.g., Corbetta & Shulman, 2011). In line with this observation, Weinbach and Henik (2014) showed that alerting cues increased the level of arousal and boosted the processing bias towards salient stimuli. Thus, although it has not been empirically verified, it is reasonable to speculate that arousal also modulates the processing of self-related stimuli (Sui et al., 2015), which are salient by nature. The present study was set out to examine how emotion modulates self-referential processing, with an emphasis on emotional arousal, an emotional dimension frequently overlooked in previous studies.

To examine the effects of emotional valence and arousal on the self-prioritization effect (e.g., Sui & Humphrey, 2012; Sui et al., 2013), Experiment 1 required the participants to complete a label-shape matching task under four emotional states of differential valence and arousal levels (i.e., happiness, anxiety, serenity, and depression; as suggested by Bradley et al., 2001). The self-prioritization effect was assessed by comparing RTs to geometric shapes associated with the participants themselves and those associated with a celebrity.[1] This task was devised as such to rule out the possibility that the processing bias towards self-related stimuli is the result of familiarity rather than self-relevance *per se*. To further isolate the contribution of familiarity, the present study also collected RTs to shapes associated with an individual that was unknown to all participants. To briefly anticipate the results, Experiment 1 revealed that the self-prioritization effect was stronger in moods of high arousal levels (anxiety and happiness). Experiment 2 further assessed the effect of arousal with neutral alerting cues, which elevate the arousal level but have no effect on valence (Weinbach & Henik, 2014). This additional experiment also showed a stronger self-prioritization effect under higher arousal levels.

Experiment 1

Experiment 1 examined how emotional valence and arousal modulate the self-prioritization effect, by requiring the participant to perform a label-shape matching task under four different emotional states.

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1 We opted to use a celebrity instead of the participant's friends as a "high familiarity" control because friends may partially overlap with the self. The celebrity figure in this study was a famous Chinese writer.

Method

The research protocol presented here was approved by a local ethics committee and all participants gave written informed consent prior to the experiment.

Participants

The task of Experiment 1 was similar to Sui et al (2016), which showed that moods modulate the self-prioritization effect. Power analyses (power = 0.80, α = 0.05) showed that the self-prioritization effect reported by Sui et al. (2012) requires 16 participants and the mood modulation effect reported by Sui et al. (2016) requires 22 participants to replicate. Considering potential loss of participants in a multi-session design, 26 participants (10 males; age range: 18 to 22 years; mean age: 19.75 years) were recruited in Experiment 1.

The participants were all right-handed and had normal or corrected to normal vision. They first completed a Self-rating Depression Scale (SDS; Zung, 1965) and a Self-rating Anxiety Scale (SAS; Zung, 1971). This pre-screening procedure helped to exclude participants who were likely suffering from depression or anxiety disorders. One male who scored over 50 (out of 80) on the SAS scale and one female who scored over 50 (out of 80) on the SDS scale were excluded from further testing. The remaining 24 participants (9 males) completed all testing sessions in Experiment 1.

Mood induction

The Velten mood induction procedure (Velten, 1968) was used to elicit four different mood states (happiness, anxiety, serenity, and depression). The participants read out a list of emotional statements while listening to emotional music for 10 minutes. For the anxiety and serenity conditions, the emotional statements were adapted from Sinclair, Soldat, and Ryan (1997); for the happiness and depression conditions, positive and negative Velten statements were adapted from Jennings McGinnis, Lovejoy, and Stirling (2000). These emotional statements were first translated into Chinese by two graduate students. The valence and arousal level of the translated Velten statements and those of the emotional music were rated by 48 undergraduates (20 males) on the Self-Assessment Manikin scale. The ratings for these experimental materials are reported in Supplement Materials (Table S1 & S2). To prevent potential carryover effect, the four mood induction procedures were tested in separate sessions, with roughly one-week intervals and cross-participant counterbalancing.

Label-shape matching task

Twelve geometric shapes (triangle, circle, square, hexagon, pentagon, octagon, diamond, ellipse, sector, parallelogram, rectangle, and trapezoid) were assigned to three labels (the participant's own name, the name of a gender-matched stranger, or a Chinese celerity—Lu Xun). After receiving instructions to associate labels with shapes, e.g., “a circle represents a stranger and a pentagon represents you”, the participants completed a shape-label matching task in which the participants made decisions on whether a shape-label pair was correct or not.

All stimuli were presented in white against a grey background, at a viewing distance of about 65 cm. The shapes measured 3.5° × 3.5° visual angle and the labels extended 2.52° × 1.6°. The shapes were presented above a white central fixation cross (0.8° × 0.8°) while the labels were presented below the fixation (see Figure 1). Stimulus presentation and response registration were controlled by E-Prime (Version 2.0, Psychology Software Tools, Inc.), running on a PC equipped with a 17 inch CRT monitor.

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Procedure

As mentioned above, all participants completed four testing sessions. In each testing session, the participants first learned label-shape pairings and they needed to score at least 80% correct on a 10-trial test to move on. Then, the participants underwent the mood induction procedure, after which the label-shape matching task was performed for a second time. At the end of each session, the participants rated their valence and arousal level on the Self-Assessment Manikin scale (Bradley & Lang, 1994). The valence scores ranged between 1 (very happy) and 9 (very unhappy) and the arousal scores also ranged between 1 (very calm) and 9 (very excited). The ratings were necessary to evaluate the effectiveness of the mood induction procedures.

In the label-shape matching task, both the learning and testing trials started with the presentation of a central fixation cross (500 ms), followed by a shape-label pair that lasted for 100 ms. Half the pairings conformed with the task instruction and the remaining half did not. The brief presentation of the shape-label pair was followed by a blank screen of 1000 ms, during which participants were required to respond as quickly as possible, without compromising accuracy. A standard QUERTY keyboard was used to collect the response and the keys for correct and incorrect shape-label pairs were counter-balanced across participants. Visual feedbacks (“Correct”, “Incorrect”, or “Too slow”) were presented for 500 ms at the end of each trial.

The label-shape matching task had 24 trials for each of the six experimental cells: 2 (pairing: match vs. mismatch) × 3 (label: self, stranger, vs. celebrity). A total of 144 testing trails and 20 practice trials were tested in each session.

Data analysis

We first examined the effectiveness of the mood induction procedure. Then, we examined the effect of mood induction on the self-prioritization effect. To examine potential speed-accuracy trade-offs, both accuracies and RTs were submitted to statistical tests. Only the RTs from trials with correct shape-label pairings were used to quantify the self-prioritization effect (e.g. Sui et al., 2016; Fuentes et al., 2016) because the self-prioritization effect in matching tasks by its nature is a response speed (processing efficiency) advantage. Responses in mismatch trials, however, involve complex decision processes, including rejecting the matching associations (Wang, Humphreys & Sui, 2016). Analyses were also performed to reveal the correlation between the valence/arousal ratings and the self-prioritization effect. For the RT analyses in the label-shape matching task, trials with anticipatory responses (RT < 200 ms) were discarded; these trials accounted for less than 4% of the trials in each condition.

Results and discussion

The effectiveness of mood induction

Because subjective emotional ratings vary greatly across individuals, the valence and arousal ratings were first converted into normalized Z-scores. The raw rating scores are presented in Supplement Material and the overall pattern of results was the same as that reported in Figure 2A.

Repeated measures ANOVAs were performed on the normalized arousal and valence ratings. For the arousal ratings, the results revealed a significant main effect of mood induction (happiness, serenity, depression, and anxiety), $F(3, 69) = 16.01$, $p < .01$, partial $\eta^2 = .41$. Post hoc comparisons showed that the participants experienced more excitement after the happiness and anxiety induction procedures compared to the depression and serenity induction procedures (Fisher's LSD, all $p < .01$). For valence ratings, the results also revealed a significant main effect of mood induction,

$F(3,69) = 21$, $p < .01$, partial $\eta^2 = .48$; the feelings the participants experienced was more positive after happiness and serenity induction procedures compared to that following depression and anxiety induction procedures (Fisher's LSD, all $p < .01$).

These results clearly showed that the emotional induction procedures were effective in Experiment 1. As is clear in Figure 2A, the induced moods varied in both the valence and arousal dimensions.

RTs in the label-shape matching task

Mean RTs of all the experimental cells are presented in Table 1. To reveal the self-prioritization effect, the analysis of the RTs was focused on trials with correct shape-label pairings (e.g., Sui & Humphrey, 2012; Sui et al., 2013; Stein et al., 2016). The ANOVA on the correct response RTs, with variables valence (positive vs. negative), arousal (high vs. low), and label (self, stranger, vs. celebrity), revealed significant main effects for label, $F(2, 46) = 56.64$, $p < .01$, partial $\eta^2 = .71$, with longer RTs observed for stranger labels than for self and celerity labels, and arousal, $F(1, 23) = 13.47$, $p < .01$, partial $\eta^2 = .37$, with longer RTs observed for low-arousal emotional states; the effect of valence, however, was not significant, $F(1, 23) = 1.04$, $p = .32$, partial $\eta^2 = .04$. Importantly, the two-way interaction between label and arousal reached significance, $F(6, 138) = 7.49$, $p < .01$, partial $\eta^2 = .25$, suggesting that the self-prioritization effect may be modulated by arousal. All other interactions did not reach significance, all $F < 1.35$, all $p > .27$.

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To properly quantify the self-prioritization effect in the label-shape matching task, the RTs were converted into a ratio: (Celebrity - Self)/(Celebrity + Self), a measure that has been used in previous studies (e.g., Ma & Han, 2010). The repeated measures ANOVA on the RT ratios (i.e. the self-prioritization effect) revealed a significant main effect of arousal, $F(1, 23) = 16.15$, $p < .01$, partial $\eta^2 = .41$; the self-prioritization effect was stronger for high arousal emotional states. The effect of valence, $F(1,23) = 1.69$, $p = .21$, partial $\eta^2 = .07$, and the two-way interaction, $F < 1$, n.s., were not significant. As clearly shown in Figure 2B, the self-prioritization effect varied primarily along the arousal dimension.

The current design also allows us to assess the effect of familiarity, which should have been controlled for in the label-shape matching task. The RTs were also converted into an RT ratio: (Stranger - Celebrity)/(Stranger + Celebrity). The results did not reveal any significant effect, all $F < 2.87$, all $p > .1$, partial $\eta^2 < .10$, suggesting that the familiarity of the labels did not systematically vary with mood states. That is, the observation that moods modulated the self-prioritization effect was not conflated by familiarity. This conclusion is also supported by the results of an additional repeated measures correlation analysis (Bakdash & Marusich, 2017) presented in Supplemental Material, which showed low and non-significant correlation between the familiarity RT ratio and the valence/arousal ratings.

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Accuracy in the label-shape matching task

The response accuracy in the label-shape matching task was above 80 % in all conditions (see Table S3 in Supplemental Material). An ANOVA on the accuracies, with variables label, valence, and arousal, revealed a significant main effect of label, $F(2, 46) = 20.57$, $p < .01$, partial $\eta^2 = .47$; participants were more accurate at responding to shapes associated with themselves than to those associated with a stranger or celebrity (Fisher's LSD, all $p < .01$). The main effect of arousal also reached significance, $F(1, 23) = 10.46$, $p < .01$, partial $\eta^2 = .31$, with higher accuracy observed in high-arousal mood states. No other effect reached significance, all $F < 3$, all p >. 09. The non-significant interactions between label and mood suggests that the critical two-way interaction in the RT analysis was unlikely affected by speed-accuracy trade-offs.

Arousal/valence ratings and the self-prioritization effect

The RT analyses suggest that the self-prioritization effect in the label-shape matching task was modulated primarily by arousal. To further explore this observation, we calculated the correlation between the self-prioritization effect and the subjective valence and arousal ratings. Because the participants were tested in four mood states, we performed repeated measures correlation analysis (Bakdash & Marusich, 2017) and details about this analysis are presented in Supplemental Materials.[2] As shown in Figures 2C and 2D, the current study revealed a medium correlation between the arousal rating and the self-prioritization effect, r = .23, p = .047. However, the correlation between valence ratings and the self-prioritization effect did not reach significance, r = .08, p = .518.

Overall, the results of Experiment 1 show that the self-prioritization effect observed in the label-shape matching task (e.g., Sui & Humphrey, 2012; Sui et al., 2013) is modulated primarily by arousal. The impact of arousal was further assessed in Experiment 2 with alerting cues.

Experiment 2

Previous studies have documented that alerting cues are closely linked to noradrenergic attenuation in the attentional network (Coull, Nobre, & Frith, 2001) and they can quickly induce a high level of arousal (Sturm & Willmes, 2001). As has been shown in Experiment 1, the self-prioritization effect was much weaker in moods of

2 Because a repeated measures correlation analysis takes into account all data points measured on each subject, it has greater power than a standard Pearson correlation. With 24 participants and four measurements on each participant, Experiment 1 had sufficient power to detect a medium-sized correlation; see Bakdash and Marusich (2017), for a discussion on the power of repeated measures correlation.

low arousal level. We reasoned that if the self-prioritization effect is modulated by arousal, using alerting cues to effectively increase the arousal level should strengthen the self-prioritization effect. Experiment 2 was designed to verify this prediction. In this experiment, we first used the mood induction procedure to elicit a depressive mood and then compared conditions with and without alerting cues. To put the participants in a depressive mood was necessary because the alerting cues can only increase the arousal level.

Method

Participants

Twenty-six undergraduates were recruited in the Experiment 2 (7 males; age range: 17 to 21 years; mean age: 19.0 years). They were all right-handed and had normal or corrected to normal vision. As in Experiment 1, all participants were screened with the SDS and SAS scales. One female who scored over 50 (out of 80) on the SDS scale was excluded from further testing.

Mood induction

In Experiment 2, the participants were first put in a depressive mood with the same mood induction procedure as in Experiment 1. The arousal level of the participants was manipulated by an alerting cue (a 100-ms auditory “beep”), a manipulation that has been proven effective in raising the arousal level (e.g. Botta, Lupianez, & Chica, 2014; Weinbach & Henik, 2014).

Label-shape matching task

As in Experiment 1, the label-shape matching task was used to assess the self-prioritization effect. The materials and task procedure were the same as Experiment 1, except that only two geometric shapes (triangle vs. hexagon) were randomly assigned to two identity labels (self vs. celebrity). We note that strangers' names were no longer used as an identity label in Experiment 2 because Experiment 1 had established that the self-prioritization effect is not conflated by familiarity.

Procedure

In the label-shape matching task, all trials began with the presentation of a central fixation cross for 500 ms, followed by a blank screen of 200 – 250 ms. The alerting-cue was presented during this blank screen period on the half of the trials. Then, a shape-label pair was briefly presented for 100 ms, followed by a 1000 ms blank screen during which the participants issued a response. Visual feedbacks were provided to the participants at the end of each trial. The assignment of response buttons was counterbalanced across participants. There were 25 trials in each of the 8 experimental cells: 2 (label: self vs. celebrity) × 2 (alerting cue: with vs. without) × 2 (pairing: match vs. mismatch). Each participant completed 20 practice trials and two blocks of 100 testing trials. Trials with and without altering cues were randomly intermixed because the effect of alerting cues on arousal is transient in nature (Coull et al., 2001) and blocking trials with alerting cues will likely introduce untoward effects (e.g., adaptation).

To assess the effectiveness of the alerting cues, all participants were required to take part in a brief arousal level assessment task. In this task, the participants rated their arousal level on the Self-Assessment Manikin scale after completing 5 trials with alerting cues and 5 trials without alerting cues.

Data analysis

We first assessed the effectiveness of the alerting cues. We then assessed the self-prioritization effect with RTs in the label-shape matching task. As in Experiment 1, responses faster than 200 ms were excluded from the analyses. These trials accounted for less than 7% of the trials.

Result and discussion

Alerting cues and arousal level

A paired t-test on the arousal ratings revealed that participants were more excited on trials with alerting cues compared to those without alerting cues, $t(24) = 9.5$, $p < .01$, $d_z = 2.35$, suggesting that alerting cues effectively raised the participant's arousal level (see Figure 3).

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RTs in the label-shape matching task

An ANOVA on the RTs revealed a significant main effect of label (self vs. celebrity), $F(1,24) = 92.03$, $p < .01$, partial $\eta^2 = .79$, with shorter RTs observed for self-associated shapes. The main effect of alerting-cue (with vs. without) was not significant, $F < 1$, n.s. However, the two-way interaction was significant, $F(1,24) = 38.1$, $p < .01$, partial $\eta^2 = .61$. As in Experiment 1, we further quantified the self-prioritization effect with an RT ratio. A paired t-test on the RT ratios revealed that the self-bias was stronger on trials with alerting cues compared to those without alerting cues, $t(24) = 6.70$, $p < .01$, $d_z = .81$

Accuracy in the label-shape matching task

The accuracy was above 81% in all conditions (see Table S4 in Supplemental Material). An ANOVA on the accuracies revealed a significant main effect of label, $F(1, 24) = 37.14$, $p < .01$, partial $\eta^2 = .61$, with higher accuracy observed for self-associated shapes than for celebrity-associated shapes. The main effect of alerting cue, $F(1, 24) = 2.95$, $p = .10$, and the two way interaction, $F(1, 24) = 2.56$, $p = .12$, did not reach significance.

With a mood induction procedure, Experiment 2 first put the participants in a depressive mood and then examined whether alerting cues would increase the self-prioritization effect. The results show that arousal level was higher and the self-prioritization effect was stronger when altering cues were presented.

General discussion

Previous work has shown that the self-prioritization effect observed in a label-shape matching task is modulated by moods (e.g. Jie Sui et al., 2016; Fan et al., 2016), however, it remains unclear whether this effect is primarily attributable to valence or the arousal. The present study was set out to examine this issue with a label-shape matching task. To assess the relative contribution of valence and arousal, Experiment 1 measured the self-prioritization effect in four mood states of varied valence and arousal levels. Statistically reliable effects were observed for arousal, with a stronger self-prioritization effect observed for moods of higher arousal level (see Figure 2), and importantly, this observation was not confounded by familiarity. Experiment 2 was carried out to further investigate the impact of arousal, a factor that was frequently overlooked in previous studies on the self-prioritization effect. Experiment 2 first induced a mood of low arousal level (depression) and used alerting cues to raise the participant’s arousal level on half of the trials. The results revealed stronger self-prioritization effects on trials with alerting cues (see Figure 3). Taken together, the results of the present experiments provide clear evidence that arousal plays a crucial role in the interaction between moods and self-referential biases.

Based on a series of studies, Sui and colleagues suggested that self-referential processing alters the perceptual priority of visual stimuli in a manner that mimics perceptual salience (Humphreys & Sui, 2015; Sui & Humphreys, 2015). It has also been demonstrated that arousal is associated with salience processing (e.g. Weinbach & Henik, 2014). Thus, it is reasonable to speculate that, in the present study, arousal may have modulated the salience of self-referential stimuli, which in turn affected the self-prioritization effect. This attention-based explanation is in agreement with a psychophysiological model known as the “self-attention network” model (SAN; Humphreys & Sui, 2016). This model maintains that self-referential biases emerge because the attentional response to self-related external stimuli is primed by self-representation.

One surprising finding of the present experiment was that valence appears to have little impact on the self-prioritization effect. As clearly shown in Figure 2B, the self-prioritization effect did not vary much along the valence dimension. The results presented in Figure 2D also show that the correlation between the self-prioritization effect and the valence ratings was non-significant and close to zero. These observations are in line with the notion that self-referential biases and biases towards stimuli linked to positive emotion may involve separate processing mechanisms (e.g. Stolte, Humphreys, Yankouskaya, & Sui, 2016; Jie Sui et al., 2016). One may note that, the present findings contradict the finding that associating oneself with negative personal traits can eliminate the self-prioritization effect (Ma & Han, 2012; 2010). We note that a recent ERPs study also found that negative statements linked to the self could eliminate the self-bias (Guan et al., 2014). However, these findings may as well be the results of the low arousal level of the negative moods elicited in these studies. As clearly shown in the present experiments, lower arousal level is associated with a weaker self-prioritization effect (see Figure 3).

In addition to providing new insights into the relation between emotion and self-referential biases, the present findings may also help to clarify which factors contribute to the self-prioritization effect. As suggested in previous studies, the self-referential biases can be driven by several factors, such as positive valence (Ma & Han, 2010), reward (Northoff & Hayes, 2011), and attentional saliency (Humphreys & Sui, 2015). The present findings lend little support to positive valence but instead establish arousal as a crucial factor that impacts the self-prioritization effect. However, the present failure to observe a statistical reliable effect of valence should not be taken as evidence that self-referential processing has nothing to do with valence.

Lastly but importantly, the present findings also provide insights into the relationship between emotional disorders and self-referential processing. Recent work has established a link between deficits in self-referential processing and major depressive disorders (MDD) (e.g. Liu et al., 2014; Quevedo et al., 2016). For instance, it has been revealed that the processing bias towards self-related stimuli were impaired in MDD patients (Liu et al., 2014). For depressed individuals with higher suicidal tendencies, lower level of neural activation in response to items related to themselves is observed in midline cortical structures (MCS), a self-related processing network (Quevedo et al., 2016). Based on the present findings, we speculate that the impaired self-referential bias in patients with depression may as well be attributable to some concomitant symptoms of MDD, such as low arousal level.

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Table 1. *Mean RTs for the experimental cells in Experiment 1. Numbers in the parentheses are standard deviations.*

		Serenity	Happiness	Depression	Anxiety
Match					
	Celebrity	547(44)	545(63)	550(47)	533(50)
	Stranger	557(63)	532(50)	563(47)	549(56)
	Self	496(57)	453(55)	515(67)	460(57)
Mismatch					
	Celebrity	595(57)	520(82)	592(60)	567(55)
	Stranger	578(60)	555(71)	578(55)	579(54)
	Self	597(60)	547(73)	614(53)	575(52)

Figures

Figure 1. An illustration of the label-shape matching task, see text for details. An alerting cue was presented before the label-shape pairs on the half of the trials in Experiment 2. For illustration only, stimuli are not drawn to scale.

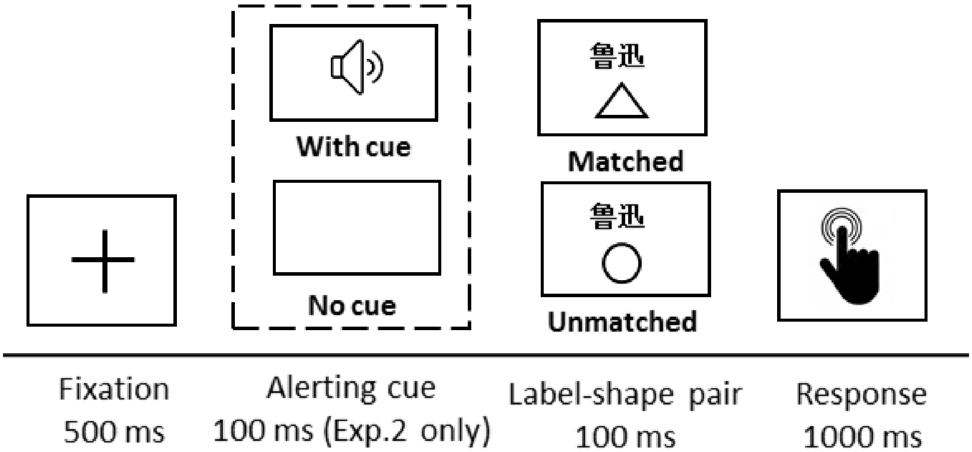


Figure 2. (A) The effects of the mood induction procedures on arousal and valence ratings. (B) The self-prioritization effect in different mood states. Values on the Y-axis are RT ratios used to quantify the self-prioritization effect (see text for details). Error

bars represent standard errors of the mean. (C) The correlation between the self-prioritization effect and the arousal ratings. (D) The correlation between the self-prioritization effect and the valence ratings. In (C) and (D), ratings from the same participant are given the same color, with corresponding lines to show the *rmcorr* fit (Bakdash & Marusich, 2017) for each participant.

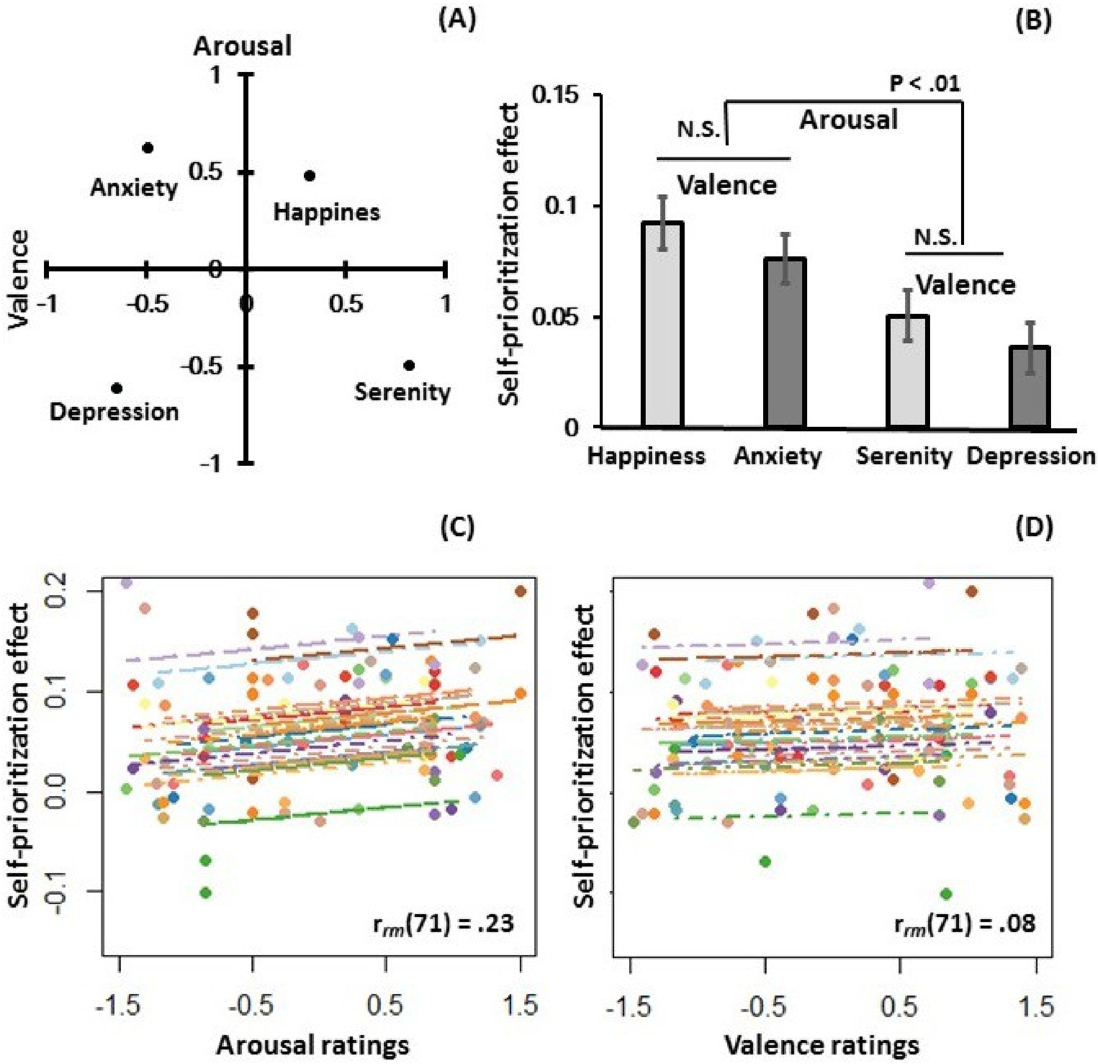
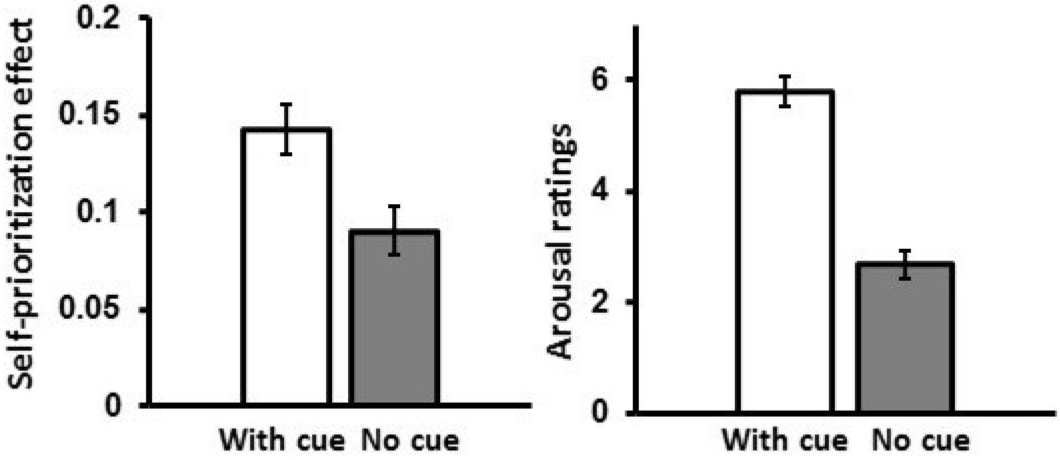


Figure 3. The self-prioritization effect and arousal ratings as a function of alerting cues (with vs. without) in Experiment 2. Error bars represent standard errors of the mean.


Self-prioritization effect
0.2
0.15
0.1
0.05
0
With cue
No cue
Arousal ratings
6
4
2
0
With cue
No cue