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Short article

Attentional orientation induced by temporarily established self-referential cues

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Self-referential stimuli such as self-face surpass other-referential stimuli in capture of attention, which has been attributed to attractive perceptual features of self-referential stimuli. We investigated whether temporarily established self-referential stimuli are different from other-referential cues in guiding voluntary visual attention. Temporarily established self-referential or friend-referential shapes served as central cues in Posner's endogenous cueing task. We found that, relative to friend-referential cues, self-referential cues induced smaller cueing effect (i.e., the difference in reaction times to targets at cued and uncued locations) when the interstimulus interval was short but larger cueing effect when the interstimulus interval was long. Our findings suggest that temporarily established self-referential cues are more efficient to capture reflexive attention at the early stage of perceptual processing and to shift voluntary attention at the later stage of perceptual processing.

Keywords: Self; Visual attention; Cueing effect.

It is well known that self-referential information can capture visual attention. For instance, people respond faster to their own than others' faces (e.g., Keenan et al., 1999; Sui, Zhu, & Han, 2006). Self-referential stimuli are harder to ignore than stimuli referenced to others even when the stimuli are task irrelevant (e.g., Brédart, Delchambre, & Laureys, 2006). These effects have been attributed

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to personal significance of self-referential stimuli that attract attention in a bottom-up fashion (Gronau, Cohen, & Ben-Shakhar, 2003). However, because self-referential materials such as one's own face and name in most cases are highly familiar to participants, it is possible that stimulus familiarity rather than self-relatedness of stimuli determines the advantage of self-referential information in attentional capture. The current work investigated whether temporarily established self-referential stimuli (e.g., shapes), which were equally familiar to participants as were temporarily established other-referential stimuli, are of advantage in guiding shift of voluntary spatial attention.

We first trained participants to associate two colourful shapes (a red and a green arrow) with the self and a friend, respectively. The arrows were then used as endogenous cues to shift participants' spatial attention to target locations in the left or right visual field. Similar to Posner's (1980) cueing paradigm, we measured behavioural performances to targets at cued and uncued locations to assess the attentional cueing effect associated with temporarily established self- and friend-referential cues. A cue presented at the central fixation produced maximum cueing effect at long stimulus onset asynchronies (SOAs, about 350 ms; Cheal & Lyon, 1991) but smaller cueing effect at short SOAs (Müller & Rabbitt, 1989). A central cue may produce two effects—that is, an early attentional capture by the cue when endogenous cues are interpreted and a late attentional shift induced by the cue following the early interpretation stage (Funes, Lupiáñez, & Milliken, 2007). The current work compared the cueing effect at both short (250-ms) and long (350-ms) SOAs to examine the difference in cueing effects between temporarily established self- and friend-referential cues at early and late stages of perceptual processing. If self-referential cues are advantageous over friend-referential cues in guiding spatial attention, we would expect that self-referential cues produce greater cueing effects than friend-referential cues in the long SOA condition in which the maximum effect of attentional shift has been observed (Cheal & Lyon, 1991; Funes et al., 2007).

Method

Participants

A total of 20 paid undergraduate students (11 males and 9 females, aged between 18 and 25 years, mean $= 21.7 \pm 2.3$ years) from the Northeast Normal University of China participated in this experiment. All were right-handed and had normal or correct-to-normal vision. Informed consent was obtained from the participants prior to the experiment. This study was approved by a local ethics committee. One participant was excluded from data analysis because of his chance-level performance in the training task.

Stimuli

Figure 1A illustrates the stimuli used in the training task, where the red and green arrows of $0.8 \times 0.8^\circ$ at a viewing distance of 60 cm were associated with the self or a friend. The association of the red and green arrows to the self or friend was counterbalanced across participants. Two white boxes of $3.8 \times 3.8^\circ$ were presented to the left and right of the arrow. The distance between the centre of the arrow and the outer edge of each box measured 5.5°. The word "You" or "Friend", measuring $3.1/3.4 \times 1.6^\circ$, was displayed below the fixation. The distance between the centre of fixation and word was 3.5°. All stimuli were shown on a grey background.

In the spatial cueing task (see Figure 1B), the stimuli were the same as those in the training task except for the following. The word "You" or "Friend" was removed from the stimulus displays. The arrow and the two boxes were shown in the centre of the screen. A target array consisting of an upright or inverted "T" embedded in the centre of eight distractor crosses was presented in one of the boxes. The target and distractor cross subtended a visual angle of $1.2^\circ \times 1.2^\circ$. We used E-prime 1.1 to present the stimuli and to collect data (Schneider, Eschman, & Zuccolotto, 2002).

Procedure

In the training session, participants were trained to associate self and friend with the two colours of the

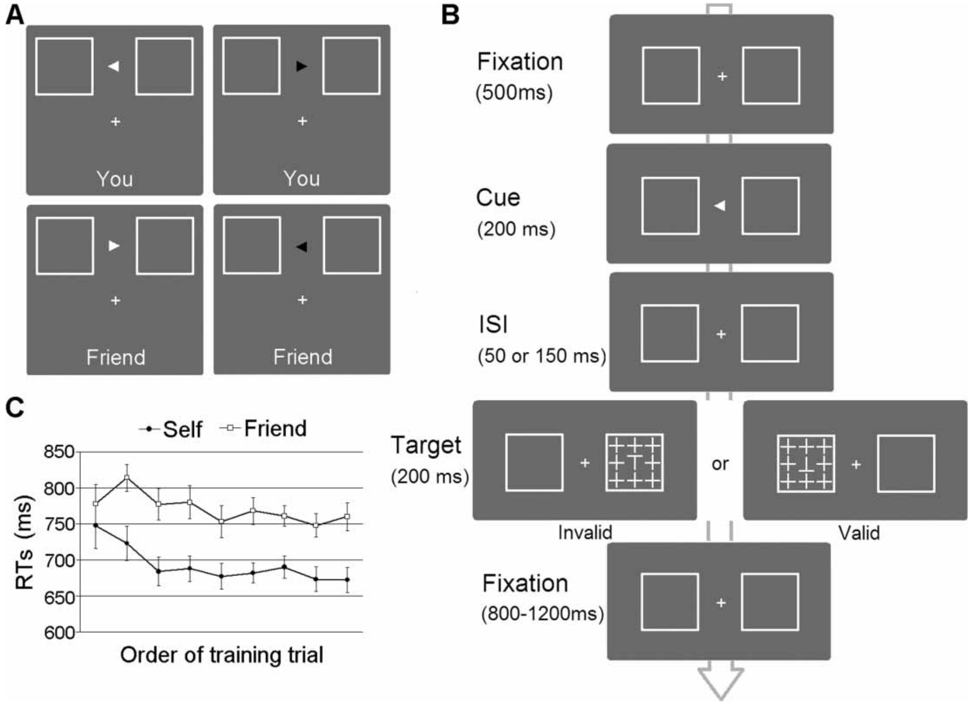

Figure 1. *(A) Stimulus displays in the association training session. The original stimuli were presented in colour. The white arrow represents red, whereas the black arrow represents green. (B) Illustration of a trial sequence in the cueing task. (C) Mean reaction times to stimuli related to the self and friend in different training sessions in the association task. Error bars represent standard errors.*

arrow. Participants were told which arrow (red or green) was associated with the self or a friend. The assignment of red or green arrow with the self was counterbalanced across participants.

On each training trial, a fixation cross was shown in the centre of the screen. After a variable interval ranging from 800 to 1,200 ms, a training stimulus was presented for 100 ms, in which the colourful arrow was presented with either the assigned person or the unassigned person. Participants had to judge whether the association between the shape and assigned person was correct by pressing one of the two buttons as quickly and accurately as possible. Feedback was given on the screen for 1,500 ms at the end of each trial. Each participant performed 224 trials, where self and friend stimuli occurred equally often in a random order. Participants were informed of their overall accuracy performance at the end of the training session.

The spatial cueing task is illustrated in Figure 1B. Each trial began with a fixation cross and two peripheral boxes for 500 ms. The fixation cross was then replaced by a central cue of 200 ms that pointed to the right or left box. The following target appeared at the cued location in 75% of the trials (valid condition) but at the uncued location in 25% of the trials (invalid condition). The interval between the onset of the cue and the target (SOA) was 250 or 350 ms. The next frame showed the fixation point and peripheral boxes for a variable interval ranging from 800 to 1,200 ms to avoid predictions about the onset of the next trial. Participants had to judge whether the target letter "T" was upright or inverted by pressing one of two keys on a keyboard. Both response speed and accuracy were emphasized.

The spatial cueing task consisted of 16 practice trials and 192 experimental trials. There were

36 valid trials and 12 invalid trials in each of the four conditions (2 types of cue × 2 SOAs).

The independent variables were stimulus category (self vs. friend) and level of training defined by the order of training trials in the association training task. The variables included in the spatial cueing task were cue type (self vs. friend), SOA (250 vs. 350), and cue validity (valid vs. invalid).

Results

The association training task

Participants responded more quickly and accurately to the arrow associated with the self than to that associated with a friend: *t*s $(18) = -5.82$ and 4.14, respectively, $ps < .001$. To examine the time course of the training procedure, we plotted reaction time (RT) data against the trial order (Figure 1C), where each point on the *x* axis represents a mean calculated over every 20 successive trials. An analysis of variance (ANOVA) of RTs showed a significant main effect of stimulus category, suggesting faster responses to the self-referential than to the friend-referential shapes, $F(1, 18) = 36.30$, $MSE = 13{,}562$, $p < .001$. However, neither the main effect of level of training $F(4.10, 65.53) = 1.95$, $MSE = 3{,}348$, nor the interaction between the two variables, $F(4.76, 76.10) = 0.95$, $MSE = 1{,}838$, was significant. The results indicate that the self-referential stimulus triggered faster response from the beginning of training and remained the same throughout the course of training.

The spatial cueing task

Overall, the response accuracy was high (90–94%). An ANOVA of response accuracy did not show significant main effect of cue type, $F(1, 18) = 1.42$, $p = .25$, or interactions involving cue type, $F(1, 18) < 1.19$, $ps > .29$.

ANOVAs of RTs showed a significant main effect of cue validity, $F(1, 18) = 28.01$, $MSE = 2{,}396$, $p < .0001$, suggesting faster responses to targets in the valid than in the invalid conditions. There was also significant main effect of SOA, $F(1, 18) = 8.73$, $MSE = 997$, $p < .01$, where responses to targets were faster in the short than in the long SOAs. Although the main effect of stimulus category was not significant, $F(1, 18) = 2.73$, $MSE = 639$, there was a significant three-way (Cue Type × SOA × Cue Validity) interaction, $F(1, 18) = 13.54$, $MSE = 1{,}013$, $p < .002$. Thus we performed two separate ANOVAs of the data in the short and long SOA conditions, respectively.

Figure 2A shows RT results in the short SOA condition. There was a significant main effect of cue type, $F(1, 18) = 7.19$, $MSE = 628$, $p < .02$, where the self-referential cue led to faster response to the target than the friend cue. There was also a significant interaction between cue type and cue validity, $F(1, 18) = 13.67$, $MSE = 487$, $p < .002$. Further analysis revealed that RTs did not differ between self- and friend-referential valid cue conditions, $t(18) = -0.49$, $p = .63$. However, responses were faster to targets at the uncued location following self-referential than following friend-referential cues, $t(18) = 4.02$, $p < .001$, suggesting that self-referential cues facilitate disengaging attention from the cued location to the uncued location.

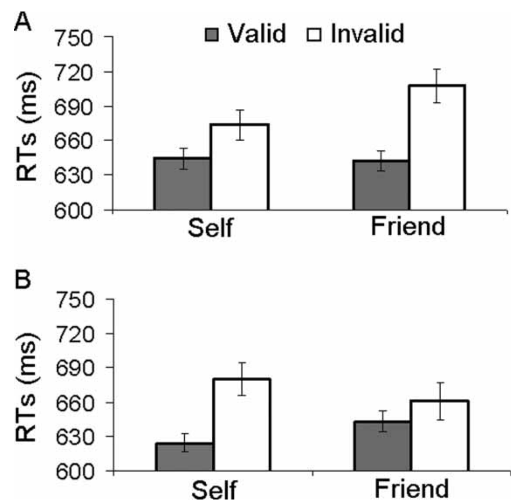

Figure 2. *Mean reaction times as a function of cue type and stimulus onset asynchrony (SOA) in the endogenous cueing task. Error bars represent one standard error. (A) Results in the short SOA (250-ms) condition. (B) Results in the long SOA (350-ms) condition.*

Figure 2B shows RT results in the long SOA condition. There was a significant interaction between cue type and cue validity, $F(1, 18) = 4.43$, $MSE = 1{,}591$, $p < .05$, where self-referential cues produced a larger cueing effect than friend-referential cues. Separate analysis confirmed that responses to targets at the cued location were faster following self-referential than following friend-referential cues, $t(18) = 2.22$, $p < .04$, whereas RTs to targets at the uncued location did not differ between self- and friend-referential cue conditions, $t(18) = -1.61$, $p = .13$.

To examine whether cue colours created any different effect, we conducted an ANOVA using the two colours as a between-subject variable, which failed to show any significant main effect of colour or interactions between this and other variables.

Correlation between the association training and cueing effect

To explore the relation between performances in the association training task and in the cueing task, we conducted a correlation analysis between the results of the two tasks. The difference between RTs for self and friend in the association training task was treated as the training effect, whereas the difference between effects of the self and friend cues in the spatial cueing task was treated as the differential cueing effect. The results showed a marginally significant correlation between the training effect and the differential cueing effect in the short SOA condition ($r = .40$, $p = .09$) but not in the long SOA condition ($r = -.35$, $p = .15$). This lack of significant correlation is probably due to the limited sample size in this study.

Discussion

The results from the training session showed that human adults respond faster to self-related stimuli than to stimuli related to others even when the self-reference is newly established. As the shapes assigned to the self and a friend were counterbalanced and equally familiar to participants, the facilitation of responses to self-related stimuli could not be attributed to any perceptual difference between the stimuli related to the self and those related to others. Such self advantage may reflect the role of the core self component independent of stimulus domains such as self-face or self-name in facilitation of behavioural performances (Northoff et al., 2006).

More importantly, we found that temporarily established self-referential stimuli were different from temporarily established friend-referential stimuli in shifting voluntary spatial attention. Moreover, the difference depended on the SOAs between the cues and targets. In the long SOA condition, self-referential cues, compared with friend-referential cues, demonstrated a larger cueing effect. As expected, self-referential cues shifted spatial attention to cued locations more effectively than did friend-referential cues and facilitated responses to targets at the cued location. In the short SOA condition, however, self-referential cues resulted in a smaller cueing effect, which mainly arose from faster responses to targets at the uncued location following self-referential than following friend-referential cues. These results fit well with the hypothesis that self-referential cues surpass friend-referential cues at different stages of visual perception. At an early stage of perception, a self-referential cue surpassed friend-referential cues to engage attention at the fixation. Consequently, attention could be redirected more easily to the uncued location and facilitate responses to targets presented there. At a later stage of perceptual processes, self-referential cues might be more efficient to guide attention to the cued location because of higher personal significance of self-related stimuli and thus facilitated responses to targets appeared at the cued location.

In sum, our results suggest that simple shapes can be associated with the self after short training procedure. Moreover, a self advantage appeared from the very beginning of the training task and remained the same over the course of training. The results support the view that the self advantage is not limited to stimulus-specific processing established by familiarity. The self advantage in behavioural performance is likely to be mediated by a tagging process in which self-relatedness/self-priority is assigned to an arbitrary stimulus. In addition, a temporarily established association between self and colourful shapes can affect the efficiency of the cues in guiding endogenous attention. Although the self-priority effect can be attenuated or even eliminated when a self-referential stimulus is presented repetitively as a task-irrelevant distractor (Harris & Pashler, 2004), our results demonstrate the advantage of a self-referential stimulus even when the stimulus was task irrelevant.

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