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Self-related shapes can hold the eyes

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Abstract

Increasing evidence suggests that individuals are highly sensitive to self-related stimuli. Here, we report two experiments conducted to assess whether two schematic stimuli, arbitrarily associated with either the self or a stranger, can shape attention holding in an oculomotor task. In both experiments, participants firstly completed a manual matching task in which they were asked to associate the self and a stranger with two shapes (triangle vs. square). Then, in an oculomotor task, they were asked to perform a saccade from the centre of the screen towards a peripheral target while either the triangle or the square were centrally presented. In Experiment 1, saccades had to be performed on each trial – irrespective of the central shape – while in Experiment 2 saccades had to be performed only when the central shape was associated with either the self or the stranger, depending on block instruction. Participants were slower to initiate a saccade away from the central shape when this was associated with the self rather than with the stranger, but this pattern of results emerged only in Experiment 2. Overall, these data suggest that stimuli associated with the self through episodic learning can hold attention when the self/other distinction is a task-relevant dimension.

Keywords: Attention, self, saccades, eye movements.

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1. Introduction

The importance of the self is unquestionable: It establishes who we are in relation to others and provides crucial insights to navigate within the social contexts successfully. In the last decades, a broad literature has extensively shown that the processing of self-related stimuli can deeply impact on our cognitive mechanisms, thus corroborating the notion that the self is a core dimension of human beings (see Sui & Gu, 2017). For instance, individuals can show stronger attentional capture towards their own face (e.g., Tong & Nakayama, 1999) or name (e.g., Yang, Wang, Gu, Gao, & Zhao, 2013), as compared to stimuli belonging to others. Furthermore, gaze-mediated orienting of attention is also stronger when cued by a physically self-similar face (e.g., Hungr & Hunt, 2012) and an eye-tracking study showed that individuals also experience more difficulties in disengaging their attention from their own face as compared to others' faces (Devue, Van der Stigchel, Brédart, & Theeuwes, 2009). Moreover, self-related information can be better stored in memory than information related to others (e.g., Sparks, Cunningham, & Kritikos, 2016; Symons & Johnson, 1997) and individuals tend to ascribe more positive attributes to both items and situations related to themselves than to others (e.g., Ma & Han, 2010).

Recently, a strong prioritization effect for self-related stimuli has been observed in response to schematic stimuli associated with the self in an arbitrary fashion (Sui, He, & Humphreys, 2012), that is an elegant way to overcome potential familiarity confounds associated with both faces and names employed in previous literature. In more detail, Sui et al. (2012) firstly asked participants to associate the self and other two individuals (e.g., a friend and a stranger) with three geometrical shapes (e.g., a triangle, a square, and a circle). Then, in a task requiring speeded manual responses, one of the three shapes appeared at the centre of the screen together with one of the three labels "you", "friend" or "stranger", and participants had to decide whether the shape and the label matched or not with the previously learned association. Overall, participants were faster and more accurate when the shape and the label matched the self as compared to the other conditions. According to Sui et al. (2012), this self-prioritization effect would reflect the modulation of visuo-

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perceptual mechanisms in a bottom-up fashion similar to what typically happens with perceptual saliency, a notion also corroborated by neuroimaging evidence (Sui, Liu, Mevorach, & Humphreys, 2015).

At the behavioural level, the potential interplay between the self-prioritization effect and visuo-perceptual mechanisms has been further confirmed by a recent study using a manual task in which a self-related shape reached visual awareness quicker than shapes associated with others (Macrae, Visokomogilski, Golubickis, Cunningham, & Sahraie, 2017). Interestingly, another recent study (Stein, Siebold, & Van Zoest, 2016) employed a similar paradigm as that used by Macrae et al. (2017), but no significant results emerged in the visual awareness task. However, in Stein et al. (2016), participants associated the self and a stranger with the same Gabor patch presented with two different orientations, rather than with two different geometrical shapes (e.g., a triangle and a square) like in Sui et al. (2012). Hence, it can be argued that the high similarity between "self" and "stranger" shapes may explain the lack of significant results. Moreover, while Stein et al. (2016) asked participants to discriminate the location of the shape, Macrae et al. (2017) asked to discriminate the identity associated with the shape, thus making the "self" a more salient task-relevant dimension. This additional difference may further explain these divergent results.

More relevant to the present work, two other recent studies explored the potential impact of self-related shapes on visuo-perceptual mechanisms by looking at saccadic eye movements, which are a more direct and sensitive index of visuo-attentional mechanisms (e.g., Kristjansson, 2011), as compared to manual responses. In a first study (Siebold, Weaver, Donk, & van Zoest, 2016), three different versions of an oculomotor visual search task were employed, in order to investigate whether self-related stimuli can impact on visual selection. In more detail, participants were asked to draw an association between two labels and two shapes, and then to make a saccade 1) towards one of the two shapes, with no instruction, 2) towards a dot-probe target appearing on one of the two shapes, or 3) towards the shape that was cued by a label presented at the beginning of the trial. The overall results did not provide any supporting evidence for the hypothesis that visual search is

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enhanced for self-related stimuli. However, it is important to note that – similarly to Stein et al. (2016) – also Siebold et al. (2016) deviated from the original paradigm of Sui et al. (2012) by asking participants to associate the self and a stranger with the same black line shown with two different orientations, rather than with two different geometrical shapes. A second study (Yankouskaya, Palmer, Stolte, Sui, & Humphreys, 2017) employed an anti-saccade task in which participants were asked to move their eyes towards a peripheral shape (i.e., pro-saccade) or towards the opposite location as that occupied by the shape (i.e., anti-saccade). The shape could be associated with either the self, a friend or a stranger. Together with the target shape, a centrally-placed label (referring to the self, a friend or a stranger) also appeared. If the shape and the label matched, then participants were asked to perform an anti-saccade, otherwise they were asked to perform a pro-saccade. The main results showed that, when both the shape and the target referred to the self (and thus an anti-saccade was required), a greater number of directional errors emerged as compared to when stimuli did not refer to the self, thus suggesting a tight coupling between the processing of self-related stimuli and the saccadic generation system.

Crucially, both in Siebold et al. (2016) and in Yankouskaya et al. (2017), participants were asked to remove the eyes from a central fixation spot and to shift their eyes towards a stimulus – varying in relevance – placed in a peripheral location, thus allowing to investigate attentional capture effects. However, several social situations also require the opposite oculomotor behaviour, that is when a relevant stimulus is presented at fixation and we have to remove the eyes from it. In this case, mechanisms ascribable to attention holding can be investigated. Surprisingly, attention holding for socially-relevant stimuli is still poorly investigated and this becomes even more evident when eye-tracking studies are considered. In this regard, a pattern of saccadic responses coherent with stronger attention holding has been reported in response to centrally-placed faces with direct gaze rather than averted/closed eyes (Dalmaso, Castelli, & Galfano, 2017; Ueda, Takahashi, & Watanabe, 2014) and centrally-placed pictures eliciting threatening rather than neutral/non-threatening emotions (e.g., Azarian, Esser, & Peterson, 2015; Belopolsky, Devue, & Theeuwes,

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2011). Overall, these results suggest that attention holding is typically associated with a more relevant social stimulus as compared to a less relevant one. To the best of our knowledge, to date no studies have explored the possibility to observe a similar attention holding effect for a schematic stimulus arbitrarily associated with the self rather than with others. Filling this gap could provide important evidence concerning the way we explore the social environment around us and further clarify and extend the range of the attentional mechanisms sensitive to the activation of a mental representation of the self even in subtle and indirect ways (e.g., through arbitrarily associated stimuli).

1.1 The present study

The aim of this work was to test whether stimuli arbitrarily associated with the self can hold attention to a larger extent with respect to stimuli arbitrarily associated with others. To this purpose, participants were asked to complete two tasks. The first task was a variant of the learning/matching task proposed by Sui et al. (2012), in which participants were asked to associate the self and a stranger with one of two geometrical shapes (a triangle and a square)[1]. After that, participants were engaged in an oculomotor task in which they were asked to look at the centre of the screen in which one of the two geometrical shapes appeared. After a variable time interval (i.e., Stimulus Onset Asynchrony, SOA) of either 100 ms or 500 ms, a peripheral target was presented either on the right or on the left with respect to the central shape and participants were asked to make a fast and

[1] In the original paradigm devised by Sui et al. (2012) a third shape, related to a highly familiar individual (i.e., best friend or mother), was employed. This allowed to control for familiarity effects, if any. However, the self-related shape led to a strong prioritization effect when both familiar and unfamiliar shapes were used as terms of comparison. For this reason, some of the subsequent studies on this topic have employed only two shapes (i.e., self vs. other; e.g., Siebold et al. 2016; Stein et al., 2016; Wade & Vickery, 2018), and the same approach was adopted also here. Furthermore, since our experiment was particularly demanding (participants completed two different tasks and had to undergo different calibration procedures related to the specific measures collected in our study, i.e., eye movements), we reasoned that a simplified version of the self-prioritization task was preferable, to prevent both an excessive task complexity and duration. Finally, because our study was aimed at testing the boundary conditions for the self-prioritisation effect, we deemed it more appropriate to focus on the two extreme conditions that are known from the literature to elicit the strongest and the weakest attention holding effect (i.e., self vs. other).

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accurate saccade towards it. In Experiment 1, saccades had to be performed on each trial – irrespective of the central shape – whereas in Experiment 2 saccades had to be performed only when the central shape was associated with either the self or the stranger, depending on block instruction. In this manner, the task-relevance of the "self" was manipulated across the oculomotor tasks of the two experiments. Overall, we expected saccadic latencies (i.e., the time needed to program and execute the saccade) to be greater in the presence of the self-related shape as compared to the shape associated with the stranger, in line with the idea that stimuli with a higher self-related saliency can induce a stronger attention holding effect (Azarian et al., 2015; Belopolsky et al., 2011; Dalmaso et al., 2017; Ueda et al., 2014). Moreover, we employed two SOAs because previous oculomotor studies (Azarian et al., 2015; Dalmaso et al., 2017; Ueda et al., 2014) found that attention holding effects were reliable only at relatively short SOAs (i.e., equal or less than 200 ms). Hence, we also predicted that the attention holding effect for the self-related shape could be more pronounced at the shorter SOA (i.e., 100 ms) than at the longer SOA (i.e., 500 ms). Finally, in line with the hypothesis that the different results reported by Macrae et al. (2017) and Stein et al. (2016) could be attributed to a different relevance of the "self" for performing the required task, we expected the predicted differences between the self- and stranger-related shapes to be more evident in Experiment 2. This predicted pattern would lend support to the view that the "self" has to be a task-relevant dimension in order to exert modulatory effects on visuo-attentional mechanisms.

2. Experiment 1

2.1 Method

2.1.1 Participants

Based on the two studies that explored the possible interplay between the self and eye movement dynamics (*n* = 12-24 in Siebold et al., 2016; *n* = 34 in Yankouskaya et al., 2017), we

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aimed to test approximately 30 naïve undergraduates with normal or corrected-to-normal vision. Data collection was ended at n = 36 (*Mean age* = 22 years, *SD* = 5.68, 15 males), when a booked testing session was terminated. The Ethics Committee for Psychological Research at the University of Padova approved the study, that was conducted in accordance with the Declaration of Helsinki. An informed consent was obtained from all participants.

2.1.2 Apparatus

Eye movements were recorded monocularly at 1000 Hz through an EyeLink 1000 Plus (SR Research). Participants sat 65 cm away from a 24-inch display PC monitor (1280 × 1024 pixels, 120 Hz). A chinrest was used to prevent head movements. Stimuli presentation was handled by Experiment Builder (SR Research). All stimuli were presented in black (R = 0, G = 0, B = 0) against a grey background (R = 180, G = 180, B = 180). Before the experimental session, each participant was asked to complete a 9-point calibration and a validation procedure.

2.1.3 Learning and Matching task

First, participants were asked to learn the association between two geometrical shapes (a triangle and a square) and two identities, namely the self and an unfamiliar individual. This was achieved by presenting the sentence "You are a triangle. A stranger is a square" on the screen for 40 seconds. The association between shape and identity was counterbalanced across participants and the two shapes were not presented in this phase. After the learning phase, the matching task started. This consisted of the presentation of a central fixation circle (diameter: 0.5°) for 500 ms (see Figure 1). After that, one of the two shapes (triangle vs. square; each 3.8° width × 3.8° height) appeared 3.5° above fixation (calculated from the centre of the fixation spot and the centre of the shape). At the same time, one of the two words ("tu" vs. "sconosciuto", meaning "you" vs. "stranger", respectively; 40-point uppercase Arial font; 2°/9° width × 1.6° height) appeared 3.5° below fixation (calculated from the centre of the fixation spot and the centre of the word). Both the shape and the

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word were selected randomly and remained visible for 100 ms. After that, a blank screen appeared and participants were asked to report, by means of a key press (counterbalanced across participants), whether the presented combination between the shape and the word matched the learned association or not. Participants were asked to respond as quickly and accurately as possible. After a correct, a wrong, or a missed response (time out: 1000 ms), a central visual feedback ("ok", "no", "too slow", respectively; 20-point uppercase Tahoma font) appeared for 500 ms. A practice block composed of 12 randomly-selected trials was followed by an experimental block composed of 200 randomly-selected trials. A short break was provided every 50 experimental trials.

[Figure 1]

2.1.4 Eye movement task

An example of trials employed in the eye movement task is depicted in Figure 2. Each trial was preceded by a drift checking procedure. This consisted of asking participants to look at a central fixation circle (diameter: 0.5°) and then the experimenter started the trial through the host PC. This procedure ensured that participants accurately fixated the centre of the screen. A successful drift checking was followed by an acoustic tone that informed participants of the imminent trial start. Each trial started with the presentation of a central fixation circle (diameter: 0.5°). After 500 ms, one of the two shapes (i.e., triangle vs. square; each 3.8° width × 3.8° height) appeared centrally. On 10% of trials, one of the two Italian words meaning "you" or "stranger" (20-point uppercase Arial font; 1°/4.5° width × 0.6° height) appeared instead of the shape, as a strategy to maintain an active representation of self vs. stranger dimensions in participants. After either 100 ms or 500 ms (i.e., SOA), a target circle (diameter: 0.5°) appeared for 1000 ms 12° either rightwards or leftwards with respect the central shape. On each trial, participants were asked to make a fast and accurate saccade towards the target. There was a practice block composed of 12

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randomly-selected trials followed by 320 experimental trials presented in random order. A short break was provided every 40 experimental trials.

[Figure 2]

2.1.5 Manipulation check

After the eye movement task, participants reported the learned association between shapes and identities by filling the blank spaces of the following sentence: "*In this experiment you were … while a stranger was …*". A wrong response (i.e., the association was not remembered) in this phase would have resulted in the exclusion of the participant data from the analyses. The whole experiment (learning phase, matching and eye movement tasks and manipulation check) lasted about 1 hour.

2.2 Results

2.2.1 Manipulation check

No participants were excluded on the basis of the manipulation check task (i.e., 100 % of correct responses).

2.2.2 Matching task

Missed responses (4.4 % of trials) and wrong responses (21 % of trials) were removed and analysed separately. Correct responses with a Reaction Time (RT) shorter than 200 ms were also removed (1.01 % of trials). Data were then analysed through three different repeated-measures ANOVAs with Shape category (2: You vs. Stranger) and Matching judgement (2: Matched vs. Nonmatching) as within-participant factors.

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As for the mean percentage of missed responses, the main effect of Shape category approached significance, $F(1, 35) = 3.255$, $p = .080$, $\eta^2_p = .085$, reflecting a trend towards fewer missed responses for the "You" shape (M = 3.99 %, SE = .719) then for the "Stranger" shape (M = 4.66 %, SE = .851). No other significant results emerged (Fs < 1.177, ps > .285).

As for the mean percentage of wrong responses, the main effect of Shape category was significant, $F(1, 35) = 60.520$, $p < .001$, $\eta^2_p = .634$, due to fewer wrong responses for the "You" shape (M = 14.821 %, SE = 2.033) than for the "Stranger" shape (M = 27.270 %, SE = 2.157), while the main effect of Matching judgement was nonsignificant ($F < 1$, $p = .799$). The interaction between the two factors was significant, $F(1, 35) = 37.022$, $p < .001$, $\eta^2_p = .514$. In Matched judgements, a two-tailed paired t-test revealed that wrong responses were fewer for the "You" shape (M = 9.422 %, SE = 1.666) than for the "Stranger" shape (M = 32.222 %, SE = 2.541; $t(35) = 8.351$, $p < .001$, $d = 1.392$). In Nonmatching judgements, the difference between the two shapes was nonsignificant, $t(35) = 1.129$, $p = .267$, $d = .188$, (see also Figure 3)[2].

As for mean RTs of correct trials, the main effect of Shape category was significant, $F(1, 35) = 50.803$, $p < .001$, $\eta^2_p = .592$, due to smaller RTs for the "You" shape (M = 593 ms, SE = 16.110) than for the "Stranger" shape (M = 643 ms, SE = 20.466), as well as the main effect of Matching judgement, $F(1, 35) = 65.767$, $p < .001$, $\eta^2_p = .653$, due to smaller RTs for the Matched pairs (M = 594 ms, SE = 17.191) than for the Nonmatching pairs (M = 642 ms, SE = 19.358). The interaction between the two factors was also significant, $F(1, 35) = 39.256$, $p < .001$, $\eta^2_p = .529$. In Matched judgements, a two-tailed paired t-test revealed that RTs were smaller for the "You" shape (M = 539 ms, SE = 13.587) than for the "Stranger" shape (M = 650 ms, SE = 23.138; $t(35) = 6.952$, $p < .001$, $d = 1.159$). In Nonmatching judgements, the difference between the two shapes

[2] Because the analysis of categorical outcomes – such as accuracy (i.e., correct vs. wrong) – could lead to spurious results (see Jaeger, 2008), the percentage of wrong responses was also analyzed by using a mixed-effect logit model. This model was computed by considering Shape category and Matching judgement as fixed effects, and participant as random effect. The results were overall consistent with those obtained through the ANOVA. In particular, the interaction between the two factors was significant, $b = -1.571$, $SE = .133$, $z = -11.856$, $p < .001$.

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approached significance, $t(35) = -1.894$, $p = .067$, $d = -.316$, reflecting a trend towards smaller RTs for the "Stranger" shape (M = 636 ms, SE = 18.74) than the "You" shape (M = 647 ms, SE = 20.369; see also Figure 3).

Overall, these results confirmed that the matching task worked properly, in line with Sui et al. (2012).

[Figure 3]

2.2.3 Eye movement task

Saccades were defined as eye movements with a velocity exceeding 30°/s and an acceleration exceeding 8000°/s^2, and with a minimum amplitude of 2°. On each trial, we extracted the first blink-free saccade performed after the onset of the target. Trials in which the word "you" or "stranger" appeared instead of the geometrical shapes were discarded from analyses, since they were added only to keep the self vs. stranger dimensions activated in participants.

Saccadic directional errors – namely saccades not performed towards the target location – were discarded and no further analysed due to their low percentage of occurrence (.95 % of trials).

Correct saccades with a starting position outside a 4° area centred on fixation (5.43% of trials) and with a latency lower than 80 ms (0.46 % of trials) or greater than 800 ms (0.02 % of trials) were also discarded. Then, median saccadic RTs were analysed through a repeated-measures ANOVA with Shape category (2: You vs. Stranger) and SOA (2: 100 vs. 500 ms) as within-participant factors. The main effect of SOA was significant, $F(1, 35) = 17.077$, $p < .001$, $\eta^2_p = .328$, due to greater latencies for the 100-ms SOA (M = 210 ms, SE = 6.859) than the 500-ms SOA (M = 191 ms, SE = 5.208), likely reflecting a foreperiod effect. No other significant results emerged (Fs < 1, ps > .394). For completeness, two-tailed paired t-tests were performed between "You" and "Stranger" shapes at each level of SOA, and no significant differences emerged (ts < 1, ps > .447;

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see also Figure 4). Nevertheless, since saccadic RTs were overall very low, we explored whether the lack of a difference between "You" and "Stranger" shapes was potentially due to a floor effect. Following a similar approach as that described by Siebold et al. (2016), saccadic RTs were clustered in 4 Bins (see also Ratcliff, 1979). Each Bin was calculated separately for each participant and experimental condition (i.e., Shape category and SOA) and contained the 25% of the total trials. Bins ranged from the lowest (Bin 1) to the highest (Bin 4) saccadic RTs. In so doing, had a floor effect affected our data, then an attention holding effect for the "You" shape could be expected at the greater Bins, namely when participants took more time to process the shape. A repeated-measures ANOVA with Shape category, SOA and Bin (1-4) was performed. However, the three-way Shape category × SOA × Bin interaction was non-significant, $F(3, 105) = 2.177$, $p = .095$, $\eta^2_p = .059$. For completeness, two further repeated-measures ANOVAs were conducted separately for each SOA. Again, the two-way Shape category × Bin interaction was non-significant either at the 100-ms SOA, $F(3, 105) = 1.570$, $p = .201$, $\eta^2_p = .043$, or at the 500-ms SOA, $F(3, 105) = .828$, $p = .481$, $\eta^2_p = .023$.

[Figure 4]

As a further attempt to uncover attention holding for the self-related shape, we conducted an explorative repeated-measures ANOVA with Shape category, SOA, and a third factor called Block (2: First vs. Second), through which we identified the first 160 trials (i.e., the first block) and the remaining 160 trials (i.e., second block). Indeed, we speculated that the expected attention holding effect for the self-related shape could be more likely detected in the first block than in the second block, in line with the notion that the impact of social manipulations on attention may decay with time when they are irrelevant for the task at hand (e.g., Dalmaso, Edwards, & Bayliss, 2016). Again, the main effect of SOA was the only significant result, $F(1, 35) = 18.687$, $p < .001$, $\eta^2_p = .348$, due to greater latencies for the 100-ms SOA ($M = 210$ ms, $SE = 6.870$) than the 500-ms SOA

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(M = 191 ms, SE = 5.130), while the main effect of Block approached significance, $F(1, 35) = 3.327$, $p = .077$, $\eta^2_p = .087$, reflecting a trend towards smaller RTs in the second block (M = 198 ms, SE = 5.817) than in the first block (M = 203 ms, SE = 5.823). No other significant results emerged (Fs < 1, ps > .473). For completeness, two-tailed paired t-tests were performed between "You" and "Stranger" shapes at each level of SOA and Block, and no significant differences emerged (ts < 1, ps > .405). Furthermore, following the same reasoning described above about a possible floor effect, another explorative repeated-measures ANOVA with Shape category, SOA, Block (1 vs. 2) and Bin (1-4) was also performed, but the critical four-way Shape category × SOA × Block × Bin interaction was non-significant, $F(3, 105) = .671$, $p = .572$, $\eta^2_p = .019$.

2.3 Discussion: Experiment 1

Two main results emerged in Experiment 1. First, in the manual matching task, we replicated the main findings reported by Sui et al. (2012), since a prioritization of the self-related shape – as compared to the shape associated with the stranger – emerged in terms of more accurate and quicker responses. Second, in the eye movement task, saccadic latency analyses did not show any significant difference between "You" and "Stranger" shapes. In particular, virtually the same saccadic latencies emerged when participants disengaged their eyes from a shape related either with the self or with the stranger, irrespective of SOA. This pattern of results would suggest that the strong association between the self and the shape practised in the matching task was not able to influence the subsequent oculomotor task. This was true even when considering the first block of trials in the eye movement task, thus minimising the possibility that the lack of significant results was due to a progressive deterioration of the association between shape and identity over time. Moreover, we also found no clear evidence supporting the possibility that a floor effect affected our data, according to distributional control analyses.

An important difference between the matching and the eye movement task employed here was that, in the former task, participants were constantly engaged in a matching comparison

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between the shape and the label whereas, in the latter task, the matching dimension was completely lacking. Indeed, participants were asked to perform a saccade irrespective of the meaning of the central stimulus. Hence, a continuous discrimination of the identity associated with the shape could be the key-factor to uncover an attention holding effect for the self-related stimulus, an idea also supported – albeit indirectly – by the existent literature on the self-prioritization effect and related phenomena (see Macrae et al., 2017; Stein et al., 2016). The potential impact of stimulus discrimination on the attention holding effect was therefore further investigated in Experiment 2, in which the two geometrical shapes were made task-relevant also in the oculomotor task.

3. Experiment 2

In Experiment 2 everything was identical to Experiment 1, with only one exception: In the oculomotor task, participants were asked to perform a saccade only in the presence of either the You or the Stranger shape, depending on instruction given at the beginning of a block of trials. In so doing, also the oculomotor task was based on a matching comparison between shape and identity. Overall, we expected to observe an attention holding effect (i.e., greater saccadic latencies) in the presence of the "You" shape as compared to the "Stranger" shape, and this was expected to be stronger at the shorter than at the longer SOA, in line with previous oculomotor evidence (Azarian et al., 2015; Dalmaso et al., 2017; Ueda et al., 2014).

3.1 Method

3.1.1 Participants

A new sample of 40 naïve undergraduates (*Mean age* = 22 years, *SD* = 4.13, 6 males) with normal or correct-to-normal vision were tested. Two participants were excluded from analyses (one left the experiment due to fatigue, one had problems with the eye tracking procedure). Hence, the final sample was composed of 38 individuals (*Mean age* = 22 years, *SD* = 4.22, 6 males). The

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Ethics Committee for Psychological Research at the University of Padova approved the study, that was conducted in accordance with the Declaration of Helsinki. An informed consent was obtained from all participants.

3.1.2 Apparatus

The apparatus was identical to that employed in Experiment 1.

3.1.3 Learning and Matching task

Both the learning and the matching tasks were identical to those employed in Experiment 1 (see also Figure 1).

3.1.4 Eye movement task

The eye movement task was identical to that employed in Experiment 1 (see also Figure 2), with the following exception: In the first block of trials (i.e., the first 160 trials), participants were asked to make a fast and accurate saccade towards the target if the central shape was associated with the self or the word “you” appeared (i.e., go trials), and to maintain the eyes on the centre of the screen if the shape was associated with the stranger or the word “stranger” appeared (i.e., no-go trials). In the second block of trials (i.e., the remaining 160 trials), participants were provided with the opposite instructions (i.e., a saccade was required only in the presence of the shape associated with the stranger or the word “stranger”). Block order was counterbalanced across participants.

3.1.5 Manipulation check

The manipulation check was identical to that employed in Experiment 1.

3.2 Results

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3.2.1 Manipulation check

No participants were excluded on the basis of the manipulation check task (i.e., 100 % of correct responses).

3.2.2 Matching task

Data were analysed in the same manner adopted in Experiment 1.

Missed responses (4.9% of trials) and wrong responses (20.9 % of trials) were removed and analysed separately. Correct responses with a Reaction Time (RT) shorter than 200 ms were also removed (1.08% of trials). Data were then analysed through three different repeated-measures ANOVAs with Shape category (2: You vs. Stranger) and Matching judgement (2: Matched vs. Nonmatching) as within-participant factors.

As for the mean percentage of missed responses, the main effect of Shape approached significance, $F(1, 37) = 4.035$, $p = .052$, $\eta^2_p = .098$, reflecting a trend towards more missed responses for the "Stranger" shape ($M = 5.319$ %, $SE = .810$) than for the "You" shape ($M = 4.342$ %, $SE = .744$), whereas the main effect of Matching judgement was significant, $F(1, 37) = 6.445$, $p = .015$, $\eta^2_p = .148$, due to fewer missed responses for the Matched pairs ($M = 4.073$ %, $SE = .685$) as compared to Nonmatching pairs ($M = 5.588$ %, $SE = .894$). The interaction was nonsignificant ($F < 1$, $p = .885$).

As for the mean percentage of wrong responses, the main effect of Shape category was significant, $F(1, 37) = 37.686$, $p < .001$, $\eta^2_p = .505$, due to fewer wrong responses for the "You" shape ($M = 15.456$ %, $SE = 2.001$) than for the "Stranger" shape ($M = 26.344$ %, $SE = 2.378$), while the main effect of Matching judgements was nonsignificant ($F = 1.157$, $p = .289$). The interaction between the two factors was significant, $F(1, 37) = 50.711$, $p < .001$, $\eta^2_p = .578$. In Matched judgements, a two-tailed paired t-test revealed that wrong responses were fewer for the "You" shape ($M = 10.240$ %, $SE = 1.801$) than the "Stranger" shape ($M = 29.587$ %, $SE = 2.666$; $t(37) =$

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7.374, $p < .001$, $d = 1.196$). In Nonmatching judgements, the difference between the two shapes was nonsignificant, $t(37) = 1.628$, $p = .112$, $d = .264$ (see also Figure 5)[3].

As for the mean latencies of correct trials, the main effect of Shape category was significant, $F(1, 37) = 32.622$, $p < .001$, $\eta^2_p = .469$, due to smaller RTs for the "You" shape (M = 594 ms, SE = 16.644) than for the "Stranger" shape (M = 634 ms, SE = 18.675), as well as the a main effect of Matching judgement, $F(1, 37) = 122.673$, $p < .001$, $\eta^2_p = .768$, due to smaller RTs for the Matched pairs (M = 584 ms, SE = 17.478) than for the Nonmatching pairs (M = 645 ms, SE = 17.644). The interaction between the two factors was also significant, $F(1, 37) = 40.527$, $p < .001$, $\eta^2_p = .523$. In Matched judgements, a two-tailed paired t-test revealed that RTs were smaller for the "You" shape (M = 541 ms, SE = 14.74) than for the "Stranger" shape (M = 626 ms, SE = 21.68; $t(37) = 6.852$, $p < .001$, $d = 1.112$). In Nonmatching judgements, the difference between the two shapes was nonsignificant, $t(37) < 1$, $p = .440$, $d = .127$ (see also Figure 5).

In line with Experiment 1, these results confirmed that the matching task worked properly (see also Sui et al., 2012).

[Figure 5]

3.2.3 Eye movement task

Data were analysed in the same manner adopted in Experiment 1.

Saccadic directional errors – namely saccades not performed towards target location – were discarded and no further analysed due to their low percentage (0.59 % of trials in the no go-trials; 1.61 % in the go trials).

[3] As in Experiment 1, the percentage of wrong responses was also analyzed by using a mixed-effect logit model (see Jaeger, 2008), with Shape category and Matching judgement as fixed effects, and participant as random effect. Also in this case, the results were consistent with those obtained in the ANOVA. In particular, the interaction between the two factors was significant, $b = -1.282$, $SE = .126$, $z = -10.104$, $p < .001$.

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The mean percentages of no-go trials in which participants executed, erroneously, a saccade towards the target (5.08 % of trials) were analysed through a repeated-measures ANOVA with Shape category (2: You vs. Stranger) and SOA (2: 100 vs. 500 ms) as within-participant factors. The main effect of SOA was significant, $F(1, 37) = 31.971$, $p < .001$, $\eta^2_p = .464$, due to more erroneous saccades executed at the 100-ms SOA ($M = 7.16$ %, $SE = .642$) SOA than at the 500-ms SOA ($M = 2.89$ %, $SE = .572$). No other significant results emerged (Fs < 1, ps > .594).

As for the go trials, saccades with a starting position outside a 4° area centred on fixation (4.73 % of trials) and with a latency lower than 80 ms (1.48 % of trials) or greater than 800 ms (0.58 % of trials) were discarded. Then, median saccadic RTs were analysed through a repeated-measures ANOVA with Shape category (2: You vs. Stranger) and SOA (2: 100 vs. 500 ms) as within-participant factors. The main effect of SOA was significant, $F(1, 37) = 505.292$, $p < .001$, $\eta^2_p = .932$, due to greater latencies for the shorter 100-ms SOA ($M = 341$ ms, $SE = 7.937$) than the 500-ms SOA ($M = 201$ ms, $SE = 5.507$), whereas the main effect of Shape was nonsignificant ($F < 1$, $p = .359$). Importantly, the interaction between the two factors was significant, $F(1, 37) = 4.216$, $p = .047$, $\eta^2_p = .102$. At the 100-ms SOA, a two-tailed paired t-test revealed that latencies were greater for the "You" shape ($M = 348$ ms, $SE = 8.666$) than for the "Stranger" shape ($M = 334$ ms, $SE = 8.848$; $t(37) = 2.134$, $p = .039$, $d = .346$). At the 500-ms SOA, the difference between the two shapes was nonsignificant, $t(37) = .793$, $p = .433$, $d = .129$ (see also Figure 6)[4].

[Figure 6]

3.3 Discussion: Experiment 2

The results of Experiment 2 can be summarized as follows: The manual matching task led to faster and more accurate matching responses for the self-related shape as compared to the shape associated with the stranger. Hence, as in Experiment 1, we successfully replicated the self-

[4] Block order had no overall effect.

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prioritization effect documented by Sui et al. (2012). In addition, in the oculomotor task, greater latencies emerged when individuals had to disengage their eyes from the self-related shape – as compared to the shape related with the stranger – and this difference was evident at the 100-ms SOA but not at the 500-ms SOA, in line with both our hypotheses and previous studies (Azarian et al., 2015; Dalmaso et al., 2017; Ueda et al., 2014).

4. General discussion

The self is a powerful social dimension that is able to shape many different human cognitive mechanisms (Sui & Gu, 2017). Recently, a strong and reliable "*self-prioritization effect*" has been observed when participants were asked to arbitrarily associate the self with a geometrical shape (Sui et al., 2012), a result then largely replicated and explored both at behavioural level (e.g., Frings, & Wentura, 2014; Fuentes, Sui, Estévez, & Humphreys, 2016; Janczyk, Humphreys, & Sui, in press;; Macrae, Visokomogilski, Golubickis, & Sahraie, 2018; Payne, Tsakiris, & Maister, 2017; Schäfer, Wentura, & Frings, 2015, 2017; Schäfer, Wesslein, Spence, Wentura, & Frings, 2016; Stolte, Humphreys, Yankouskaya, & Sui, 2017; Sui, Yankouskaya, & Humphreys, 2015; Wade & Vickery, 2018; Yankouskaya, Bührle, Lugt, Stolte, & Sui, in press) and neural level (e.g., Humphreys & Sui, 2016; Sui, Rotshtein, & Humphreys, 2013; see also Cunningham & Turk, 2017, for a review).

According to Sui and colleagues (Sui et al., 2012, 2015), this self-prioritization effect would rely on visuo-perceptual mechanisms similar to those underlying perceptual saliency, and recent studies have been carried out with the aim to explore its potential impact on both perception and attention (Macrae et al., 2017; Siebold et al., 2016; Stein et al., 2016; Yankouskaya et al., 2017). Here, we conducted two experiments with the aim to investigate whether a self-related shape can modulate attention holding. First, participants completed a manual matching task (see Sui et al. (2012), in which "You" and "Stranger" labels appeared alongside with either a triangle or a square. In both experiments, faster and more accurate responses emerged for the self-related matching. Then, participants completed an oculomotor task, in which they disengaged their eyes from a

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centrally-placed shape and were required to make a saccade towards a peripheral target. This behaviour was requested regardless of the central shape identity (Experiment 1) or in response to a specific shape-identity, depending on block instruction (Experiment 2). Saccadic latencies were greater when the central shape was associated with the self rather than with the stranger, but this pattern emerged only in Experiment 2 and only at the shorter SOA (i.e., 100 ms).

Two main considerations can be drawn from this pattern of results. On the one hand, the oculomotor task elicited an attention holding effect for the "You" shape only when participants were forced to constantly discriminate the matching between shape and identity (Experiment 2). In Experiment 1, this matching task was neither explicitly required nor necessary to perform the task, given that participants were to perform saccades irrespective of the central shape identity. The possibility that the lack of a difference between "You" and "Stranger" shapes might simply reflect a floor effect is unlikely because distributional control analyses suggested that this difference was absent irrespective of whether the fastest or the slowest saccades of each participant were considered.

In sum, the present findings suggest that discriminating shape identity might be a key-condition to unveil self-prioritization effects (see also Humphreys & Sui, 2015; Sui & Humphreys, 2015) and related phenomena. This methodological aspect could also explain the divergent results reported by Macrae et al. (2017) and Stein et al. (2016), who employed a very similar paradigm to study the impact of self-related shapes on visual awareness. However, while Macrae et al. (2017) asked participants to discriminate the identity associated with the shape – reporting a prioritization effect for the self-related shape – Stein et al. (2016) asked participants to discriminate the location of the shape, and null results emerged. A similar rationale could also be applied to explain the lack of self-related modulations in the visual search tasks employed by Siebold et al. (2016). In both their Experiments 1 and 2, participants were asked to perform a saccade towards a shape previously associated with either the self or a stranger, but the meaning of the shape was task irrelevant. An exception is provided by Experiment 3, in which the saccade had to be performed towards the

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stimulus cued by a previously-presented label, but also in this case no evidence for a self-bias emerged. However, it is important to note that the shape stimuli were always presented peripherally, and therefore the additional localization mechanisms required to complete the task may have masked the emergence of self-related modulations. In addition, it is important to remind that both Stein et al. (2016) and Siebold et al. (2016) deviated from the original task of Sui et al. (2012) by creating a self vs. other association with the same stimulus (a Gabor patch or a black line) presented with two different orientations. Hence, this simplification in stimuli may also have contributed to the null results reported by Stein et al. (2016) and Siebold et al. (2016). Indeed, the behavioural advantage expected for the self-related shape may have been abolished because the "self" and the "stranger" were – basically – associated with the same shape. On the other hand, the modulation due to the SOA on the attention holding effect for the self-related shape would confirm that this is a fast-rising phenomenon that may vanish over time. This temporal variation was expected, since the few previous studies that explored attention holding for highly-relevant social stimuli (i.e., eye contact and emotions) found reliable differences only at relatively short SOAs (i.e., equal or less than 200 ms; see Azarian et al., 2015; Dalmaso et al., 2017; Ueda et al., 2014). Interestingly, a similar temporal modulation has also been reported in studies investigating the role of social variables on gaze-mediated attentional orienting. For instance, social status, dominance and group membership can shape this form of orienting at relatively short (i.e., 200 ms) but not long SOAs (Dalmaso, Galfano, Coricelli, & Castelli, 2014; Jones et al., 2010), and this holds true also for oculomotor measures (Dalmaso, Galfano, & Castelli, 2015). Hence, the self – and other social variables – would impact the most reflexive components of attentional mechanisms, that are typically early rising and short-lasting (e.g., Müller & Rabbitt, 1989), while longer SOAs would favour the emergence of more volitional mechanisms that, in turn, would overcome the modulatory effect of the self.

Intriguingly, in recent years an emerging hypothesis has proposed that perception cannot be penetrated by higher-order top-down mechanisms (e.g., Firestone & Scholl, 2016). Following this

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view, the numerous "cognitive" modulations on perception reported in the literature could be rather explained by considering other processes, such as memory or decision and judgement strategies. Reuther and Chakravarthi (2017) have proposed that the self-prioritization effect reported by Sui et al. (2012) would arise not by shaping visuo-perceptual mechanisms but because self-related shape-label associations would be stored in memory in a stronger and more stable way as compared to associations related to others. Moreover, also the analyses conducted by Macrae et al. (2017) – that were based on a hierarchical drift diffusion model approach – provided evidence that the self-prioritization effect observed for visual awareness would mainly rely on a decisional bias rather than on a perceptual mechanism. In sum, both Reuther and Chakravarthi (2017) and Macrae et al. (2017) suggest that the nature of the self-prioritization effect may not be purely perceptual, but could rely – at least to some extent – on different mechanisms. Future studies are therefore needed to shed light on the neuro-cognitive origins of the self-prioritization effect.

To conclude, in two experiments we provided replication for the self-prioritization effect (Sui et al., 2012). Furthermore, we also observed that the self-related shape can elicit an attention holding effect as compared to the shape associated with the stranger when the self was made a task-relevant dimension. This latter evidence suggests that the self-prioritization effect – and related phenomena – are contingent on attentional control settings.

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Figure captions

Fig. 1 Example of stimuli (not drawn to scale) and trials employed in the matching task of both Experiments 1 and 2. Panel A shows a trial in which the square shape appeared together with the word “you” and a correct response was provided. Panel B shows a trial in which the triangle shape appeared together with the word “stranger” and a wrong response was provided. Participants were asked to press a button to indicate whether the shape and label combination matched the association presented in the learning phase.

Fig. 2 Example of stimuli (not drawn to scale) and trials employed in the eye movement task of both Experiments 1 and 2. Panel A shows a trial in which the square shape appeared and the target was placed rightwards. Panel B shows a trial in which the triangle shape appeared and the target was placed leftwards.

Fig. 3 Percentage of wrong responses and manual RTs for correct responses observed in the matching task of Experiment 1. A greater accuracy and smaller RTs emerged when the shape matched the “You” label rather than the “Stranger” label. No differences emerged when there was a mismatch between the shape and the label. Overall, these results confirm that the matching task worked properly. Asterisk denotes $p < .05$. ns = nonsignificant. Error bars are SEM.

Fig. 4 Saccadic RTs observed in the oculomotor task of Experiment 1. No significant differences emerged between the “You” and “Stranger” shapes at both SOAs. ns = nonsignificant. Error bars are SEM.

Fig. 5 Manual RTs and wrong responses observed in the matching task of Experiment 2. As in Experiment 1, smaller RTs and a greater accuracy emerged when the shape matched the self

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rather than the stranger. No differences emerged when there was a mismatch between the shape and the label. Overall, these results confirm that the matching task worked properly. Asterisk denotes $p < .05$. ns = nonsignificant. Error bars are SEM.

Fig. 6 Saccadic RTs observed in the oculomotor task of Experiment 2. Greater latencies emerged for the "You" shape as compared to the "Stranger" shape, but only at the 100-ms SOA. At the 500-ms SOA, no significant differences emerged between the two shapes. Asterisk denotes $p < .05$. ns = nonsignificant. Error bars are SEM.

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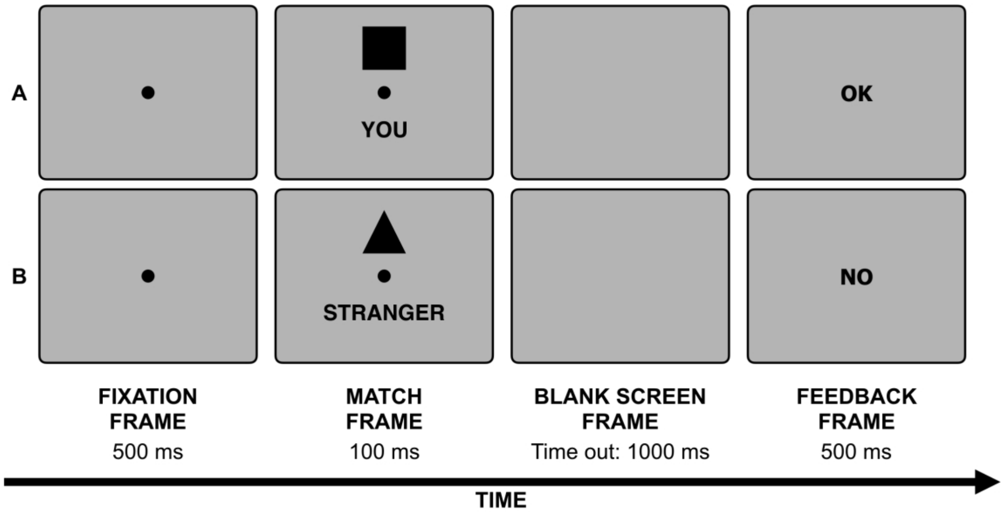

Fig. 1 Example of stimuli (not drawn to scale) and trials employed in the matching task of both Experiments 1 and 2. Panel A shows a trial in which the square shape appeared together with the word "you" and a correct response was provided. Panel B shows a trial in which the triangle shape appeared together with the word "stranger" and a wrong response was provided. Participants were asked to press a button to indicate whether the shape and label combination matched the association presented in the learning phase.

811x440mm (72 x 72 DPI)

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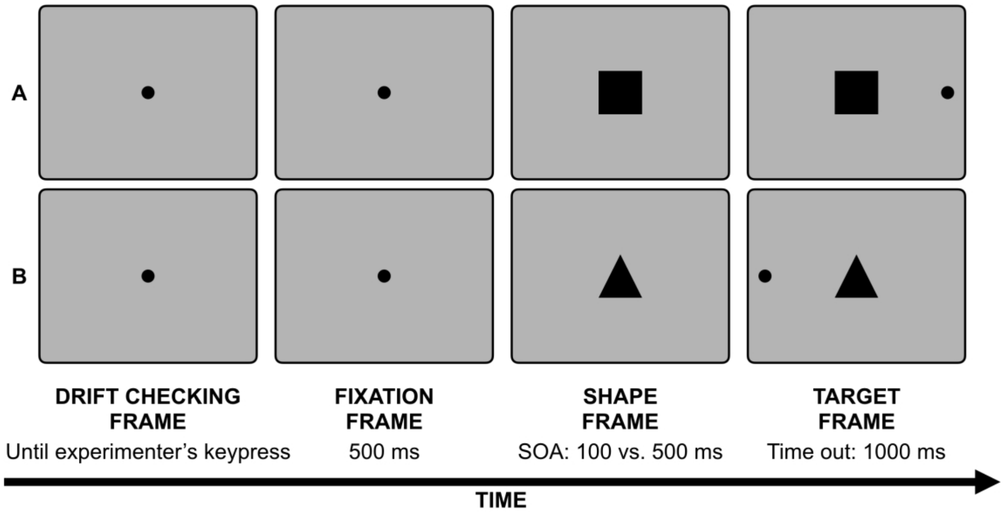

Fig. 2 Example of stimuli (not drawn to scale) and trials employed in the eye movement task of both Experiments 1 and 2. Panel A shows a trial in which the square shape appeared and the target was placed rightwards. Panel B shows a trial in which the triangle shape appeared and the target was placed leftwards.

811x440mm (72 x 72 DPI)

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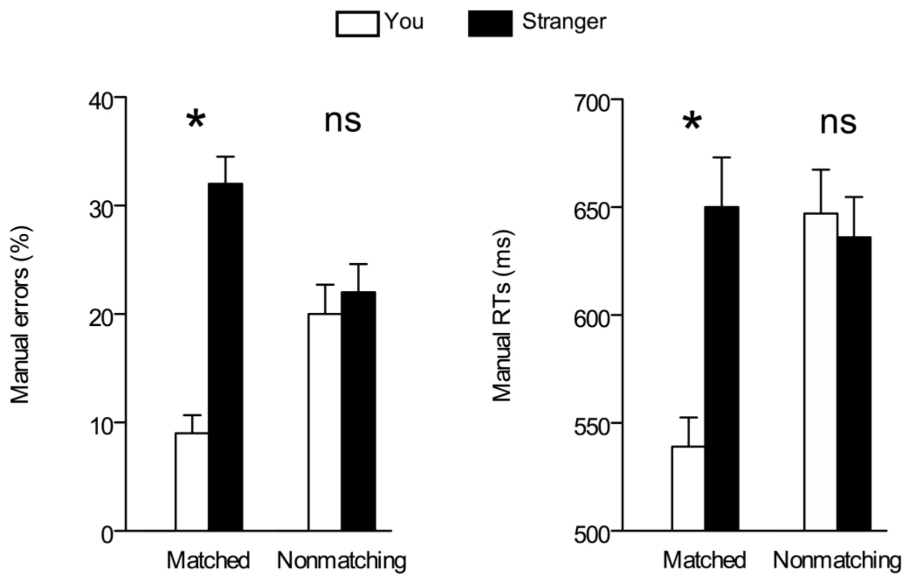

Fig. 3 Percentage of wrong responses and manual RTs for correct responses observed in the matching task of Experiment 1. A greater accuracy and smaller RTs emerged when the shape matched the “You” label rather than the “Stranger” label. No differences emerged when there was a mismatch between the shape and the label. Overall, these results confirm that the matching task worked properly. Asterisk denotes $p < .05$. ns = nonsignificant. Error bars are SEM.

250x159mm (300 x 300 DPI)

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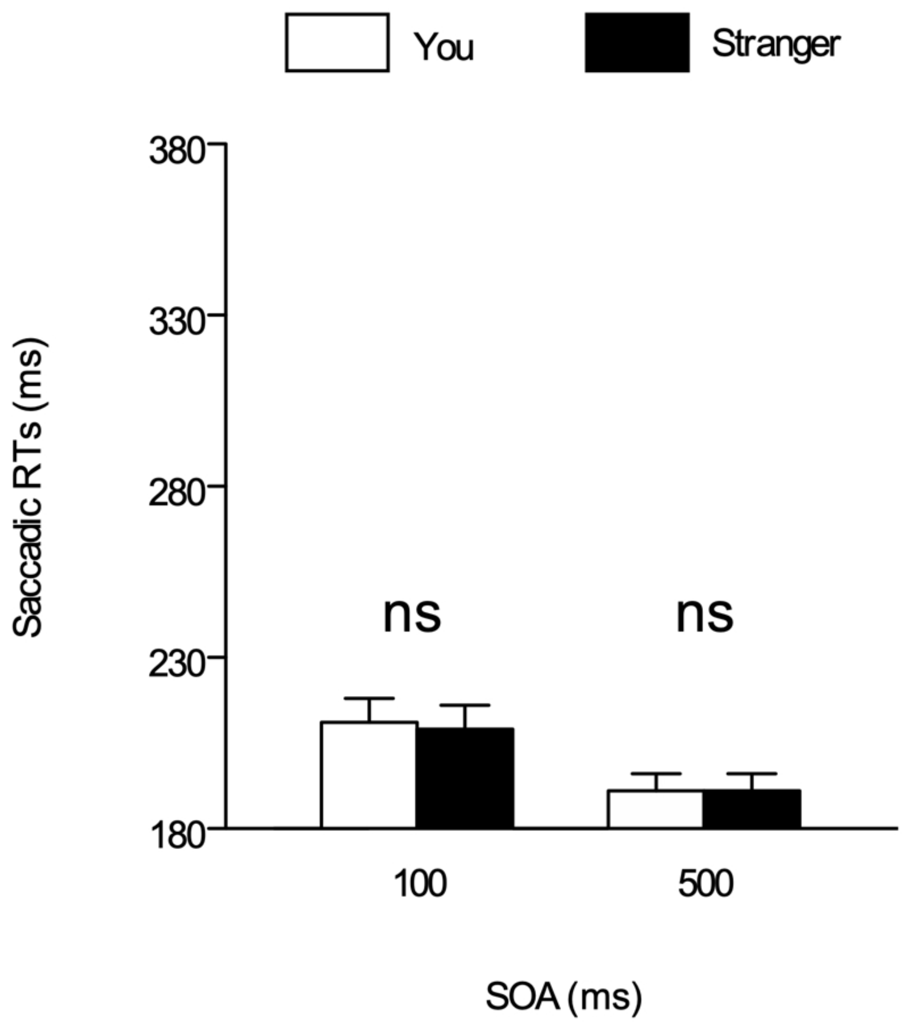

Fig. 4 Saccadic RTs observed in the oculomotor task of Experiment 1. No significant differences emerged between the "You" and "Stranger" shapes at both SOAs. ns = nonsignificant. Error bars are SEM.

74x85mm (300 x 300 DPI)

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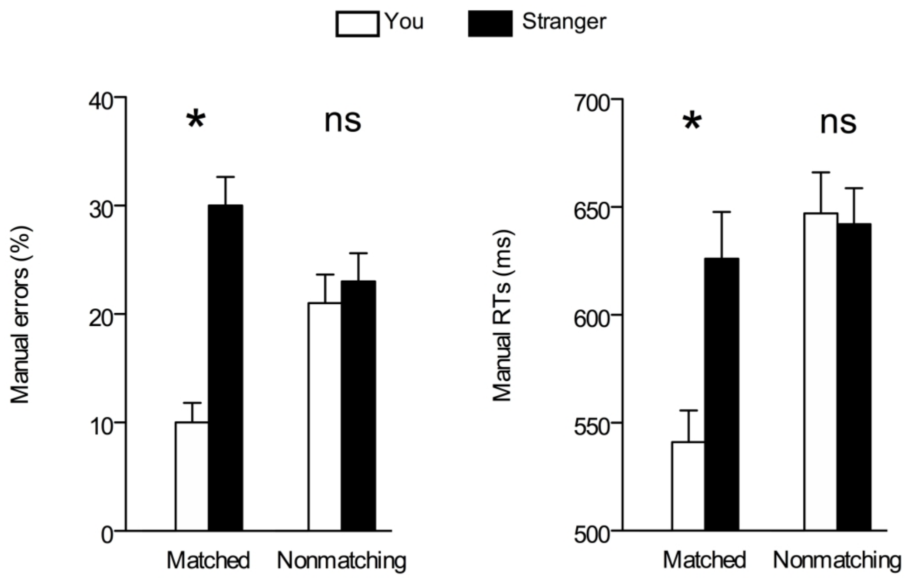

Fig. 5 Manual RTs and wrong responses observed in the matching task of Experiment 2. As in Experiment 1, smaller RTs and a greater accuracy emerged when the shape matched the self rather than the stranger. No differences emerged when there was a mismatch between the shape and the label. Overall, these results confirm that the matching task worked properly. Asterisk denotes p < .05. ns = nonsignificant. Error bars are SEM.

250x159mm (300 x 300 DPI)

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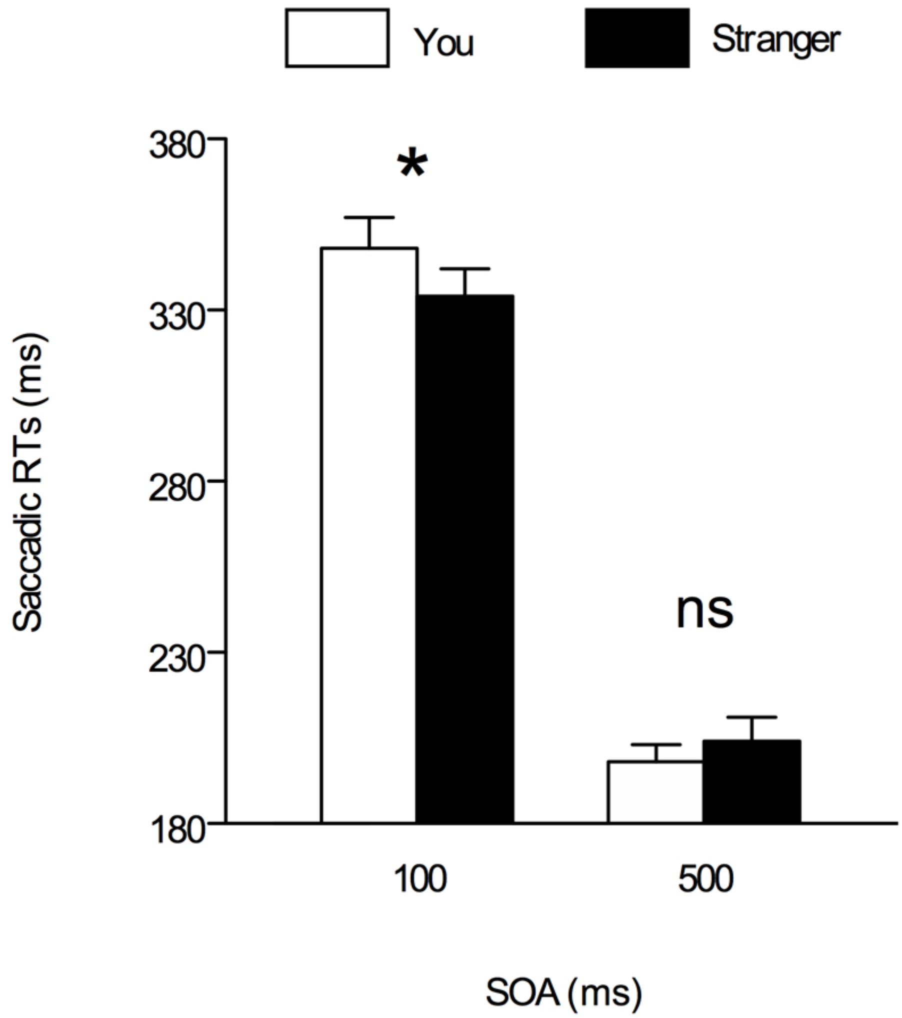

Fig. 6 Saccadic RTs observed in the oculomotor task of Experiment 2. Greater latencies emerged for the You shape as compared to the Stranger shape, but only at the 100-ms SOA. At the 500-ms SOA, no significant differences emerged between the two shapes. Asterisk denotes $p < .05$. ns = nonsignificant. Error bars are SEM.

74x85mm (300 x 300 DPI)

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