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A pre-existing self-referential anchor is not necessary for self-prioritisation

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ABSTRACT

Self-prioritisation effect (SPE) has consistently occurred in perceptual matching tasks in which neutral stimuli are paired with familiar labels representing different identities (e.g., triangle-Self, square-Friend). Participants are faster and more accurate at judging self-related shape-label pairings than the pairings associated with others. Much evidence has suggested that the SPE is driven by the self acting as an integrative hub that enhances stimulus processing (e.g., triangle). However, there is a growing debate as to whether the SPE is genuine or determined by the labels (e.g., 'me', 'you') being pre-existing self-referential anchor points. We investigated this in an adapted perceptual matching task in which participants were instructed to associate arbitrary stimulus pairs (visual features: shape and colour) with different people and then immediately carried out a colour-shape matching task. The results showed the standard pattern of the SPE in this perceptual matching task without familiar labels, indicating that the effect is not critically dependent on familiar labels. Further analysis revealed that the SPE emerged only when the complete shape-colour pairing was presented rather than individual elements (self-shape or self-colour). The theoretical implications of these findings are considered.

The concept of the self remains a prominent area of interest due to its far-reaching impact on many phenomena. The self receives particular attention in cognitive sciences as it enhances cognitive processes and promotes human behaviour (e.g., enhanced memory and efficient responses in decision making), referred to as the *self-prioritisation effect* (SPE). Recently, a testing paradigm examining the SPE has been developed to overcome the effect of stimulus familiarity, a challenging issue on the topic of self. Participants learn associations between arbitrary shapes and personal identities (You = square, Friend = triangle, Stranger = circle) before performing a matching task where they judge whether a shape and label match one of the previously learnt pairings (Sui, He, & Humphreys, 2012). Responses are quicker and more accurate when the pairing is associated with the self (Sui et al., 2012). These findings have been replicated many times across varying conditions (self vs. mother, self vs. ingroup members) (Enock, Hewstone, Lockwood, & Sui, 2020; Enock, Sui, Hewstone, & Humphreys, 2018; Frings & Wentura, 2014; Golubickis et al., 2020; Humphreys & Sui, 2015; Macrae, Visokomogilski, Golubickis, Cunningham, & Sahraie, 2017; Maire, Brochard, & Zagar, 2020; Schäfer, Wesslein, Spence, Wentura, & Frings, 2016; Sui, Rotshtein, & Humphreys, 2013; Wang, Humphreys, & Sui, 2016; Yin, Sui, Chiu, Chen, & Egner, 2019). A critical debate within the paradigm is about the effect of the labels and newly tagged shapes in perceptual matching tasks, that is, do the sensory inputs (e.g., shapes, Gabor patches) matter or is it an effect of the familiar labels (e.g., 'me', 'you', 'yourself') being pre-existing self-referential anchors? How does the self-concept expand beyond the pre-existing self-knowledge from the label to incorporate the shape? To date, the SPE has primarily been shown in the tasks where established self-related stimuli (e.g., personal labels, faces, names) are presented with neutral stimuli (but see, Woźniak & Knoblich, 2019). It, therefore, remains unknown whether the SPE occurs in tasks in which there is no pre-existing self-knowledge (e.g., labels) for binding. Instead the reference to the self must be incorporated in the integration of multiple sensory inputs (e.g., shapes and colours). This issue links to theoretical questions about self-specificity (Northoff, 2016) and the integrative self (Sui & Humphreys, 2015).

One account for the SPE is that the self acts as an integrative hub during information processing to bind external input to internal self-representation, which gives rise to the SPE (Sui & Humphreys, 2015; Sui, 2016). That is, the activation of self-representation modulates the mapping between external inputs (e.g., shapes, faces) and cognitive processes (e.g., perception, memory and decision-making), and the integration of cognitive processes. This account is supported by rich evidence from behavioural, neuroimaging and neuropsychological studies showing: self-reference helps to bind memories to their source (Rogers, Kuiper, & Kirker, 1977), increases perceptual integration

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(Keyes & Brady, 2010), forms strong associations that are difficult to overcome (Wang et al., 2016), modulates coupling between attention and decision-making (Liu, He, Rotsthein, & Sui, 2015), and increases interactions between brain regions (Sui et al., 2013; Yankouskaya & Sui, 2021). The self has therefore been likened to a 'glue' that enhances these processes. The integrative capacity is driven by the activity of a core self-representation in the cortical midline structures and the anterior cingulate cortex (Murray, Debbané, Fox, Bzdok, & Eickhoff, 2015; Northoff, 2016). Specifically, the ventral medial prefrontal cortex (vmPFC) has been implicated due to its capacity to link a variety of disparate processes when coordinating behaviour (Roy, Shohamy, & Wager, 2012). This results in enhanced coupling between brain regions and consequently mapping across cognitive processes that enhance performances. Existing evidence comes from studies that typically present established self-related stimuli that trigger self-representation. For example, a functional magnetic resonance imaging (fMRI) study using the shape-label matching paradigm showed increased activation in the vmPFC in response to self-related labels, but not to the newly self-associated shapes (Sui et al., 2013), whereas the left posterior superior temporal sulcus (LpSTS) was activated by self-associated shapes and labels (Sui et al., 2013). Dynamic causal modelling analysis showed that the strength of neural couplings from the vmPFC to the LpSTS correlated with the magnitude of the SPE (Sui et al., 2013). This result indicates that the SPE in shape-label tasks may rely on the presence of the label triggering internal self-representation via the vmPFC which results in attentional tuning to external self-related stimuli (e.g., shapes). The fMRI results have been supported by a recent transcranial direct current stimulation (tDCS) study (Yin, Bi, Chen, & Egner, 2021) that demonstrates the causal relationship between the vmPFC and SPE (but see Martínez-Pérez, Campoy, Palmero, & Fuentes, 2020; Schäfer & Frings, 2019). Although the mixed results may be due to different approaches for testing the SPE, the critical issue of whether the emergence of the SPE in the perceptual matching task depends on the presence of labels has remained unclear.

There has been growing discussion that it is the labels in the perceptual matching tasks that drive the SPE (Schäfer, Wentura, & Frings, 2017; Wade & Vickery, 2017; Woźniak & Knoblich, 2019). Evidence has demonstrated that the labels may lead to an overestimation of the SPE (Schäfer et al., 2017; Wade & Vickery, 2017). Self-related labels (e.g., 'me', 'you') received preferential processing compared to other-related stimuli as indicated by enhanced P300 amplitude in an event-related potential study (Zhou et al., 2010). Researchers argued that the labels predominantly used to represent the self differ from the other labels by imaginability, concreteness and grammar. When these differences in labels were controlled, the SPE diminished (Schäfer et al., 2017; Wade & Vickery, 2017). This evidence suggests that the SPE is driven at least in part by the labels in the task.

In contrast, Woźniak and Knoblich (2019) overcame potential effects of labels by creating a no-label task. Participants were instructed to pair unfamiliar faces with unfamiliar symbols and associate these pairs with three identities (you, a friends name and stranger) before completing the matching task. The authors reported the standard pattern of SPE, and they argued that the SPE was not dependent on the use of familiar labels (Woźniak & Knoblich, 2019). Nevertheless, the unfamiliar faces were initially paired with labels and tested over 360 trials. This initial training with the labels likely resulted in differences in short-term encoding of these associations and may have led to the unfamiliar faces becoming self-knowledge anchors in the subsequent task where the self-associated face would act as a pre-existing self-reference point (equivalent to labels in previous tasks) that the symbol would be bound to. Therefore, the SPE observed in the subsequent task may reflect the effects of learning. Can the SPE emerge with minimal training whilst controlling for the effect of labels? To test the issue, we investigated whether associations to unfamiliar stimuli (e.g., shapes, colours) with a minimal possible form of self-anchoring led to an immediate SPE in the perceptual matching task.

Based on the account of the integrative self for the SPE, it is expected that two arbitrary sensory inputs (e.g., self-shape, self-colour) will be 'holistically' bound to the self (Sui, Yankouskaya, & Humphreys, 2015) and the SPE will exist in colour-shape combination trials. A question is whether the SPE will emerge in the single feature conditions where only one self-referential feature (e.g., self-colour or self-shape) are present? Schäfer, Frings, and Wentura (2016) proposed a conjunction model suggesting that the SPE in the shape-label matching occurs when the self-relevant perceptual whole is present rather than individual parts. In this study, identity was first paired to a coloured shape and the shape-label matching task was then used. The SPE was only observed when complete matches (i.e., correct coloured shape with label) were presented. In this task the familiar label was used. It is therefore important to ascertain whether conjunction occurs in multiple self-related stimuli when there is no pre-existing self-reference anchor present.

In summary, the present study aimed to test whether the SPE occurs in a perceptual matching task without labels, where the holistic binding of multiple sensory inputs (i.e., shape and colour) is crucial for the presence of the SPE. This task consisted of two phases: instruction and matching. In the instruction phase participants were asked to associate two stimuli (a shape and colour) with three individuals (e.g., Orange+Square = You, Green+Triangle = Friend, Purple+Circle = Stranger). These associations were immediately tested in the matching stage in which colour-shape pairs were presented, and participants judged whether the pairings matched the previously learnt association. In previous literature this task is used with a single new stimulus being paired with a known label. The current design allows exploration into the SPE when two new stimuli are associated with each individual. This design is different from previous 'no-label' tasks (Woźniak & Knoblich, 2019) as minimal training is conducted and participants are told the colour and shape represent the individual in contrast to being told each stimulus individually represents the individual. This adapted task tested the SPE without issues of familiarity, imaginability, concreteness or grammatical saliency whilst examining how multiple self-related stimuli are incorporated. From the previous studies (Schäfer, Frings, & Wentura, 2016; Sui, Yankouskaya, & Humphreys, 2015), we would predict that the SPE only emerges in the colour-shape combination condition, as the self-association (shape and colour) is perceived as a whole rather than individual parts. However, if the SPE is determined by the labels, then it is expected that no SPE will present in this task.

1. Method

1.1. Participants

A priori power analysis was conducted using G*Power (Erdfelder, Faul, & Buchner, 1996). Based on the pilot study, the sample size of 44 participants was determined to be sufficient to have an effect size of 0.34 with a power of 0.80 at the standard 0.05 alpha for the critical effect of colour-shape association in reaction times (RTs). The target number of participants was set to 48 to allow for full counterbalancing of shape-colour associations and response keys. Participants' performance was checked against pre-registered chance level exclusion criteria (see osf.io/hdz47). Those who failed these tests were excluded and a replacement participant was tested. Participant replacement continued until the target number of valid participants was reached. In total, 57 participants were recruited from Prolific (www.prolific.co) and tested, with nine excluded (two female and seven male) due to performance at chance level.

The average age of the 48 participants was 27.1 years (SD = 8.1, range = 18–61) consisting of 25 females and 23 males. 44 participants were right-handed, 3 left-handed and 1 ambidextrous. All participants had normal or corrected to normal vision and were fluent in English. One participant was removed due to being an outlier (with RT falling outside of 2.5 standard deviations of the group mean). Informed consent was acquired from all participants before the experiment following procedures approved by a local ethics committee.

1.2. Stimuli

Three geometric shapes and three colour blots (circle, square and triangle; green, orange and purple, each 254 × 254 pixels) were randomly paired and then associated with three people ('self', 'friend' and 'stranger'). The pairing of colours and shapes and association with individuals were counterbalanced across participants. In half the trials, the shape was presented 250 pixels above a white fixation cross (16 × 17 pixels) and the colour presented 250 pixels below the fixation cross. In the other half, the shape and colour position were reversed. The order of positioning was random. All stimuli in white were shown against a grey background. The experiment was conducted online through the internet browser Google Chrome using Testable software (Rezlescu, Danaila, Miron, & Amariei, 2020) (the test material can be viewed online at https://www.testable.org/experiment/3784/665743/start).

1.3. Procedure

The experiment consisted of two stages: instruction and matching (see Fig. 1). In the instruction stage participants were told that a colour and shape would represent themselves, a previously named best friend and a stranger. Each representation was displayed for 20 s. The order of presentation was counterbalanced across participants. Participants were then tested on these representations. Colours and shapes were presented individually and, in their pairings, and participants selected whom they represented. Incorrect responses led to immediate retesting until a correct response was given. The instruction phase took approximately 1 min on average.

Following the instruction, the matching stage began. Participants had to judge whether colour-shape pairs matched one of the previously learnt associations. Each trial began with a fixation cross displayed at the centre of the screen for 500 ms. Subsequently, a colour-shape pairing was presented for 150 ms. The pairing could represent an individual or could be a recombination of colours and shapes from different individuals. A blank screen was presented until a response made or until 1500 ms elapsed during which participants judged whether the colour-shape pairing matched a learnt association (representing an individual) or was a mismatch (recombination of shapes and colours from different people) by pressing one of two keys ("v" or "b") as quickly and accurately as possible. The allocation of response keys was counterbalanced across participants. Following the response, feedback (correct, incorrect, too slow) was provided for 500 ms. Correct responses to match conditions stated whom the pairing represented to reinforce the learnt associations with different people. Average accuracy and RT were reported at the end of each block. Colour-shape pairing associations were retested before the next block started.

There were three practice blocks of nine trials. In the first practice block, a colour-shape pairing was displayed for 1000 ms with instruction provided above stating whether the pairing matched or not and the corresponding key (e.g; Match - so you press 'v' with your left index finger). A blank screen was next presented for 1500 ms, participants had to make a response during this time window. The second practice was identical to the first, except for a shorter (500 ms) stimulus presentation and no instructions were provided. The final block was carried out at the real speed. For the real experiment, each participant performed three blocks of 60 trials, colour-shape pairs representing self, friend, and stranger (match condition) and recombinations (mismatch condition) were randomly presented. Thus, there were 30 trials in each shape-colour match association (self, friend, stranger) and 30 in each shape-colour mismatch condition. Due to the current design treating each stimulus equally, a self-colour and friend-shape mismatch trial could be classified as a self-colour mismatch or a friend-shape mismatch. To avoid trial overlap in analysis, the single element analysis of mismatching trials consisted of self-colour, self-shape and a baseline (Table 1).

1.4. Data analysis

To examine whether the SPE occurs in the perceptual matching task without labels, we conducted repeated measure ANOVAs with one within-subject factor of association (self, friend, or stranger) for RT and accuracy in the match condition (complete configuration).

Data in the mismatch conditions were explored using repeated measure ANOVAs with one within-subject factor of single dimension mismatch association (self-shape, self-colour, or baseline) were

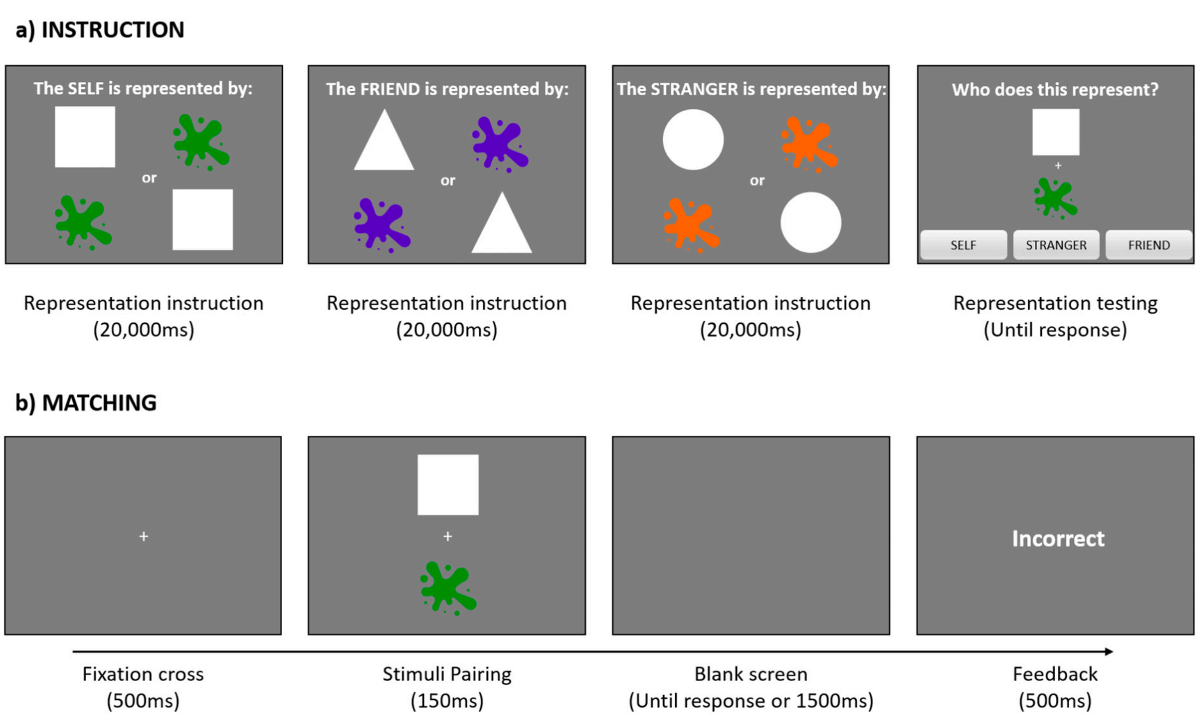

Fig. 1. Procedure of the experiment: a) an example of the instruction stage. Order of stimulus representation in the instruction is counterbalanced across participants. b) An example of a single trial during the matching task.

Table 1
The shape and colour associations and number of trials in the match and mismatch association conditions.

Condition	Association	Colour	Shape	Number of trials
Match	Self	Self	Self	30
	Friend	Friend	Friend	30
	Stranger	Stranger	Stranger	30
Mismatch	Self-colour	Self	Friend	15
		Self	Stranger	15
	Self-shape	Friend	Self	15
		Stranger	Self	15
	Baseline	Friend	Stranger	15
		Stranger	Friend	15

conducted independently for RT and accuracy. The baseline condition consists of single dimension mismatches from the friend and stranger stimuli (Table 1).

In all ANOVAs we tested for violations of the assumption of sphericity using the Mauchly's test. When it was violated the Greenhouse-Geisser correction was used. If the main effect from an ANOVA was found to be significant post hoc tests were conducted using the Bonferroni correction.

2. Results

Trials with response times shorter than 200 ms were excluded from analysis, eliminating less than 1% of all trials. Mean RT in each condition included only correct response trials. Table 2 shows the mean accuracy and RT data.

2.1. SPE in complete configurations (match condition)

A bootstrapping procedure combining accuracy and RT performance was used to examine the distribution characteristic of match judgments to each association. Accuracy and RT in match trials were paired for each participant to create a single data point (x, y). A bootstrapped data set was created using replacement with the sample size as the number of participants. The mean of the bootstrapped data set was calculated and plotted (x, y) and this was repeated 5000 times to estimate the population variation and mean. The visual demonstration shows that self-judgments fall in the bottom right corner whilst the friend and stranger judgments predominantly overlap in the upper middle section (Fig. 2a).

The bootstrapped data shows a separation for the self-association away from the other-associations, consistent with previous findings in the literature (e.g., Sui et al., 2012). To test the SPE, the data were analysed using a repeated measure analysis of variance (ANOVAs) with a within-subject factor of association (self, friend, or stranger). The results in accuracy showed a significant effect of association, $F(2,92) = 6.21$, $p < .01$, $\eta^2 = 0.12$ (Table 2). Post hoc tests using the Bonferroni correction revealed that accuracy was higher for the self ($M = 0.85$, $SD = 0.11$) than the stranger ($M = 0.77$, $SD = 0.17$) which was statistically significant ($p = .005$). Accuracy was marginally greater for the self than friends ($M = 0.80$, $SD = 0.16$, $p = .06$). There was no significant difference between friend and stranger ($p = .74$).

ANOVAS for RT also showed a significant effect of association, $F(2,92) = 7.23$, $p < .001$, $\eta^2 = 0.14$ (Table 2). Post hoc tests using the Bonferroni correction revealed that responses were faster for the self ($M = 691$, $SD = 129$) than for the friend ($M = 735$, $SD = 140$, $p = .005$). The self was also faster than the stranger ($M = 738$, $SD = 140$, $p = .01$). There was no significant difference between friend and stranger ($p = 1.00$).

Table 2
Mean reaction times and accuracy for the match conditions (self, friend and stranger).

Association	Mean RT (ms)	Accuracy
Self	691 (129)	0.85 (0.11)
Friend	735 (140)	0.80 (0.16)
Stranger	738 (140)	0.77 (0.17)

Note. RT = reaction time, Accuracy = proportion correct. Standard deviations are shown within parentheses.

The results indicate that the SPE can occur in a perceptual matching task without familiar labels. Associating two dimensions (visual features: shape and colour) with the self leads to performance enhancement in the judgement task without the presence of a familiar label.

2.2. SPE in single dimension mismatches

Mismatch trials were examined to explore whether prioritisation occurred for single self-associated elements as well as the complete configuration. The data was analysed using analysis of variance (ANOVAs) with a within-subject factor of single dimension mismatch association (self-shape, self-colour, baseline). There was no significant effect of single dimension mismatch association in accuracy, $F(2,92) = 0.37$, $p = .69$, $\eta^2 = 0.01$ (Fig. 2b), or in RT, $F(2,92) = 2.19$, $p = .12$, $\eta^2 = 0.05$ (Fig. 2c). The results suggest there is no prioritisation for single self-related elements over the single baseline condition.

3. Discussion

Previous studies have consistently demonstrated the SPE using the shape-label matching task (Enock et al., 2018; Frings & Wentura, 2014; Golubickis et al., 2020; Humphreys & Sui, 2015; Maire et al., 2020; Schäfer, Wesslein, et al., 2016; Sui et al., 2013; Wang et al., 2016). Researchers argued that the effect might be driven by the familiar labels, rather than reflecting a binding between external input (shapes) to self-representation (tuned by the labels) (Schäfer et al., 2017; Wade & Vickery, 2017; Woźniak & Knoblich, 2019). To this methodological issue and the account of the integrative self, this study adds information about whether the labels are crucial for producing the SPE, and specifically, in which way self-reference acts as an integrative hub enhancing task performance. We found the standard SPE using an adapted colour-shape matching task in which no familiar labels were presented. The SPE occurred under the 'complete' match condition rather than single dimension mismatch (shape or colour) conditions. This advantage was evident through increased accuracy and faster RT in colour-shape pairs associated with the self than the pairs associated with friends or strangers. There was no advantage in accuracy or RT for single self-dimensions (colour or shape). These data are consistent with previous literature and support the account of the integrative self (Sui & Humphreys, 2015) that self-reference increases perceptual integration (Sui, Yankouskaya, & Humphreys, 2015). They are also in line with the conjunction model (Schäfer, Frings, & Wentura, 2016; Schäfer, Wesslein, et al., 2016) that self-related stimuli are processed 'holistically' rather than by elements.

This study addresses the growing discussion within SPE research about the use of familiar labels in perceptual matching tasks. The main arguments are that the self-referential labels are grammatically salient and have stronger imaginability and concreteness, and thus these differences are the drivers of the SPE. Indeed, the use of a grammatically salient label (a pronoun amongst nouns) leads to prioritisation for any association, irrespective of whether it is linked to the self (Schäfer et al., 2017). Similarly, when words comparable in imageability and concreteness (e.g., frog) are used in a perceptual matching task, there is no significant difference between self- and other-associations (Wade & Vickery, 2017). The researchers claimed that the labels are a likely driving factor of the SPE and are at least overexaggerating the effect. Our results indicate that labels may exaggerate the SPE effect. In the original shape-label matching task the effect size (η^2 for RTs) was 0.62 (Sui et al., 2012) whereas it was 0.14 in this current study. This replicates the reduction seen in effect size from label (0.38) to non-label (0.15) tasks effect sizes in previous experiments (Woźniak & Knoblich, 2019). It

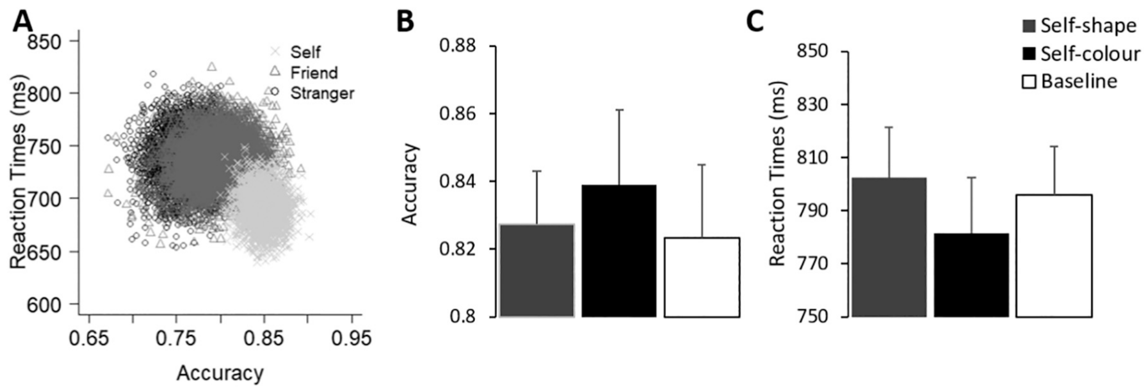

Fig. 2. A shows the bootstrapped sample means for match pairs. C and D show the accuracy and reaction time results, respectively, as a function of association in mismatches (self-shape, self-colour, or baseline). Error bars represent standard errors.

should also be worth noting that the present findings came from online tests with a smaller number of trials and a longer duration of stimulus presentation, compared to previous lab-based studies. These changes may reduce the effect size. Nevertheless, the results also demonstrate that the SPE is not solely driven by labels.

Our results support the findings from other tasks exploring the SPE in which labels were not used. For example, when self-associated shapes were used as distractors they impaired task performance in global-local tasks (Sui, Liu, Mevorach, & Humphreys, 2015). However, when treated as targets in a classification task they facilitated task performance by increasing redundancy gains compared to other-associated stimuli (Sui, Yankouskaya, & Humphreys, 2015). Our results also replicated findings of the SPE in other perceptual matching tasks in which there was no pre-existing self-referential anchor (Maire et al., 2020; Woźniak & Knoblich, 2019). However, in contrast to these previous studies that used familiar labels within a preliminary training phase, we showed that the SPE emerges in a completely arbitrary task in which associations briefly occurred in the instruction phase. In addition, our study showed that the SPE was present even when self-reference was not explicitly required (i.e., whether shapes and colours matched each other). Practically, this indirect self-referential task is useful for testing changes in altered self-presentation in clinical populations such as depression as it does not require self-reference that may recall or reflect negative experiences.

Our results support and strengthen conclusions from previous research that labels are not crucial for driving the SPE (Woźniak & Knoblich, 2019). However, a key question is where the SPE comes from? Our results support the account of the integrative self and conjunction model for the SPE (Schäfer, Frings, & Wentura, 2016; Sui & Humphreys, 2015). The current study used simple visual features to explore the binding function. Self-related neutral pairs were prioritised in the complete (match) condition, suggesting that the integration of two dimensions occurred, which leads to prioritisation in responses to the 'complete' self-related stimuli over the baseline stimuli. In line with previous findings (Schäfer, Frings, & Wentura, 2016; Sui, Enock, Ralph, & Humphreys, 2015; Sui, Liu, et al., 2015; Sui, Yankouskaya, & Humphreys, 2015), we did not find any prioritisation for single self-dimensions. The prioritisation for the colour-shape combined self-condition, but not individual parts, indicates that self-related features may access prioritised binding, even with no pre-existing self-referential point to bind to. This mirrors findings that complete matches, rather than partial matches, lead to prioritisation (Schäfer, Frings, & Wentura, 2016). Similarly, in a classification task where the same responses were required for single and double self-conditions no advantage was observed for the single self-condition (Sui, Yankouskaya, & Humphreys, 2015). These results support the account of the integrative self, specifically the increased perceptual integration of self-related neutral items.

Our finding that there is no prioritisation in single self-conditions is also in line with previous studies demonstrating the SPE only occurs in one aspect of the self (e.g., present self vs. future self, morally good self vs. morally bad self) when multi-dimensions of the self were presented (Golubickis et al., 2017; Hu, Lan, Macrae, & Sui, 2020). Self is a multi-facet construal, but there may be one self-concept activated in an ongoing task to achieve an optimal behaviour, subsequently leading to a benefit for a currently accessible concept (I am green-square against I am green or I am a square).

Another possible explanation for no benefit for the single self-features in the present study may be due to the difference in match and mismatch responses. In the present study, the single self-trials were always presented with items linked to others, which may cause difficulty in responses for self-other mixed trials. Different levels of processing may be responsible for controlling match and mismatch decisions. The self-attention network (Humphreys & Sui, 2015) proposes that in match conditions bottom-up orienting occurs, whereas in mismatch conditions top-down attentional control networks moderate bottom-up network activity. Considerable evidence has demonstrated that the SPE is related to bottom-up processing of familiar stimuli (e.g., own face or name) (Alexopoulos, Muller, Ric, & Marendaz, 2012; Tong & Nakayama, 1999; Wójcik, Nowicka, Kotlewska, & Nowicka, 2018; Woźniak & Hohwy, 2020). However, bottom-up processing appears limited to familiar stimuli, instead top-down processes have been observed in arbitrarily self-associated stimuli (Siebold et al., 2015; Stein et al., 2016; Woźniak & Knoblich, 2019). It therefore seems probable that top-down processing occurred in this experiment for match and mismatch trials as no familiar stimuli were used. The SPE observed in the matching conditions therefore suggests that top-down processing is also prioritised when processing self-related stimuli. It is likely in the mismatch conditions that top-down attentional control networks are still activated to moderate the responses due to paired stimuli associated with different individuals. Thus, the lack of the SPE in the single conditions in the present study may then reflect the interaction between the top-down control processing of the combined self- and other-related stimuli (see Humphreys & Sui, 2015 for an overview). These various accounts for the null SPE in single conditions raise some points of interest for future investigation. For example, what is the boundary condition underlying the SPE? In which way can the magnitude of the SPE be modulated? Future work may focus on mismatch trials and single self-features. Particularly, research that uses a neutral stimuli (e.g., not associated to any individual) in mismatch trials would help to ascertain whether the SPE is absent in single self-related features due to the interference of being paired with other trials, or whether it is linked to the integrative self and the prioritisation occurs due to facilitated binding.

To the best of our knowledge, this is the first study that has shown that the SPE can occur in a perceptual matching task with a minimal pre-existing self-knowledge anchor (i.e., with limited learning practice, 3 trials per association), going beyond previous assertions that the SPE only emerges due to explicit task requirements in perceptual matching tasks (Caughey et al., 1986; Falbén et al., 2019). In previous studies, the self-referential labels provide an explicit link to pre-existing self-knowledge, and they act as an anchor to which new associations are bound; self-label presentation in the perceptual matching task increased the activity in the vmPFC, which in turn primed the LpSTS (Sui et al., 2013). Although these results indicated a central role of the self-label for the SPE, the vmPFC has also been involved in other self-referential tasks (Roy et al., 2012). Therefore, it seems not vital to have an explicit self-anchor (e.g., labels) for the emergence of SPE. Our results show that the arbitrary self-related visual features were rapidly incorporated into the self-concept through the brief association instruction that subsequently led to efficient responses, even when no self-reference was explicitly required. That is, the effect of self-association can occur without the presence of pre-existing self-related reference.

Despite demonstrating the usual pattern of the SPE, our results showing the absence of friend prioritisation was not consistent with the predominant finding in previous literature that typically reported a familiar prioritisation over an unfamiliar other (stranger). This null effect may be due to greater task difficulty in the present study than in the previous studies in which participants associated one stimulus to one personal label. Also, the advantage for familiar stimuli (friend) has previously been shown exclusively to stimuli consolidated in memory rather than extending to newly learnt associations (Woźniak & Knoblich, 2019). Hence, another possibility for the lack of friend prioritisation may reflect no pre-existing friend-knowledge presented (e.g., labels) in the present study.

In conclusion, our results demonstrated that the SPE is not determined by familiar labels. Further, associations can be formed for multiple self-related elements that can be incorporated in unison. The data supports the idea that the self acts as an integrative hub enhancing information processing 'holistically' in line with the account of the integrative self and the conjunction model.

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CRediT authorship contribution statement

Naomi Lee: Conceptualization, Methodology, Software, Formal analysis, Investigation, Writing – original draft. Jie Sui: Conceptualization, Methodology, Writing – Review & Editing, Supervision. Douglas Martin: Writing – Review & Editing, Supervision.

Declaration of competing interest

None.

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