Original Articles

Try to see it my way: Embodied perspective enhances self and friend-biases in perceptual matching

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ABSTRACT

Four experiments tested whether self- and friend-biases in perceptual matching are modulated by whether stimuli are presented aligned with the participant's body and seen from the same perspective (the embodied perspective). Participants associated three colours (blue, green, and red) with three people (self, friend, and stranger) and then judged if a pairing of a colour and a personal label matched. The colour was painted on the T-shirt of an avatar. We modulated the perspective of the avatar along with its alignment with the participant's body. In Experiment 1 a single avatar appeared. In Experiments 2–4 there were two avatars, and we varied the social communicative environment between the two avatars (social vs. non-social in Experiments 2/4 vs. 3) and the distance between the two avatars and fixation (close, far, or equal in Experiment 2, 3 or 4). With a single avatar, performance on friend-match trials selectively improved when the avatar was aligned with patient's body and viewed from the participant's (first-person) perspective. The self-bias effect was unaffected by the perspective/embodiment manipulation and it was strong across all conditions. However with two avatars performance on both self- and friend-match trials improved when the target stimulus appeared on the avatar adopting a first person perspective and aligned with the participant's body, when two avatars were shown in a social-communicative context. These selective improvements disappeared when two avatars turned their back on one another in a non-communicative setting. The data indicate that self- and friend-biases in perceptual matching are modulated by both how strongly stimuli align with the participant's perspective and body, and the social communicative situation. We suggest that self-biases can reflect an embodied representation of the self coded from a first-person perspectives.

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1. Introduction

People show biased responses towards stimuli relating to themselves and people/groups relating to them rather than to other people. These effects are pervasive and modulate performance on a wide range of tasks including recall and recognition (Cunningham, Turk, & Macrae, 2008; Moradi, Sui, Hewstone, & Humphreys, 2015; Rogers, Kuiper, & Kirker, 1977; Sui & Humphreys, 2013), trait judgments (Klein, Loftus, & Burton, 1989; Rogers et al., 1977) and face discrimination (Ma & Han, 2010; Sui, Zhu, & Han, 2006). The factors that underlie these biases,

however, remain poorly understood. In the present study we report novel data which show that these biases in simple perceptual matching tasks reflect an embodied, first-person perspective based representation, with performance being boosted by seeing stimuli from the perspective aligned with the participant's body (Tsakiris, 2010;Vogeley & Fink, 2003). The data indicate that the biases draw on domain-specific information (an embodied self-representation) that qualitatively distinguishes ourselves from other people, but which can be applied also to people close to us (e.g., our best friend). This idea differs from prior work emphasizing the role of domain-general factors such as reward and emotion (basic behavioural drivers) in self-bias (Northoff & Hayes, 2011; Sui, He, & Humphreys, 2012). We consider below potential candidate factors that could contribute to biases to ourselves and close others by contrasting prior research focusing on domain-general factors (e.g., attention, reward, emotion) to the current study focusing on domain-specific biases.

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1.1. Factors contributing to self biases

There is evidence that self-related information recruits attention more strongly than other types of information, and this leads to enhanced processing of self-related stimuli (Humphreys & Sui, 2015; Sui & Humphreys, 2015). For example, Sui, Liu, Mevorach, and Humphreys (2013) used a shape association procedure that we will exploit also in the current study. They first had participants associate a shape with either themselves, their best friend or a stranger. Subsequently they presented the shapes in hierarchical (local-global) figures and had participants discriminate whether the shapes at one level (e.g., the local forms) were either (i) the self or the stranger or (ii) the friend or the stranger. There were strong interference effects from the distractor level (e.g., the global shape for local targets) when it corresponded to the self relative to when it corresponded to the friend, consistent with self-related distractors automatically attracting attention. The behavioural effects were similar to those found when the perceptual saliency of the target and distractor levels is varied (e.g., by blurring to make the global shape more salient; see Mevorach, Shalev, Allen, & Humphreys, 2009). Moreover, the neural structures involved in rejecting self-related distractor shapes overlapped with those involved in rejecting perceptually salient distractors (Sui et al., 2013), suggesting that self-related stimuli had enhanced salience - though this was related to their social significance rather than having distinctive perceptual properties.

However even if self-related stimuli are attentionally salient, what can bring about this effect? One argument is that self-biases emerge due to the influence of some 'domain general' factor which can apply to any stimulus but which happens to be more strongly linked to the self than to other people. A candidate factor here is reward, which can generally modulate the processing of many stimuli but perhaps particularly the self. For example, Northoff and Hayes (2011) have argued that self-related stimuli may be intrinsically rewarding, and so such stimuli might attract attention through their associated reward. There is evidence that differential reward values can modulate attention to visual displays. For example, Anderson and Yantis (2012) trained stimuli with different reward values and then presented them as distractors in a subsequent search task. Distractors associated with high reward attracted attention away from targets (see also Chelazzi et al., 2014; Chelazzi, Perlato, Santandrea, & Della Libera, 2013; Hickey, Chelazzi, & Theeuwes, 2010, 2014). There is also both neural and behavioural evidence indicating similarities between reward and self-processing. For example, self-related processing is associated with the activation of cortical midline structures (Northoff & Bermpohl, 2004; Schneider et al., 2008) which are also activated by reward (e.g., Izuma, Saito, & Sadato, 2008; Richards, Plate, & Ernst, 2013; Rushworth, Noonan, Boorman, Walton, & Behrens, 2011; Sescousse, Caldú, Segura, & Dreher, 2013). At a behavioural level, Sui et al. (2012) showed similar effects on perceptual matching from self- and reward-associations. Participants associated different shapes with either labels for the self, a friend or a stranger (see Sui et al., 2013, above) or with different reward values. After this the task was to decide if shape-label associations were as originally shown or re-paired. Matching performance was substantially better both for self- and for high-reward associated stimuli, relative to stimuli associated with other people or low reward. Furthermore, the self- and high reward-biases both increased when the shapes were degraded, consistent with both affecting perceptual processing of the shapes (though see Enzi, de Greck, Prösch, Tempelmann, & Northoff, 2009; Sui, Yankouskaya, & Humphreys, 2015).

We may consider a factor such as reward to be 'domain general', as it will modulate many aspects of learning and does not have any intrinsic aspect that specifically relates to the self. However, there may be 'domain specific' aspects of the self, that are particular to the self and not shared with other stimuli. One potential factor is that self-judgments recruit an embodied representation of the self that is not typically recruited by other stimuli. Decety and Grezes (2006) proposed that a domain-specific embodied representation of the self is one driver of social biases as well as any domain-general mechanisms (e.g., reward and emotion). Vogeley and Fink (2003) have similarly proposed that self-consciousness is dependent upon participants adopting an egocentric (first-person perspective) reference frame centered to the orientation of our own body. The importance of first-person perspective and embodiment for self-related judgments has been demonstrated in a number of paradigms. For example, the rubber hand illusion reflects a misattribution of body ownership to a rubber hand that is stimulated congruently with the participant's own hand (Maister, Slater, Sanchez-Vives, & Tsakiris, 2015; Tsakiris, 2010). However, the illusion can be abolished if the rubber hand is not aligned with a reference frame based on the position aligned with the participant's own hand (Costantini & Haggard, 2007). Vogeley and Fink (2003) also proposed that the orientation of the body reflects personal perspective taking, and the first personal perspective taking refers to the centeredness of one's own experiential space on one's own body, which reflects bodily self-consciousness. Also judgments about whether pairs of objects would be used together are affected by the spatial positioning of the objects (e.g., whether a knife is to the right or left of a fork), but only when the stimuli are seen from a first-person perspective and aligned with the participant's body (Yoon, Humphreys, & Riddoch, 2010). Similarly, the ability of patients with visual extinction[1] to be aware of two objects is affected by placing objects in the normal locations for action (e.g., a knife to the right of a fork), but primarily when the object locations are seen from a first-person perspective aligned with the patient's body (Humphreys, Wulff, Yoon, & Riddoch, 2010). Extinction is reduced when objects are typically used together and seen from this reference frame. Such results suggest that embodied representations of the self, specifying a first-person perspective, modulate self-related judgments.

On the other hand there is also evidence that perspectives other than our own can automatically be computed. Samson, Apperly, Braithwaite, Andrews, and Bodley Scott (2010) had participants make judgments about the number of targets that could be seen either from the participant's own perspective or from the perspective of an avatar present in the scene with the objects. They found effects of congruity (whether the avatar and the participant would see the same number of targets) not only on judgments made to the avatar but also on judgments made about the participant's own perspective. The former result would be expected if the participant's own perspective is computed automatically; however interference from the avatar's perspective suggests that the other person's perspective was also computed. Qureshi, Apperly, and Samson (2010) extended these results by showing that the effects of perspective incongruity (Samson et al., 2010) increased when participants carried out a secondary task, but this effect was constant for the self- and other-perspective judgments. The data indicate that the other's as well as the self perspective is computed automatically, affecting selection of whichever perspective is demanded for the task. There are constraints on these effects, however, Mattan, Quinn, Apperly, Sui, and Rotshtein (2015) had participants associate particular avatars with the self or with another person and then examined performance when two avatars were present (self and other person). The task was to decide on the number of dots seen by one of the avatars. Mattan reported an advan-

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[1] Patients with visual extinction are able to report a single item presented in the visual field contralateral to their lesion but fail to notice the same stimulus when an item appears at the same time on the ipsilesional side.

tage of judgement from the perspective of the self-associated avatar, indicating that, even if more than one perspective can be computed there is prioritization to the perspective associated with the self. Hence the circumstances under which there is dominance of a participant's own, embodied first person perspective remain unclear.

1.2. The present study

In the present study we examined whether there is evidence for the involvement of such a domain-specific, embodied representation when participants respond to self-related stimuli in a simple perceptual matching task and perspective information is irrelevant to the task. Using avatars we also manipulated the social, communicative context between the stimuli, to assess if effects of an embodied, first-person perspective were increased when a social, communicative context is present.

Following Sui et al. (2012) we had individuals form associations between the self, a friend or a stranger and a neutral visual stimulus (in this case a particular colour, one for each association). After this, judgments had to be made about whether the colour and label presented on a trial matched or were re-paired. The colours were presented on avatar bodies (representing the upper torso of a human form). We modulated whether stimuli are presented aligned with the participant's body and seen from the same perspective (the embodied perspective). Three colours (blue, green, and red) were associated with three people (self, friend, and stranger) and participants judged if a pairing of a colour and a personal label matched. In Experiments 1–3, the label fell below fixation and the avatar's body above. In Experiment 4, the labels were presented in-between the two avatars and the avatars in a pair faced one other. The avatar's body was depicted either facing away (the embodied, first-person perspective) or facing towards participants (the third-person perspective). Even though the avatar was irrelevant to the perceptual matching task, we assessed if judgments were affected by the perspective of the avatar. In particular, were self-related judgments enhanced if the perspective and alignment of the avatar matched that of the participant?

We report four experiments. In Experiment 1 we presented a single avatar, which appeared in a single location above fixation (see Fig. 1a). In Experiments 2 and 3 we presented two avatars and varied the spatial location of the two avatars to create a social (facing one another in Experiment 2, Fig. 1b) or non-social (turning away from each other in Experiment 3, Fig. 1c) communicative situation between the avatars. In Experiment 2, the avatar adopting a first-person perspective was presented in the location close to fixation, while the avatar adopting an embodied, third-person perspective was presented in the location distant to fixation. To contrast, in Experiment 3 the avatar with the embodied, first-person perspective fell in the location distant to fixation and the avatar adopting a third person perspective fell close to fixation. To tease apart whether the effect of the first-person embodied perspective in Experiments 2 and 3 reflected the distance between fixation and the avatar with an embodied, first-person perspective, Experiment 4 was conducted. This experiment was identical to Experiment 2 except that the personal label fell in between the two avatars, there was an equal distance between the two avatars and fixation, and the avatars maintained a socio-communicative context.

What can be predicted? When two avatars are presented, two factors may contribute to the activation of an embodied first-person representation of the self: the perspective of the avatar and its alignment with the participant's body, its location (close to, equal or distant from fixation, where the participant was attending), and the relation between two avatars (facing each other in a socio-communicative context vs. facing away from each

other). We propose that an embodied, first-person based self-representation would be activated most strongly when the target colour fell on the avatar aligned with the participant's body and perspective. Furthermore, this may be recruited most strongly with an appropriate socio-communicative context encouraging the coding of self- and other-perspectives (in Experiments 2 and 4). Under these conditions we predict that the self-advantage would increase when the self-related colour falls on the avatar with a first-person perspective. Experiment 4 ensured that any modulation of the self-advantage by re-positioning the avatars (e.g., in Experiment 3, where the avatars face away from one another) was not due to a confound based on the distance of the first- and third-person perspective avatars from fixation (as the embodied, first-person perspective avatar fell further from fixation in Experiment 3 vs. Experiment 2). In Experiment 4, by having the personal label fall in between the two avatars, were move any effects of distance from fixation while maintaining the presence of a socio-communicative context.

The predictions for Experiment 1, when a single avatar was presented, are less clear. While, as we have noted above, there is evidence for an embodied first-person perspective mediating self-related judgments (Costantini & Haggard, 2007; Mattan et al., 2015; Yoon et al., 2010), there is also evidence that perspective coding can be flexible and not in all cases confined to a first-person viewpoint (Ramsey, Hansen, Apperly, & Samson, 2013; Samson et al., 2010). Notably, under appropriate conditions there can be automatic coding of another person's perspective (Samson et al., 2010). This apparent automatic coding of the other's perspective may also help participants rapidly impose their own perspective on that of the other person supporting judgments such as whether a stimulus is in front of or behind another person (Kessler & Rutherford, 2010) – an argument in line with the mirror neuron account of processing (Uddin, Iacoboni, Lange, & Keenan, 2007).

Here we assessed whether presenting stimuli from an embodied first-person perspective influenced self-biases in a perceptual matching task when perspective information was irrelevant to the task. With a single avatar, then, we predict that the effects of implicit first- vs. third-person perspective may be weak. One possibility was that an embodied self representation may be recruited in both the first- and third-person perspective conditions (cf. Samson et al., 2010), On the other hand, even when researchers have found evidence for automatic coding of the other's perspective (Samson et al., 2010), overall judgments remain slower and more error prone for judgments about the other's relative to the participant's own perspective, consistent with a default selection of a first-person reference frame. This default selection may particularly influence performance when a second avatar is present adopting a different perspective, so that stronger effects of perspective emerge when there are two rather than one avatar.

What about responses to friend-related stimuli? Here there are at least three possibilities. One is that our representation of a close friend also incorporates information about a first-person perspective; we literally represent things from our friend's point of view. This would be consistent with there being representational overlap between ourselves and a friend (e.g., see Swann, Jetten, Gómez, Whitehouse, & Bastian, 2012). A second is that a close friend can activate our self representation, which reflects an embodied first-person perspective, so that we code the 'other' from our own viewpoint, consistent with a mirror neuron account of processing (Gallese & Goldman, 1998). In both cases we predict that effects of perspective may emerge for friend- as well as for self-related stimuli. The third possibility is that friend-related stimuli do not activate representations where viewpoint is coded, in which case no effects of the avatar's perspective are predicted. It is also possible that effects of perspective may even be stronger for the friend- than for the self, if a strongly activated self representation (i.e., for
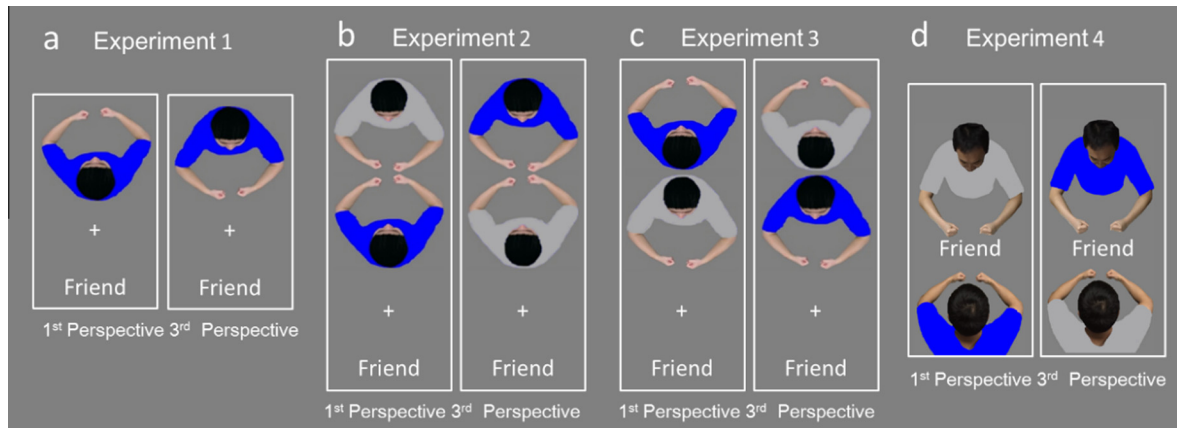
Fig. 1. The examples of stimuli used in Experiments 1–4 (a–d) (friend condition).

self-related stimuli) can be rapidly imposed on a new perspective (particularly in the single avatar condition). We evaluated these possibilities by testing matching performance with friend- as well as self-associated stimuli. A condition in which a colour was associated with a stranger label served as the baseline.

2. Experiment 1: Effects with a single avatar

2.1. Material and method

2.1.1. Participants

27 undergraduate and graduate students took part (15 males, ages 18–33 years, mean age 23.41 ± 4.46 years). All participants had normal or corrected-to-normal vision. Informed consent was obtained from all individuals prior to the experiment according to procedures approved by a local ethics committee.

2.1.2. Stimuli and tasks

Three colours (blue, green, and red) were assigned to three people (friend, self, and stranger) and mounted on the T-shirt of an avatar. The avatar subtended a visual angle of $5° \times 4.28°$ it was presented above a white fixation cross ($0.8° \times 0.8°$) at the centre of the screen. A label 'You', 'Friend', or 'Stranger' ($1.76°/2.52° \times 1.76°$ of visual angle) was displayed below the fixation of cross. The distance between fixation and both the centre of the avatar and the label was $2.9°$. An avatar was presented either facing the participants (third-person perspective) or with its back to the participants (first-person perspective). Stimuli were shown on a grey background (see Fig. 1a). Participants were not informed about the avatars in order to assess the implicit effect of embodied sensory processing on biases to the self and other people. The task was to judge whether the colour of the avatar's T-shirt and the label matched their original assignments or not (Sui et al., 2012). The experiment was run on a PC using E-prime 2.0.8. The stimuli were displayed on a 22-in monitor (1024×768 at 100 Hz).

2.1.3. Procedure

Participants were first instructed to associate three colours to people – one to the self, one to a named best friend, and one to a stranger (Sui et al., 2012). The particular combinations of colours and labels were counterbalanced across participants. For example, a participant was told that blue represents your best friend – Mary; you are green; and red represented a stranger. The avatar was not presented during the instruction. This took about 1-min. After this participants carried out a colour-label matching task, where they judged whether pairings of the colour and the label matched or

not. Each trial started with the presentation of a 500 ms central fixation cross, followed by the pairing of a colour and label for 100 ms. Half the pairings conformed to the instruction (match trials), and the other pairs had re-combined colours and labels (mismatch trials). The order of the combinations (which colour was paired with which label) on mismatch trials was counterbalanced across labels; for example, green (friend) was re-paired with either of two mismatched labels 'You' and 'Stranger'. The next frame was a blank with a range of 800–1200 ms (to capture the response). Participants were encouraged to press one of the two responses keys as quickly and accurately as possible within this last timeframe. Subsequently, written feedback (correct, incorrect, or slow!) was given in the centre of the screen for 500 ms. Participants were also informed of their overall accuracy performance at the end of each blocks. There were 6 blocks of 120 trials following 12 practice trials, and 60 trials in each condition.

2.1.4. Data analysis

Separate data analyses were conducted for the match and mismatch trials (organized according to the colour of the stimulus) as the different responses were made to these two types of stimuli. We conducted repeated-measures ANOVAs with two within-subject factors – association (self, friend, or stranger) and perspective (first- vs. third-person perspective). There was no trade-off between reaction times (RTs) and accuracy performance for any condition. We reported data on RTs and d prime respectively. We calculated the d prime as our original paper (Sui et al., 2012) in terms of the hits ('yes' responses to colour-label match pairs) and false alarms ('yes' responses to colour-label mismatch pairs, based on the colour assigned to the avatar), in order to calculate the sensitivity to the target colours. We tested if there is an enhanced sensitivity to the colour being associated with the self. Holm-Bonferroni corrections for $\alpha = 0.05$ were applied to all multiple comparisons (Holm, 1979).

2.2. Results and discussion

RTs. A repeated-measures ANOVA for matched trials showed a significant main effect of association, $F(2,52) = 28.83$, $p < 0.001$, $\eta^2 = 0.52$, there were faster responses to the matched self than to the matched friend ($p < 0.001$) and stranger ($p < 0.001$) trials; friend-associated stimuli were also faster than stimuli associated with a stranger ($p = 0.004$). The main effect of perspective was also significant, $F(1,26) = 8.49$, $p = 0.007$, $\eta^2 = 0.25$ due to faster responses to the first- than to the third-person perspective. The main effects were qualified by a significant interaction of association and perspective, $F(2,52) = 3.22$, $p = 0.048$, $\eta^2 = 0.11$ (Fig. 2a).
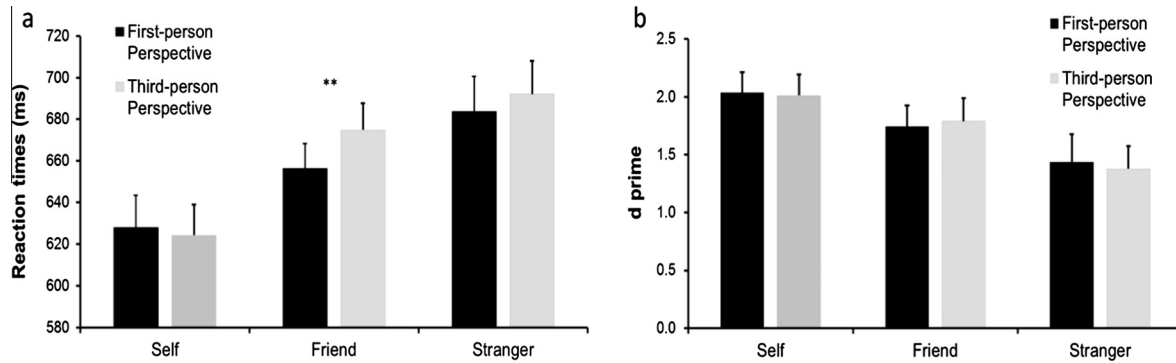
Fig. 2. The mean performance of Reaction times and d prime in Experiment 1. (a) The RTs in match trials as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective). (b) d prime as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective). Error bars represent standard errors.

Paired sample *t* tests for each type of association revealed that, compared to third-person perspective stimuli, first-person perspective stimuli facilitated matching responses to the friend association, $t(26) = -3.18$, $p = 0.004$. In contrast, the perspective of the avatar did not affect responses to either the self ($t(26) = 0.75$, $p = 0.46$) or the stranger ($t(26) = -1.34$, $p = 0.19$) association.

In order to assess how perspective modulated perceptual matching, the interaction of association and perspective was examined separately for the first- and third-person perspective trials. For the first-person perspective trials, there was a significant effect of association, $F(2,52) = 18.86$, $p < 0.001$, $\eta^2 = 0.42$, reflecting faster responses to the self ($t(26) = -5.742$, $p < 0.001$) and friend stimuli ($t(26) = -3.322$, $p = 0.003$) than to the stranger stimuli, along with faster responses to the self than to the friend trials ($t(26) = 3.076$, $p = 0.005$). There was also a significant effect of association for third-person perspective stimuli, $F(2,52) = 26.96$, $p < 0.001$, $\eta^2 = 0.50$. In this case there was a self-advantage relative to the friend ($t(26) = 5.9$, $p < 0.001$) and stranger ($t(26) = -5.918$, $p < 0.001$) trials, but no difference between the friend and stranger trials ($t(26) = -2.037$, $p = 0.052$).

An ANOVA for mismatch trials failed to show any significant effects, $F < 2.15$, $p > 0.15$ (Table 1).

The results indicated that the perspective of the single avatar did not affect the self-bias effect but it did alter the friend-biases, enhancing performance in the first-person compared to in the third-person perspective condition.

d prime. Accuracy performance is illustrated in Table 2. d prime was computed by taking performance on match trials and mismatch trials where the same colour was presented (Sui et al., 2012). A two-way ANOVA with association and perspective demonstrated a significant main effect of association, $F(2,52) = 17.90$, $p < 0.001$, $\eta^2 = 0.40$; there were larger d prime values for self ($t(26) = 5.323$, $p < 0.001$) and friend ($t(26) = 3.928$, $p = 0.001$) associations than for the stranger association, along with faster responses to the self than to the friend trials ($t(26) = -2.535$, $p = 0.018$) (Fig. 2b). This result is consistent with prior data (Sui et al., 2012). No significant effects of perspective and no interaction between association and perspective were observed ($F < 0.03$, $p > 0.88$). d prime was not affected by the perspective of the avatar.

Presenting the avatar in a first-person perspective affected the speed of making simple perceptual matching judgments for a colour and a label, even though the avatar was irrelevant to the primary task. The effect took a particular form, benefitting responses to friend-related stimuli but not those to self- and stranger-related items. One argument is that the benefit to the friend-related stimuli arose because, with the single avatar, stimuli affectively close to the participant (friend-related items) activated a default embodied first-person perspective related representation

Table 1
The mean and standard deviation (in brackets) of reaction times for colour-based match and mismatch trials as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective) in Experiments 1–4.

Experiment	Match	Perspective	Association		
			Self	Friend	Stranger
Experiment 1	Match	First	628(61)	656(79)	683(85)
		Third	624(65)	674(76)	692(81)
	Mismatch	First	731(72)	730(81)	717(79)
		Third	732(79)	729(84)	715(71)
Experiment 2	Match	First	624(69)	676(71)	722(76)
		Third	646(68)	694(73)	723(79)
	Mismatch	First	743(55)	749(60)	728(60)
		Third	740(59)	745(60)	739(65)
Experiment 3	Match	First	672(78)	719(57)	748(65)
		Third	657(68)	708(59)	744(62)
	Mismatch	First	767(67)	765(76)	758(57)
		Third	774(65)	768(67)	752(63)
Experiment 4	Match	First	457(59)	488(65)	522(70)
		Third	468(51)	497(70)	516(75)
	Mismatch	First	535(74)	538(70)	519(77)
		Third	537(78)	533(73)	525(69)

of the self, which facilitated shape matching (e.g., by increasing attention to the stimuli). This did not take place with stimuli more distant from the self (stranger-related stimuli). A second possibility is that participants have a representation of close friends that is also coded from a first-person perspective, and this enhances response to friend-related stimuli. This would be consistent with the idea that there is representational overlap between the self and a close other (Swann et al., 2012).

In contrast to the effects with the friend, there was no effect of perspective for self-related items which were responded to rapidly in all cases. It may be that the match for self-related items was simply too fast to enable an effect of the avatar to emerge. A somewhat different account is that the embodied representation of the self may be recruited both for first- and third-person perspective avatars, due to the automatic coding of both perspectives in relation to the self (Samson et al., 2010). Alternatively, participants may hold an expectation for the self with the self-representation being imposed irrespective of the perspective of the avatar; or at the lack of the effect for self-related stimuli may reflect attention being captured by the head of the self-related avatar when seen from an embodied, first-person representation (e.g., Samson et al., 2010; Senju & Johnson, 2009). This may subsequently disrupt the ability to match the T-shirt and label. These ideas were tested further in Experiment 2.

In Experiment 2 we employed two avatars, each adopting a different perspective. Under these circumstances we predicted that

Table 2
The mean and standard deviation (in brackets) of accuracy performance for colour-based match and mismatch trials as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective) in Experiments 1–4.

Experiment	Match	Perspective	Association		
			Self	Friend	Stranger
Experiment 1	Match	First	0.87(0.08)	0.82(0.11)	0.67(0.19)
		Third	0.86(0.09)	0.82(0.13)	0.67(0.19)
	Mismatch	First	0.76(0.13)	0.74(0.14)	0.77(0.15)
		Third	0.75(0.15)	0.73(0.18)	0.78(0.13)
Experiment 2	Match	First	0.88(0.08)	0.83(0.14)	0.73(0.15)
		Third	0.88(0.09)	0.81(0.13)	0.70(0.16)
	Mismatch	First	0.82(0.12)	0.78(0.11)	0.80(0.13)
		Third	0.80(0.14)	0.79(0.12)	0.81(0.14)
Experiment 3	Match	First	0.89(0.10)	0.80(0.20)	0.73(0.21)
		Third	0.91(0.08)	0.83(0.19)	0.72(0.21)
	Mismatch	First	0.82(0.15)	0.81(0.15)	0.85(0.14)
		Third	0.80(0.15)	0.81(0.15)	0.85(0.13)
Experiment 4	Match	First	0.88(0.07)	0.85(0.11)	0.77(0.10)
		Third	0.87(0.07)	0.85(0.09)	0.80(0.11)
	Mismatch	First	0.84(0.09)	0.83(0.10)	0.86(0.12)
		Third	0.85(0.10)	0.84(0.09)	0.88(0.09)

the embodied self-representation could be biased to the stimulus with the first-person perspective if the two perspectives compete to activate the self-representation. An effect of perspective for self-related judgments may then emerge. Such a result would go against the idea that it is an expectation for the self or attention to the head of the embodied, first-person perspective stimulus that is critical.

3. Experiment 2: Two avatars, first-person close

In Experiment 2 we presented participants with two avatars, one with a first-person perspective and one with a third-person perspective. The avatar with the first-person perspective always fell closer to fixation than the avatar adopting a third person perspective.

3.1. Material and method

There were 29 college students who took part (11 males, ages 18–31 years, mean age 22.13 ± 3.85 years). The Method was identical to Experiment 1 except for the number and positions of the avatars. The T-shirt of one avatar was painted with one of the person-associated colours and the other with shallow grey (RGB 170, 170, 170) and both appeared against a dark grey background (RGB 64, 64, 64). Avatars of $5° \times 9°$ visual angle were presented above a white fixation cross. The distance between the centre of the avatar distant to fixation and the fixation cross was about 6.86°, and the distance between the centre of the avatar close to fixation and the fixation cross was about 2.9°.

3.2. Results and discussion

RTs. The mean correct RTs and d prime results are presented in Fig. 3. A repeated-measures ANOVA for match trials showed a significant main effect of association, $F(2,56) = 48.73$, $p < 0.001$, $\eta^2 = 0.64$; there were faster responses to the matched self than to the matched friend ($p = 0.002$) and stranger ($p < 0.001$) stimuli, and also faster responses to the matched friend than to the matched stranger associations ($p = 0.001$). The main effect of perspective was also significant, $F(1,28) = 16.36$, $p < 0.001$, $\eta^2 = 0.36$; responses were faster when the target fell on an avatar adopting a first-relative to a third-person perspective. These main effects were qualified by a significant interaction of association and per-

spective, $F(2,56) = 5.049$, $p = 0.01$, $\eta^2 = 0.15$ (Fig. 3a). Paired sample t tests for each type of association revealed that, compared to when the target fell on the third-person perspective avatar, falling on an avatar with a first-person perspective facilitated self-association trials, $t(28) = -4.768$, $p < 0.001$ and also friend-association trials ($t(28) = -3.358$, $p = 0.002$) while there was no effect on stranger trials ($t(28) = -0.153$, $p = 0.88$).

An ANOVA for mismatch trials only showed a significant main effect of association, $F(2,56) = 24.53$, $p < 0.001$, $\eta^2 = 0.47$. There was no significant main effect of perspective and no interaction between association and perspective, $F = 0.77$ and 0.57, $p = 0.77$ and 0.57, $\eta^2 = 0.003$ and 0.02 (Table 1).

The results indicated that the perspective of the avatar altered both self- and friend matching, enhancing performance when the target fell on the avatar adopting a first-person compared to a third-person perspective.

d prime. A two-way ANOVA was conducted on the d prime data with main effects of association and perspective. This demonstrated a significant main effect of association, $F(2,56) = 18.95$, $p < 0.001$, $\eta^2 = 0.39$; d prime values were larger for self ($t(28) = 5.279$, $p < 0.001$) and friend ($t(28) = 2.94$, $p = 0.006$) associations than for the stranger association, and for self relative to friend associations ($t(28) = -3.535$, $p = 0.001$) (Fig. 3b). These data are consistent with prior results (Sui et al., 2012). Neither an effect of perspective nor an interaction between association and perspective was observed ($F = 3.171$, $p = 0.09$).

Cross-experiment comparison. In order to test whether the presence of two relative to one avatar modulated the self- and friend-bias effects, we conducted an across-experimental analysis on RTs. There was one between-subjects factor of experiment (Experiment 1 vs. 2), and within-subjects factors of bias (self-bias vs. friend-bias, both computed relative to the stranger baseline), and perspective (first- vs. third-person perspective). The analysis showed a significant three-way interaction, $F(1,54) = 5.293$, $p = 0.025$, $\eta^2 = 0.09$. The analyses for the self-bias and friend-bias were then conducted respectively. For the self-bias effect there was a significant interaction between experiment and perspective, $F(1,54) = 8.264$, $p = 0.006$, $\eta^2 = 0.133$. There was an enhanced self-bias in the first relative to the third person perspective in Experiment 2 ($t(28) = 3.071$, $p = 0.005$), but not in Experiment 1 ($t(26) = -1.297$, $p = 0.206$). In contrast, the analysis for the friend-bias showed a significant main effect of perspective, $F(1,54) = 6.249$, $p = 0.015$, $\eta^2 = 0.10$, reflecting a larger friend bias appearing in the first than the third person perspective condition, but neither the main effect
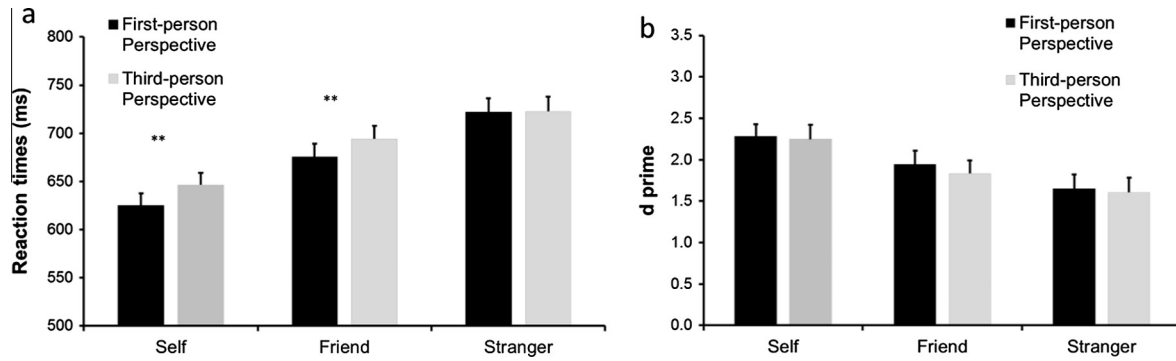
Fig. 3. The mean performance of Reaction times and d prime in Experiment 2. (a) The RTs in match trials as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective). (b) d prime as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective). Error bars represent standard errors.

of experiment nor the interaction between experiment and perspective was significant, $Fs < 3.33$, $ps > 0.077$. The data confirm that while the presence of two- relative to one avatar modulated the effect of perspective on self-bias, it did not modulate the friend-bias which showed a benefit from the first-person perspective across the two studies.

The emergence of a perspective effect here for self-related stimuli makes it unlikely that the absence of this effect, in Experiment 1, was due simply to performance being at ceiling (with performance in the self-related condition being difficult to improve), due to an expectation for the self imposed irrespective of the perspective of the avatar or due to attention being attracted to another part of the body of the self-related avatar. The data are more consistent with the idea that, when two avatars are presented in a socio-communicative context, there is a default bias to select the embodied, first-person perspective for self-related items. This then too modulates performance for friend-related stimuli.

4. Experiment 3: Two avatars first-person distant

4.1. Material and method

There were 26 participants (15 males, ages 19–30 years, mean age 22.85 ± 3.12 years). The Method was identical to that in Experiment 2 except that the two avatars reversed their positions. Thus the avatar with the third-personal perspective was close to fixation and the avatar adopting a first-person perspective fell more distant from fixation (Fig. 1c).

4.2. Results and discussion

RTs. A repeated-measures ANOVA for match trials showed a significant main effect of association, $F(2,50) = 46.51$, $p < 0.001$, $\eta^2 = 0.65$; there were faster responses to the self-related stimuli than to stimuli related to the friend ($p < 0.001$) and stranger ($p < 0.001$), and faster responses to friend- than to stranger-related stimuli ($p < 0.001$). However, neither the main effect of perspective nor the interaction between perspective and association were significant, $F(1,25) = 4.072$, $p = 0.05$, $\eta^2 = 0.14$; $F(2,50) = 1.063$, $p = 0.35$, $\eta^2 = 0.04$ (Fig. 4a).

An ANOVA for mismatch trials only showed a significant main effect of association, $F(2,50) = 3.438$, $p = 0.040$, $\eta^2 = 0.12$; there were faster responses to the mismatch trials based on the self colour than to mismatch trials based on the stranger's colour ($p = 0.002$). There was no difference between the mismatch self and friend trials ($p = 0.043$), or the friend and stranger trials ($p = 0.095$). There were no significant main effect of perspective

and no interaction between association and perspective, $F = 3.19$ and 1.59, $p = 0.58$ and 0.21, $\eta^2 = 0.013$ and 0.06 (Table 1).

The results indicated that there was no effect of perspective on RTs in this experiment.

d prime. A two-way ANOVA was conducted on the d prime scores with association and perspective are main effects. This demonstrated a significant main effect of association, $F(2,50) = 15.03$, $p < 0.001$, $\eta^2 = 0.38$; there were larger d prime values for self-associations than for friend-associations ($t(25) = -3.848$, $p = 0.001$) and stranger-associations ($t(25) = 5.17$, $p < 0.001$). There was no difference between friend-associations and stranger associations ($t(25) = 1.359$, $p = 0.124$) (Fig. 4b). This matches prior data (Sui et al., 2012). There was no significant main effect of perspective and no interaction between association and perspective ($F < 2.6$, $p > 0.62$).

Cross-experiment comparisons. An across-experimental analysis was conducted on RTs in Experiments 2 and 3, with experiment as a between-subjects factor and bias (self-bias vs. friend-bias, relative to the stranger baseline), and perspective (first- vs. third-person perspective) as within-subjects factors. There was a significant effect of bias, $F(1,53) = 56.7$, $p < 0.01$, $\eta^2 = 0.51$, reflecting a stronger effect of self-bias relative to friend-bias. There was also a significant interaction between perspective and experiment, $F(1,53) = 10.4$, $p < 0.001$, $\eta^2 = 0.16$, which was not qualified by an interaction with bias, $F(1,53) = 0.023$, $p = 0.881$. Averaging across the self- and friend-biases there was an increase in the biases for first- relative to third-person perspectives in Experiment 2, $t(28) = 3.295$, $p = 0.003$, but not in Experiment 3, $t(25) = -1.36$, $p = 0.19$.

Unlike in Experiments 1 and 2, there was no evidence here for the perspective of the avatar having any effect on performance. There remained reliable self- and friend-biases, compared with the stranger baseline condition, but these effects were not affected by perspective. Here presenting the target on an avatar adopting a first person, embodied perspective did not increase the biases when the avatars were placed in a non-communicative social context. However, in Experiment 3, the avatar with the third person perspective fell closer to fixation then the avatar with the first-person perspective. Thus the lack of an effects of perspective may be due to the variation in distance to fixation, not whether a socio-communicative context was present. This was tested in Experiment 4.

5. Experiment 4: Two avatars equally distant from fixation, placed in a socio-communicative context

5.1. Material and method

There were 27 participants (13 males, ages 18–26 years, mean age 21.44 ± 2.08 years). The Method was identical to that in Exper-
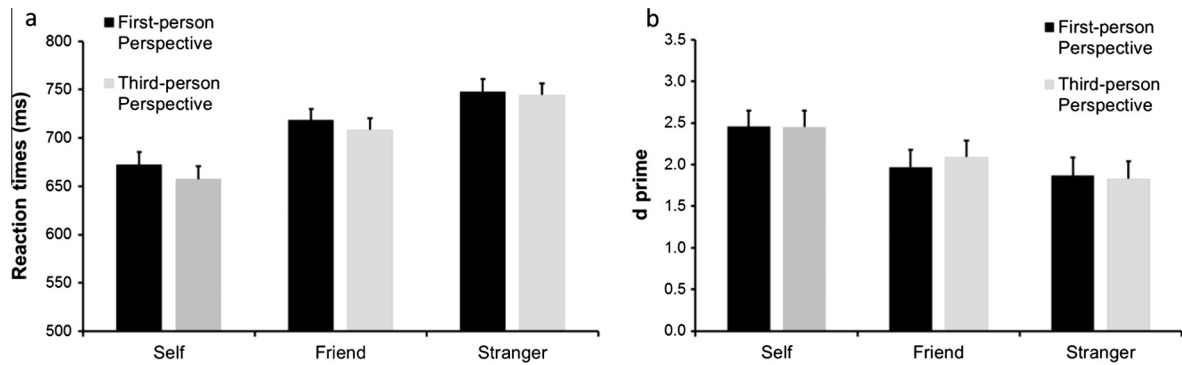
Fig. 4. The mean performance of Reaction times and d prime in Experiment 3. (a) The RTs in match trials as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective). (b) d prime values as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective). Error bars represent standard errors.

iment 2 except that (i) there was a prime display showing a pair of avatars facing each other for 300 ms followed by (ii) the label displayed for 300 ms between the two avatars (replacing the fixation cross). The avatar with the first-person perspective fell below fixation and the avatar adopting a third-person perspective was above fixation (Fig. 1d).

5.2. Results and discussion

RTs. A repeated-measures ANOVA on match trials demonstrated a significant main effect of association, $F(2,52) = 24.55$, $p < 0.001$, $\eta^2 = 0.48$; there were faster responses to self-related stimuli than to stimuli related to both the friend ($p = 0.003$) and a stranger ($p < 0.001$). In addition, faster responses were made to friend- than to stranger-associated stimuli ($p = 0.003$). There was also a significant main effect of perspective, $F(1,26) = 4.340$, $p = 0.047$, $\eta^2 = 0.14$; there were faster responses when the target fell on an avatar adopting a first- relative to a third-person perspective. The two main effects were qualified by a significant interaction of association and perspective, $F(2,52) = 4.678$, $p = 0.014$, $\eta^2 = 0.15$. Paired sample t tests for each type of association revealed that, compared to when the target fell on the third-person perspective avatar, falling on an avatar with a first-person perspective facilitated both self-associated trials, $t(26) = -2.61$, $p = 0.015$ and friend-associated trials ($t(26) = -2.17$, $p = 0.039$); there was no significant effect on stranger trials ($t(26) = 1.35$, $p = 0.19$) (Fig. 5a).

An ANOVA for mismatch trials only showed a significant main effect of association, $F(2,52) = 5.800$, $p = 0.005$, $\eta^2 = 0.18$. Responses to the mismatch trials with the self colour were faster than those to the mismatch trials involving the stranger colour ($p = 0.008$), responses to mismatch friend were also faster than those to mismatch stranger colour ($p = 0.001$), but there was no difference between the mismatched self and friend trials ($p = 0.98$). Neither the main effect of perspective nor the interaction between association and perspective was significant, $F < 0.113$, $p > 0.36$ (Table 1). The data indicated that there was no effect of perspective taking on self-biases on mismatch trials.

d prime. An ANOVA was conducted on the d prime scores with association and perspective as within-subjects factors. The analysis failed to show a significant effect of association, $F(2,52) = 1.597$, $p = 0.212$, $\eta^2 = 0.058$; neither the main effect of perspective nor the interaction between association and perspective was significant ($F < 0.09$, $p > 0.43$).

Cross-experiment comparisons. An across-experimental analysis was conducted on RTs in Experiments 2 and 4, with experiment as a between-subjects factor and bias (self-bias vs. friend-bias, relative to the stranger baseline), and perspective (first- vs. third-person perspective) as within-subjects factors. There was a

significant effect of bias, $F(1,54) = 37.6$, $p < 0.001$, $\eta^2 = 0.41$, reflecting a stronger effect of self-bias relative to friend-bias. There was also no significant interaction between perspective and experiment, $F(1,54) = 0.24$, $p = 0.63$. Averaging across the self- and friend-biases there was an increase in the biases for first- relative to third-person perspectives in Experiment 2, $t(29) = 3.295$, $p = 0.003$. The effect was also in Experiment 4, $t(26) = 3.076$, $p = 0.005$. The three-way interaction with perspective, experiment and experiment was not significant, $F(1,54) = 0.001$, $p = 0.97$.

6. General discussion

We examined the effects of embodied perspective on a simple perceptual matching task in which participants had to judge whether a label and a colour were as originally paired or re-paired. When the label related to the self there was a consistent advantage for matching performance compared to when the label related to a friend, and the friend condition was in turn facilitated relative to when there was an association to the label for a stranger. This result replicates prior data showing substantial self- and friend-biases on perceptual matching, extending the result from shape-label matching (e.g., Sui et al., 2012) to colour-label matching (Sui, Liu, Wang, & Han, 2009). This highlights the robustness of these person-related biases on matching. In previous studies we have shown that these biases remain when factors such as word length and concreteness are controlled for (Sui et al., 2012).

In addition to extending the evidence for the effects of personal-relations on perceptual matching we demonstrated that the self- and friend-biases are influenced by presenting the to-be-matched target stimuli on avatars that are irrelevant to the task. Moreover, performance was affected by whether the avatar adopted a first- or a third-person perspective. When two avatars were present in a socio-communicative context (Experiments 2 and 4), both the self- and the friend-biases were enhanced when the target fell on an avatar adopting an embodied, first-person perspective, even when the distance to fixation was equated for the different avatars (Experiment 4). The effect was not due to the embodied, first-person perspective avatar being perceptually more salient or simpler, since there were no effects on matches in the stranger condition. Also the effect of embodied perspective was eliminated in Experiment 3 when the avatars were depicted in a non-communicate social context. We conclude that both self- and friend-matches were sensitive to activation of self presentation coded from an embodied, first-person perspective which generates enhanced attention to stimuli. The most parsimonious account of these results is that both self- and friend-related stimuli activate an embodied representation of the self that is coded from a
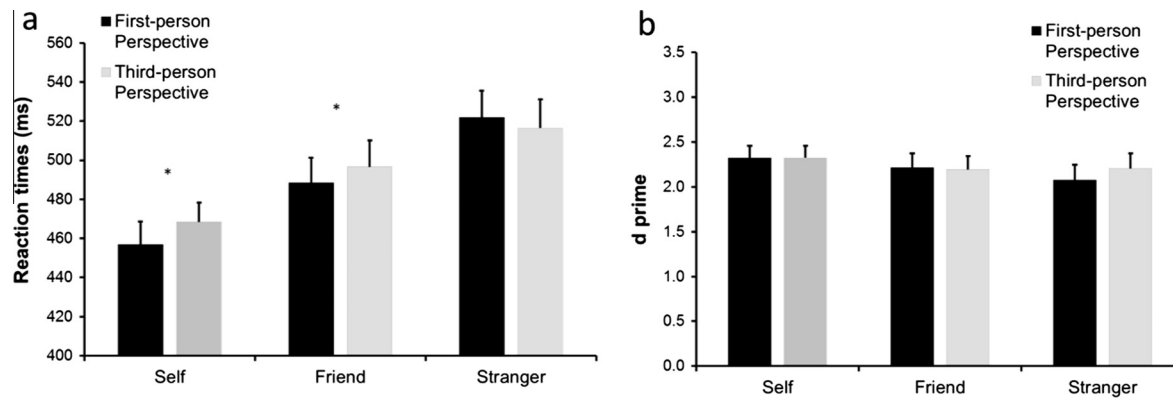
Fig. 5. The mean performance of Reaction times and d prime in Experiment 4. (a) The RTs in match trials as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective). (b) d prime results as a function of association (self, friend, or stranger) and perspective (first- vs. third-person perspective). Error bars represent standard errors.

first-person perspective and activated when two people are shown in a socio-communicative context. The activation of this representation enhances attention to the stimulus (see Humphreys & Sui, 2015; Sui et al., 2013), facilitating matching performance. According to this account, a close friend can rapidly be linked to the participant's own representation so that friend-related stimuli are 'seen' from the participant's own viewpoint – an argument in line with the mirror neuron theory of social interaction (Gallese & Goldman, 1998; Uddin et al., 2007). An alternative account is that we have a representation of a close friend that captures the friend's own viewpoint, which is recruited when the avatar expresses a first-person perspective. In either case, the data indicate that forms of domain-specific, embodied representation can be rapidly recruited and influence perceptual matching. This effect occurs over and above effects of a domain-general factor such as the reward or emotion value of the stimulus, which should be present irrespective of the perspective of the avatar in relation to the participant's body.

When a single avatar was presented, there were effects of embodied perspective for the friend-related stimuli but not for self-related items. This result was unexpected. To account for it we propose that, with a single avatar, strongly activated embodied self-representations can be rapidly imposed on another viewpoint, minimizing the effects of perspective for self-related items. On the other hand, effects may still occur for friend-related stimuli if either (i) the activation of self-representations by the friend is insufficient to enable the representations to subsequently be imposed on another perspective, or (ii) friend-representations are less flexible and cannot be easily adjusted across different perspectives. The effect of perspective on friend stimuli was robust across all experiments showing any effect of perspective, confirming the reliability of the result.

Previously, authors have argued that the rapid instantiation of self-perspective to a new orientation can be either effortful or effortless (Kessler & Rutherford, 2010), depending on the information that needs to be represented. To make explicit judgments about whether another person can see stimuli falling on their left and right appears to involve an effortful mental rotation process (Surtees, Apperly, & Samson, 2013). In contrast, to judge whether another person can see something and whether it falls to the front or back, then an alternative perspective can be instantiated without demanding such effort. The latter process also develops earlier in children and can be present in non-human primates (Kessler & Rutherford, 2010; Surtees, Butterfill, & Apperly, 2012). We propose that this pre-reflective, non-effortful process was involved in responding to the single avatar when self-related stimuli were presented in a first-person perspective matching the participant's

body position. Irrespective of this, the current data demonstrate the involvement of embodied perspective information even when we respond to stimuli that do not require explicit embodiment.

In contrast to the effects with the self and friend, stranger-related stimuli showed no effects of perspective. One possibility is that participants automatically identified the other 'grey' vested person as a stranger and were unaffected by the perspective of the other avatar. However this seems very unlikely. Participants simply had to match the colour with the label, and it seems most likely that they attend to the colour and simply made the judgement. Also in Experiment 4 two grey-vested avatars were initially presented and it would not be possible for participants to attend to one selectively as the stranger before the target colour appeared.

There are some additional caveats though. One point is that the avatars were seen from a bird's eye view, which may not fully capture the effects of perspective on information processing. While acknowledging that, we do note that effects of an embodied, first-person perspective were present throughout, which reinforces the argument that the effects of embodied perspective are robust. A second point is that the analyses of d' across all experiments consistently showed a significant main effect of association, but neither the main effect of embodied perspective nor the interaction between personal association and perspective taking was significant. In contrast, in previous studies we have shown reliable effects of self-bias on d' in tasks involving matching of a personal label to a shape (Sui et al., 2012). The contrast here may reflect a difference between the sensitivity of perceptual processing for colour and for shape. In simple colour judgments (as here), there may be little room for effects of self- and friend-bias to modulate perceptual processing; shape perception, on the other hand, may be more strongly permeated by top-down effects (self- and friend-bias). This possibility could be explored in future studies using colours that are more difficult to discriminate. Do effects of self- and friend-bias then emerge on label-colour matching? Even if the effects of self- and friend-bias on colour perception were weak, significant effects were present on RTs in all the experiments. These bias effects may have emerged at a decision stage. This issue requires further research.

Conclusions. The present study indicates that both the self- and friend-biases on label-colour matching were modulated by embodied perspective; presenting targets on stimuli depicted from an embodied, first-person perspective enhanced the magnitude of self- and friend-biases compared to when stimuli were depicted from a third-person perspective. This was particularly the case when two individuals were shown in a socio-communicative context. The results indicate that self- and friend-biases are modulated

by an embodied representation coded from a first-person perspective.

Acknowledgements

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