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RESEARCH ARTICLE

Interpersonal memory-based guidance of attention is reduced for ingroup members

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Abstract Participants jointly engaged in common tasks with co-actors can be influenced in guiding their own attention by representations of what the co-actor also holds in memory (He et al. under review). This demonstrates an effect of interpersonal memory on attention. Here, we tested how this interpersonal memory effect is affected by the relationship between the actors. Participants searched for targets while maintaining images in working memory or after previewed images that co-actors had to memorise. We examined three groups: Caucasian strangers (low ingroup relations) and two other groups with likely higher ingroup relations (Caucasian friends and Chinese participants living in Britain). In all three groups, attention was directed to stimuli that matched the item the individual had to memorise. However, images that had to be memorised by co-actors only attracted the attention of Caucasian strangers but not the Caucasian friends and Chinese participants. We suggest that interpersonal memory-based guidance of attention is modulated by the nature of the relationship between individuals and reduces when individuals have higher ingroup relations.

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Introduction

In everyday social life, people frequently have to perform tasks together. In those socially interactive scenarios, individuals can direct attention to the objects and events attended by others (Eilan et al. 2004; Schuch and Tipper 2007), prevent attention from being allocated to locations inhibited by a testing partner (Frischen et al. 2009; Welsh et al. 2005, 2007) and adjust actions to others' behaviour (Chartrand and Bargh 1999; Knoblich and Jordan 2003). For instance, Sebanz et al. (2003, 2005) studied the spatial compatibility effect (Simon 1969) when tasks were divided among people. The spatial compatibility effect reflects the conflict in response selection that occurs in a two-choice reaction time (RT) task when both response alternatives are at disposal of a single participant. The effect can be eliminated when a single participant performs a go/nogo version of the task, but it is restored when two participants each perform a go/nogo version, when they appear jointly to form a complete representation of the two-choice task.

Recently, we (He et al. under review) have provided additional evidence that individuals performing a task together also memorise the same stimuli (even if a stimulus is relevant only to one participant), and this interpersonal memory can guide attentional allocation. Visual attention, in an information-rich world, is critical to select task-relevant stimuli (Eriksen and Yeh 1985; Pashler et al. 2001; Yantis 1998) and to prioritise their processing (Cave and Bichot 1999). There is evidence that visual attention is guided in a top-down manner from stimuli held in working memory (WM) (Chelazzi et al. 1993), and this can happen even when the stimulus is irrelevant to the task being performed. For example, when a stimulus is held in WM while participants search for another item, search is affected if the WM stimulus is re-presented in the search display (Downing 2000; Olivers et al. 2006; Soto et al. 2005, 2006b, 2008; see also Han and Kim 2009). This interaction between WM and attention, however, is not necessarily confined to a single person and may also be found in interpersonal task-sharing setups (Böckler et al. 2010). He et al. (under review) adapted the WM and visual search paradigm by asking a pair of participants to sit alongside each other and perform the memory and search tasks across alternating trials. Each participant was asked only to memorise items from a particular category (if the memory was from category A, participant A memorised it; if from category B, then participant B remembered it; if it was from category C, then neither participant memorised it—this provided a priming baseline to test for the effects of mere re-appearance of the participant's own or the other participant's memory in the search task). When the memory item belonged to the participant's category and re-appeared in the search display, there was an effect of the memory item on search (the own memory effect). More interestingly, participants were affected by re-appearance in the search display of the WM cue from their co-actor's category. There were minimal effects of re-presenting an initial cue that belonged to the category that neither participant had to memorise (the priming baseline condition). These data suggest that participants code in memory information that is held in a co-actor's memory, when participants engage in the same task. This interpersonal memory modulates the subsequent allocation of attention.

These effects observed in joint action scenarios reflect interpersonal interactions in forming a common coding of the task (Knoblich and Sebanz 2006, 2008; Sebanz et al. 2006). For instance, joint action effects are observed when participants believe that they interact with another human being, but not when interactions are with a non-human agent (Tsai and Brass 2007). Given the importance of interpersonal interactions, then, it seems very likely that the effects of joint action and interpersonal memory may be modulated by the social relationship between the participants. This was investigated here. We assessed the role of interpersonal memory in directing attention when the co-actors were British Caucasian strangers, British Caucasian friends and Chinese strangers.

Friendship is crucial for social grouping (Tajfel et al. 1971). A friend can be included in one's own identity (Aron et al. 1991) and closely related with our self-representation via emotional and motivational links (forming a relational self-concept; Andersen and Chen 2002). Hence, pairs of Caucasian friends may be expected to have a stronger ingroup relationship than pairs of Caucasian strangers. It can also be argued that pairs of Chinese strangers form stronger ingroup pairs than Caucasian strangers, given that Asian cultures tend to reward group rather than individual success (Markus et al. 2007; Triandis 1995), and, for studies run in the UK, the ingroup status of Chinese individuals may be increased further as the individuals form a minority set, emphasising their ingroup status. To strongly emphasise their ingroup here, we also conducted the study with Chinese students in Mandarin Chinese as the working language. Because language is a carrier of social identity (Tong et al. 1999), our use of Mandarin Chinese should activate the Chinese culture system (Bond and Yang 1982; Hong et al. 2000; Kemmelmeier and Cheng 2004; Ross et al. 2002), increasing any effects of perceived similarities between the Chinese participants (see also Briley and Wyer 2002; Hogg 2004). Hence, we expect that, as is the case for British friends, the ingroup status will be higher for the Chinese participants than the Caucasian strangers.

The question then is how this ingroup status influences WM and the effect of WM on the allocation of attention. Interpersonal WM-based guidance may be enhanced or reduced by increased ingroup status, in a manner similar to social facilitation and social inhibition effects (e.g., Bond and Titus 1983). An enhancement account can be derived from the finding that ingroup members usually have a tendency to cooperate and to intervene more strongly in their group's behaviour (Kramer and Brewer 1984; Tajfel 1982). For instance, people having a more positive relationship (as is typically the case for ingroup members) show stronger joint action effects (Hommel et al. 2009). It follows that, in our study, ingroup members may take particular interest in their partner's memory, generating strong effects of the other's memory on their own allocation of attention. In contrast, an alternative prediction can be made, namely that high ingroup relations may lead to reduced effects of the other's memory stimulus on one's own attention. This might come about if there is greater trust between ingroup members (Brewer and Kramer 1985; Brewer and Yuki 2007; Williams 2001). With higher mutual trust, participants may recruit less information from WM items relevant to the co-actor's tasks, and so there will be less effect of the other's memory on the guidance of each participant's attention. The present study tested these two predictions.

It is also important to understand that in studies of interpersonal memory on attention, we can separate out two effects: one on the memory representation itself and one on attentional guidance. For example, if ingroup members take more note of their partner's memory items, then they should show better longer-term memory for those items than for items they did not attend to, in addition to attending to those items when they are subsequently presented. It is also possible that any effects of memory to a partner's actions are transient and do not lead to better longer-term consolidation of the items, when memory is tested over the longer term. These possibilities for effects on longer-term memory as well as on attention were evaluated here.

The present experiment used a modified version of the WM and attention procedure (Downing 2000). As in our previous study (He et al. under review), participants were tested in pairs and, depending on the item initially shown, one or neither participant had to hold a previewed image in WM as they performed a visual search task for a target shape. The previewed image belonged either to (1) a category that the participant was told to remember (own memory), (2) a category that their co-actor was told to remember (other's memory) or (3) a priming baseline (a category that neither participant was told to remember). This initial stimulus could re-appear in the search display at the location of either the search target (on valid trials) or a distractor (invalid trials). Following He et al. (under review), we assessed whether participants were affected by the re-presentation of their own memory item or their co-actor's memory item in the search display, compared with the priming baseline. Following the main experiment, participants were also given a surprise recall task for the items they had been presented with. If attention to a partner's actions influences their long-term memory (LTM), then there should also be better recall for the partner's items than for neutral items, which do not have to be attended by either the participant or their partner.

Method

Participants

Three groups of age- and sex-matched volunteers participated in the present study. The first group (*Caucasian strangers*) consisted of 24 native British Caucasian college students aged between 18 and 27 years ($M = 20.1$ years, SE = .4 years), including 20 women and 4 men. The second group (*Caucasian friends*) were 32 native British Caucasian students of 18–26 years of age ($M = 20.4$ years, SE = .3 years). They were 23 women and 9 men and were included if they self-reported as being close friends who met each other frequently (at least twice a week). The third group (*Chinese*) consisted of 24 Chinese students and postdoctoral fellows with an age range of 21–35 years ($M = 24.6$ years, SE = .6 years), five of whom were men and the rest were women. All the Chinese participants were born and raised in China and were living in UK at the time of the study. At the time of the experiment, the Chinese participants had been away from China and experiencing direct exposure to the UK society for a period of 0–6 years ($M = 1.7$ years, SE = .3 years).

All participants came from the University of Birmingham and had normal or corrected-to-normal eyesight. Three participants in the Caucasian stranger group, one in the Caucasian friends group, and two in the Chinese group were left-handed, while all others were right-handed. Participants were tested in pairs seated next to each other. In the conditions with strangers, the two participants were randomly assigned and they did not know each other before the experiment. The tasks were spelled out to each participant, one instruction at a time, with the other participant present. The participants viewed simultaneously a single screen that was of equal distance to each participant.

English was used as the working language for the Caucasian groups. In order to reduce any priming effect from British culture upon the Chinese participants, and to activate the Chinese culture system, we used Chinese as the working language for the Chinese participants. The experimenter was Chinese, and he communicated with the Chinese participants in Mandarin Chinese (including the instructions); all documents were translated into Chinese for testing purposes.

Stimuli and procedure

The experiment was programmed and run with E-Prime 1.1, and it consisted of a memory task and a subsequent visual search task. There were three image categories, each of which consisted of forty images, which were counterbalanced across participant pairs. One category (e.g. fruit) was requested to be remembered by one participant, and another category (e.g. four-footed animal) was designated for the memory task for the other participant. The third category (e.g., musical instrument) was not relevant to any participant's memory task and trials where this occurred formed the priming baseline.

The experiment consisted of four 60-trial blocks. Each trial started with a fixation cross presented along with a peripheral cue ('X') in the left or right field with equal probabilities. The cue indicated which participant was to perform in this trial. The cue lasted for 500 ms. The fixation was presented 500 ms longer than the cue, followed by a 500-ms preview image ($2.1 \times 2.1°$) at the centre of the screen, randomly selected from one of the three categories (see above). The cued participant had to keep this image in WM if it belonged to his/her category. After a 2,000-ms interval, the visual search display appeared, which lasted for 1,000 ms or until response. This display contained two images ($2.1 \times 2.1°$), which appeared randomly at two out of four positions (2.9° to fixation) at the corners of a virtual square. One stimulus was always the previewed image on that trial; the other was a new image that was not from any of the categories used for the preview. Each image in the search display was flanked by a pair of circles or squares (.6 × .6°). The circles flanked the previewed image (valid) or the other image (invalid) on 40% of total trials, respectively, and they did not appear (replaced by squares; catch trials) on the remaining 20% of the trials. The cued participant had to respond as quickly as possible to the circles by pressing ‘c’ on the keyboard (the participant on the left) or by clicking the left mouse button (the participant on the right); the response had to be withheld if only squares were presented. If the previewed image had to be memorised by the responding participant (due to it belonging to the appropriate category), there was another 500-ms interval after the search display and then a memory test. The memory test contained two images, one of which was always the memorised image and the other was a different image from the same image category. These stimuli appeared side by side for 3,000 ms or until response. The responding participant indicated which picture matched the image in memory by pressing ‘c’/’v’ (left participant) or by clicking the left/right mouse button (right participant) for the left/right image. The next trial followed after 2,000 ms (Fig. 1).

At the end of the experiment, there was a surprise memory test in which participants were asked to write down all the previewed items they could.

Results

Search RTs

RTs more than three standard deviations away from the mean values for any participant were removed. A three-way (3 Memory × 2 Validity × 3 Group) mixed-design analysis of variance (ANOVA) showed a significant effect of Group, $F(2, 77) = 8.40$, $P < .0006$. Overall RTs were longer for the Caucasian strangers (526 ms) than for the Caucasian friends (468 ms) and Chinese (461 ms) participants, Ps $< .0008$, who did not differ, $P > .6$. There was also a significant main effect of Memory, $F(2, 154) = 18.67$, $P < .0001$. RTs were shortest in the other’s memory condition (476 ms) than the priming condition (484 ms) and the own memory condition (496 ms), all pairwise Ps $< .003$. We also found a significant Validity effect, $F(1, 77) = 40.61$, $P < .0001$. This effect of Validity interacted with Memory, $F(2, 154) = 4.72$, $P < .011$, and there was a Memory × Validity × Group interaction, $F(4, 154) = 3.09$, $P < .018$. This interaction was broken down in two ways to reflect (1) the distinct effects for ingroup and outgroup members and (2) the contrast between the Validity effects in the other’s memory and priming conditions.

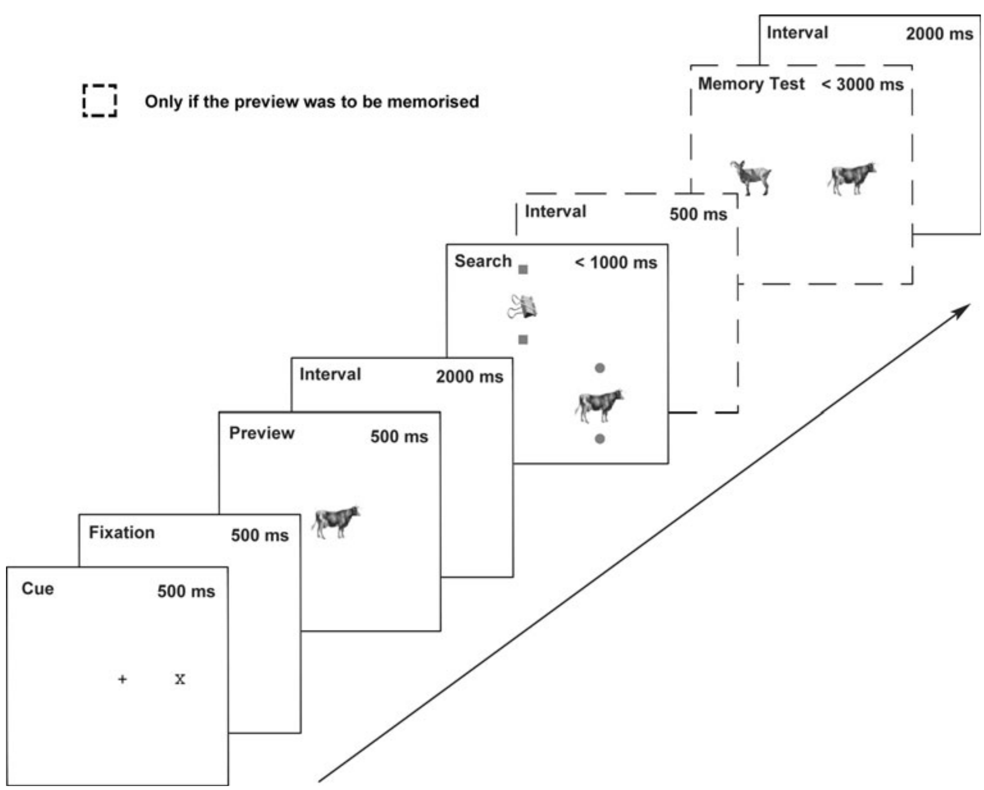

Fig. 1 Example of a trial. A peripheral cue (‘X’) at the beginning of each trial indicated which participant was to perform the memory and search tasks. The cued participant kept the preview image in memory if it was from his/her category or did nothing for the preview if the cue was from another category. There then followed a search display, and the task was to make a speeded response to the presence of circles. After the search display, there was a memory test where the participant had to judge which of two images was presented as the preview, but only when the previewed image was to be memorised

Contrasting ingroup and outgroup partners

An analysis of the data for the Caucasian strangers (Fig. 2) revealed a significant effect of Memory, $F(2, 46) = 4.00$, $P < .026$. This effect of Memory was due to the RT difference between the conditions of own memory (537 ms) and other's memory (517 ms), $P < .017$ (other pairwise Ps > .1). The main effect of Validity was significant as well, $F(1, 23) = 11.42$, $P < .003$. A significant Memory × Validity interaction, $F(2, 46) = 4.48$, $P < .017$, demonstrated that the Validity effect varied across the different memory conditions. Further, separate one-way ANOVAs for the three memory conditions revealed a significant Validity effect for own memory, (valid 519 ms vs. invalid 555 ms), $F(1, 23) = 15.74$, $P < .0007$, and for other's memory, (502 ms vs. 532 ms), $F(1, 23) = 10.79$, $P < .004$, but not for the priming condition, (524 ms vs. 524 ms), $F(1, 23) = .003$, $P > .9$. The size of the Validity effect did not differ across the own memory and other's memory conditions ($F(1, 23) = .16$, $P > .6$, for the interaction of Memory × Validity when only the own memory and other's memory conditions were included).

An analysis of the data for the two ingroups (Figs. 3, 4) showed significant main effects of Memory, $F(2, 108) = 16.18$, $P < .0001$ (own memory 475 ms, other's memory 456 ms, priming 464 ms, all pairwise Ps < .004), and Validity, $F(1, 54) = 29.55$, $P < .0001$, but no differences between the two ingroups, (468 ms vs. 461 ms), $F(1, 54) = .17$, $P > .6$. There was also a significant Validity × Memory interaction, $F(2, 108) = 5.94$, $P < .004$, not qualified by the ingroup type, Fs < 2.01, Ps > .1. There were significant effects of Validity in the own memory and priming conditions, $F(1, 54) = 24.10$, and $F(1, 54) = 18.11$, both Ps < .0001 (mean benefits for valid over invalid trials of 29 and 23 ms, respectively). But this effect was not reliable in the other's memory condition (a difference of 5 ms between valid and invalid trials; $F(1, 54) = 1.37$, $P > .2$).

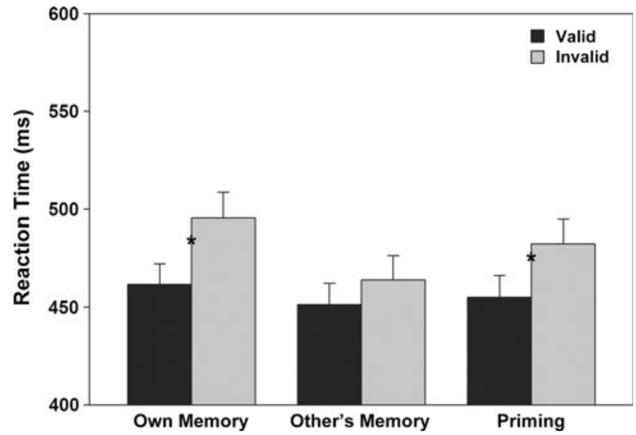

Fig. 3 RT results of the Caucasian friends group. Significant validity effects were found in the own memory and priming conditions, but there was no validity effect in the other's memory condition. *Asterisks* indicate significant validity effects

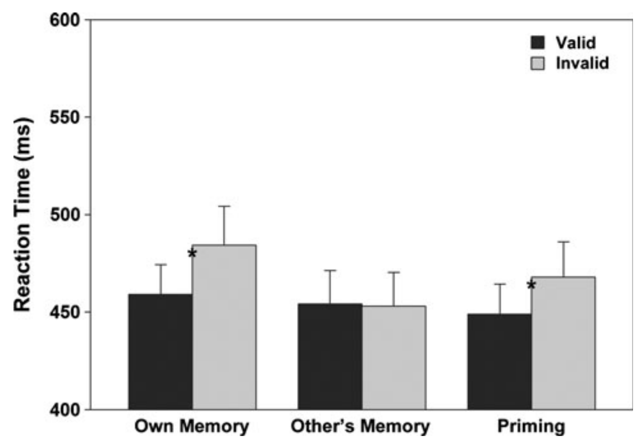

Fig. 4 RT results for the Chinese group. A significant validity effect was found in the own memory and priming conditions, but the effect was absent in other's memory condition. *Asterisks* indicate significant validity effects

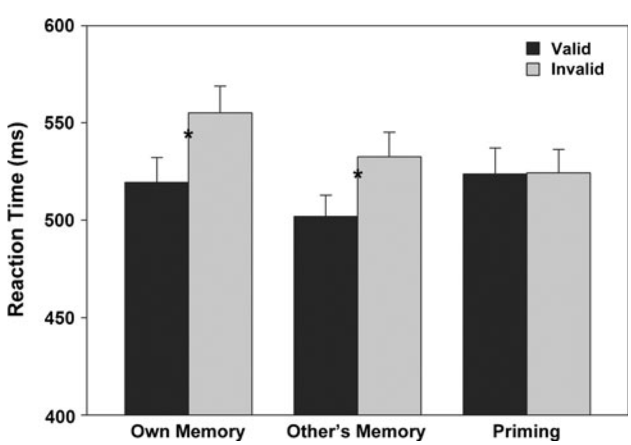

Fig. 2 Reaction time (RT) results for the Caucasian strangers group. A significant validity effect was found in the own and other's memory conditions. *Asterisks* indicate significant validity effects

Contrasting the other's memory and priming conditions

The specific contrast between the other's memory and priming conditions, suggested above, was confirmed in two further separate Validity × Ingroup (ingroup vs. outgroup) ANOVAs for each memory condition (other, priming). For both ANOVAs, there were main effects of Validity, Fs > 4.95, Ps < .029, and Ingroup, Fs > 15.27, Ps < .0001, and Validity × Ingroup interactions, Fs > 4.47, Ps < .038. However, the interactions reflected different patterns for the two memory conditions. In the other's memory condition, a Validity effect was found for individuals with low ingroup relations (502 ms vs. 532 ms), $F(1, 23) = 10.78$, $P < .004$, but not for individuals with high ingroup relations (453 ms vs. 459 ms), $F(1, 55) = 1.89$, $P > .1$. In contrast, in the priming condition, a Validity effect was found for ingroup members (453 ms vs. 476 ms), $F(1, 55) = 19.59$, $P < .0001$, but not for outgroup participants (524 ms vs. 524 ms), $F(1, 23) = .003$, $P > .9$.

Search accuracy

False alarm rates did not differ across conditions, Fs < 1.49, Ps $> .2$, and had a mean value of 7.3%. A three-way (3 Memory × 2 Validity × 3 Group) ANOVA for hit rates showed a significant effect of Group, $F(2, 77) = 8.46$, $P < .0005$, with Caucasian strangers being less accurate (92.1%) than Caucasian friends (95.4%) and Chinese (96.6%), Ps $< .003$ (the latter two groups did not differ, $P > .2$). There was also a Validity effect, $F(1, 77) = 4.57$, $P < .036$, which interacted with Group, $F(2, 77) = 7.19$, $P < .002$ (all other effects were not significant, Fs < 2.83, Ps $> .097$). Further ANOVAs suggested that this Validity effect was reliable for the outgroup participants (valid 93.5% vs. invalid 90.6%), $F(1, 23) = 8.83$, $P < .007$, but not for the ingroup members (Caucasian friends: 94.6% vs. 95.7%; Chinese: 97.2% vs. 95.9%), Fs < 4.15, Ps $> .053$.

Immediate and long-term memory performance

Participants showed good performance in the immediate memory test (at the end of each trial), confirming that they followed the instructions to keep images for the corresponding category in memory. A one-way ANOVA showed that memory test accuracy differed significantly across groups, $F(2, 77) = 3.17$, $P < .048$. A Tukey post hoc comparisons further revealed that Chinese participants had slightly better performance overall than the Caucasian strangers (98.8% vs. 96.8%), $P < .037$. Memory performance for the Caucasian friends did not differ from the other two groups, Ps $> .3$.

Performance in the surprise (longer term) memory recall task was analysed with a two-way (3 Memory category × 3 Group) mixed-design ANOVA with Group as the between-subject factor. There was a significant main effect of Group, $F(2, 77) = 23.27$, $P < .0001$; Caucasian friends had better performance (37.0%) than the other two groups, Ps $< .0005$, and the Chinese group had better performance than the Caucasian strangers (29.2% vs. 22.7%), $P < .006$. The effect of Memory category also reached significance, $F(2, 154) = 121.90$, $P < .0001$, but it did not interact with Group, $F(4, 154) = .61$, $P > .6$. Further pairwise tests for Memory category showed that report was best for the participant's own memory category (39.5%) then for their

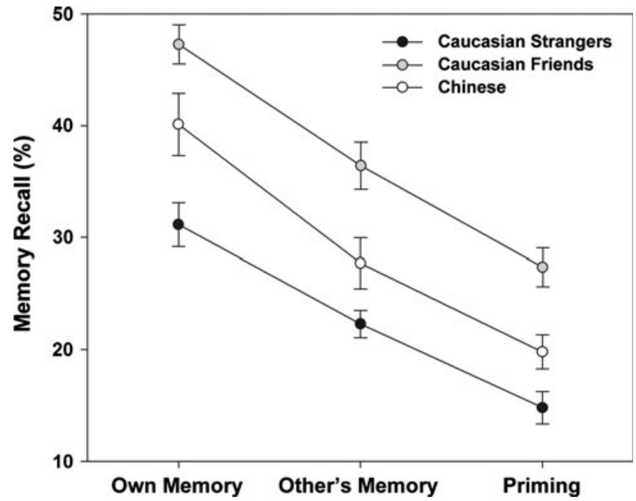

Fig. 5 Memory recall performance. Memory was best in the own memory condition, while memory for the other's memory condition was better than that for the priming condition

partner's memory category (28.8%), compared with items from the category defining the priming baseline (20.6%), all Ps $< .0001$ (Fig. 5).

Discussion

WM and attention

The present study showed that visual attention was directed by images that had been memorised and then re-appeared in a visual search display, as performance was affected by whether the memorised cue fell in the same or a different location to the search target. This result in the own memory condition replicated previous findings in showing faster RTs on valid than invalid trials, consistent with attention being directed to the location of the cue when it re-appeared (Downing 2000; Olivers et al. 2006; Soto et al. 2005, 2006b). In addition, we demonstrated that visual attention can be guided interpersonally by images that only a co-actor is instructed to memorise (i.e., there is an 'interpersonal memory effect'). Strikingly, this result occurred only for pairs of Caucasian strangers, who showed no differences in memory-based guidance between the category they were instructed to memorise (the own memory condition) and the category their partner was instructed to memorise (the other's memory conditions). The validity of the initial cue did not affect the performance of these participants in the priming condition, confirming that the cue effects were linked to holding a representation in WM. For these participants, then, there was clear evidence of their attention being affected by the items their partner was meant to memorise, even though items in this category were never relevant to their memory and visual search tasks. Because the other's memory category was always irrelevant, the data indicate that interpersonal memory guidance is involuntary, and such memories are formed and guide attention even when never beneficial to memory.

It is also interesting that, in the unexpected test of explicit LTM, the Caucasian strangers (similarly to the participants in other groups) showed better memory for items from their own memorised category relative to items from their partner's category, with memory for the latter items also being better than for items in the priming condition. This indicates a dissociation between explicit LTM (affected by the assignment of stimuli to own or other's memory conditions) and short-term guidance of attention from WM (not affected by stimulus assignment to own or other's memory groups, for these participants). It may be, for instance, that longer-term memory is affected by differential rehearsal for own memory items, operating in addition to whether the items are initially maintained in WM (which takes place for both the own and other memory conditions).

In contrast to the Caucasian strangers, though, there was no evidence for an interpersonal memory guidance effect with Caucasian friends or with Chinese strangers – both of whom are likely to have higher ingroup relations with their partner (e.g., Tong et al. 1999; Triandis 1995). This result runs counter to the idea that ingroup members might take greater account of their partner's task representation, thereby generating larger rather than smaller effects of the other's memory on attentional guidance. For this result, there are several possible explanations since in- and outgroup participants may differ along a number of dimensions—for instance in self-presentation, arousal/anxiety levels, motivation for competition and levels of mutual trust. The possible effects of these factors are discussed below.

Self-presentation is the process by which individuals socially present their self-identities, which is typically more modest to friends (ingroup members) than to strangers (Baumeister 1982; Tice et al. 1995). It has been found that self-presentation competes for resources with cognitive control processes. When a counter-normative presentation is adopted (being modest to strangers and self-enhancing to friends), it will impair cognitive control (Tice et al. 1995; Vohs et al. 2005). In the present study, without any self-presentation manipulation, the participants would likely have adopted normative presentation styles (being modest to ingroup members and self-enhancing to outgroup members), which in prior experiments benefit memory and action for ingroup members (see Tice et al. 1995; Vohs et al. 2005). It follows that there should be generally enhanced performance for ingroup members, in terms of both attentional control and LTM. There was evidence for this in LTM, where the two sets of ingroup participants scored more highly than the outgroup participants (Caucasian friend and Chinese strangers > Caucasian strangers). It can also be argued that there was stronger top-down control of search in the ingroup participants, particularly in the other's memory condition. Top-down control in search can be brought about by participants partitioning the cue in WM from the 'template' for the search target, so that search is directed to the search target irrespective of whether the memory item re-appears in the search display. Neuropsychological evidence indicates that this process is disrupted after damage to frontal lobe structures associated with executive control of cognition, so that frontal patients are strongly affected by irrelevant cues in WM (Soto et al. 2006a). Executive processes have also been reported to be enhanced in bilingual participants, and, consistent with this, bilingual participants are less affected than monolinguals by irrelevant cues in WM (Hernández et al. in press). Here, enhanced top-down control in ingroup members would lead to reduced effects of WM on search generally. This would impact on any effects of the other's memory category, perhaps due to partitioning of these items from the template used for search or even due to suppression of the memory stimulus. This notion is illustrated in Fig. 6. In contrast, there may remain effects of bottom-up priming; note that Hernández et al. (in press) reported that bottom-up priming was the same in bilingual and monolingual participants, though top-down guidance to irrelevant WM stimuli decreased. We observed positive effects of validity for ingroup members in the own memory and priming conditions, which may reflect both (a) a lack of suppression of the priming item in WM and (b) stronger bottom-up priming in the own

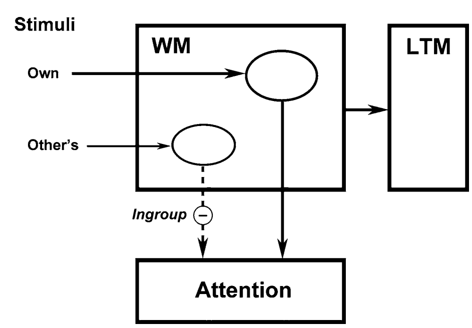

Fig. 6 Memory representation (from *left* to *right*) and WM guidance on attention (from *top* to *bottom*). The stimuli from the participant's own and other's categories are represented in WM in different compartments (at different encoding strength) and further encoded into LTM. Attention is involuntarily guided by one's own WM content. However, the attentional guidance from interpersonal WM representations is dependent on ingroup status—high ingroup relations reduce effects of interpersonal WM on visual attention

memory condition, overriding any suppression of the own memory cue in WM.

A second possibility is that the in- and outgroup differences reflect variations in trust. Greater trust is commonly experienced among ingroup members because of shared experiences, views and goals (Brewer and Kramer 1985; Brewer and Yuki 2007; Williams 2001). Higher levels of trust may reduce the required amount of attention or neural resource deployed to the actions and memory sets of others. As a consequence, ingroup members may not encode items from their partner's category into WM, and hence these items do not guide attention. However, this interpretation should be considered with caution, as we did not assess or manipulate the trust level between participants, while our sole measure of attention to the other's actions is based on whether items from the other's memory category influenced selection. In addition, it is not clear why variation in trust should lead to the overall differences in LTM performance we observed.

A third possibility is that the differences between in- and outgroup member reflects contrasting arousal levels. Challenge and threat are more generally experienced between outgroup than ingroup members, and this may lead to higher arousal in out- than ingroup pairs (Stephan and Stephan 1985; see also Mendes et al. 2008). Conditions of high arousal are associated with narrowed attention, a reduced attentional capacity (Kahneman 1973; Mueller and Thompson 1984), and a tendency for people to generate overlearned/dominant responses (Zajonc 1965). The consequence of this will be that less attention may be paid to the tasks of an outgroup partner. This does not fit with the reduced effect of interpersonal memory for ingroup members, and it also is difficult to explain the overall enhancement in memory performance.

Finally, differences in competition between group members could be a factor. Outgroup members may have a greater tendency to compete than ingroup members, who tend to generate cooperation (Kramer and Brewer 1984; Tajfel 1982)[1]. Stronger competition could again lead to an increased focus on the participant's own memory items and not on their partner's (e.g., de Bruijn et al. 2008), predicting a reduced effect of shared memory on attention for outgroup partners. In contrast to this, there was reduced influence of the other's memory items for in- rather than outgroup members. It is also not clear why memory performance should increase overall.

Whichever account of the in- and outgroup behaviours is put forward, it is important to note that increased ingroup membership does not always have a negative effect on joint action performance. For instance, Hommel et al. (2009) found that the 'interactive' Simon effect in joint action is enhanced when participants share a more positive relationship. The social Simon task they used consists of a single stimulus to be responded to by one or two participants according to its colour. In this task, there is stimulus-generated prompting of who responds, contrasting with the present study in which the respondent was cued at the start of each trial. The net result would be greater uncertainty in agency in the interactive Simon task (Brass et al. 2005; Hommel et al. 2009; Ruby and Decety 2001), leading to stronger effects of the other's actions on ingroup members. Against this, we employed a long interval between the preview image and the search display, giving ample time for participants to decide who performed the memory task. Under these conditions, the benefits of increased attentional control in ingroup members should lead to reduced effects of shared irrelevant memories on search.

Joint memory

There have now been several studies addressing the issue of interpersonal memory representation. For instance, interpersonally shared memories, so-called transactive memories (Hollingshead 2000; Wegner 1986), are better between individuals with a close relationship (Wegner et al. 1991). Similarly, memory recall is better among friends than non-friends (Andersson and Rönnberg 1995) and memory is more strongly biased by socially tuned messages delivered to an ingroup audience than to an outgroup audience (Echterhoff et al. 2005, 2008). Shteynberg (2010) also suggested that stimuli experienced across ingroup members are more accessible to individuals. Our finding of a raised overall level of memory performance for ingroup members fits with this. Our results also indicate that joint LTMs can dissociate from information held in WM, since all participants showed an own memory advantage in LTM, while outgroup participants showed equal effects of other's and own memory on WM-based modulation of attention. We have suggested that LTM may be affected by additional rehearsal processes, biased to own memory items. It should also be noted that ingroup participants showed no effect of the other's memory stimuli on attention, but did recognise these items better in the longer term. This in turn suggests that ingroup members did differentially code the other's memory stimuli in WM, but were able to successfully partition these stimuli from the search template, so that search was impervious to stimuli from their partner's category.

Overall, these arguments highlight that the effects of WM on attention are modulated by the group membership of the participants, with effects differing according to

[1] Friends may show greater involvement (competition) in a competitive game. However there is overwhelming prior evidence indicating that increased cooperation is more likely in non-competitive situations as in the present study (where no performance feedback was given).

whether co-acting participants have relatively high or low ingroup membership. The control of WM effects on attention are modulated by group context.

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References

Andersen SM, Chen S (2002) The relational self: an interpersonal social-cognitive theory. Psychol Rev 109:619–645

Andersson J, Rönnberg J (1995) Recall suffers from collaboration: joint recall effects of friendship and task complexity. Appl Cogn Psychol 9:199–211

Aron A, Aron EN, Tudor M, Nelson G (1991) Close relationships as including other in the self. J Personal Soc Psychol 60:241–253

Baumeister RF (1982) A self-presentational view of social phenomena. Psychol Bull 91:3–26

Böckler A, Knoblich G, Sebanz N (2010) Socializing cognition. In: Glatzeder BM, Goel V, Müller A (eds) Towards a theory of thinking. Springer, Berlin, pp 233–250

Bond CF Jr, Titus LJ (1983) Social facilitation: a meta-analysis of 241 studies. Psychol Bull 94:265–292

Bond MH, Yang KS (1982) Ethnic affirmation versus cross-cultural accommodation: the variable impact of questionnaire language on Chinese bilinguals from Hong Kong. J Cross Cult Psychol 13:169–185

Brass M, Derrfuss J, von Cramon DY (2005) The inhibition of imitative and overlearned responses: a functional double dissociation. Neuropsychologia 43:89–98

Brewer MB, Kramer RM (1985) The psychology of intergroup attitudes and behavior. Annu Rev Psychol 36:219–243

Brewer MB, Yuki M (2007) Culture and social identity. In: Kitayama S, Cohen D (eds) Handbook of cultural psychology. Guilford Press, London, pp 307–322

Briley DA, Wyer RS Jr (2002) The effect of group membership salience on the avoidance of negative outcomes: implications for social and consumer decisions. J Consum Res 27:157–178

Cave KR, Bichot NP (1999) Visuospatial attention: beyond a spotlight model. Psychonom Bull Rev 6:204–223

Chartrand TL, Bargh JA (1999) The chameleon effect: the perception-behavior link and social interaction. J Personal Soc Psychol 76:893–910

Chelazzi L, Miller EK, Duncan J, Desimone R (1993) A neural basis for visual search in inferior temporal cortex. Nature 363:345–347

de Bruijn ERA, Miedl SF, Bekkering H (2008) Fast responders have blinders on: ERP correlates of response inhibition in competition. Cortex 44:580–586

Downing PE (2000) Interactions between visual working memory and selective attention. Psychol Sci 11:467–473

Echterhoff G, Higgins ET, Groll S (2005) Audience-tuning effects on memory: the role of shared reality. J Personal Soc Psychol 89:257–276

Echterhoff G, Higgins ET, Kopietz R, Groll S (2008) How communication goals determine when audience tuning biases memory. J Exp Psychol Gen 137:3–21

Eilan N, Hoerl C, McCormack T, Roessler J (2004) Joint attention: communication and other minds. Oxford University Press, Oxford

Eriksen CW, Yeh Y (1985) Allocation of attention in the visual field. J Exp Psychol Hum Percept Perform 11:583–597

Frischen A, Loach D, Tipper SP (2009) Seeing the world through another person's eyes: simulating selective attention via action observation. Cognition 111:212–218

Han SW, Kim M-S (2009) Do the contents of working memory capture attention? Yes, but cognitive control matters. J Exp Psychol Hum Percept Perform 35:1292–1302

Hernández M, Humphreys GW, Costa A (in press) Escaping capture: bilingualism modulates distraction from working memory. Cognition

Hogg MA (2004) Social identity, self-categorization, and communication in small groups. In: Ng S-H, Candlin CN, Chiu C-y (eds) Language matters: communication, culture, and identity. City University of Hong Kong Press, Hong Kong, pp 221–243

Hollingshead AB (2000) Perceptions of expertise and transactive memory in work relationships. Group Proc Intergr Relat 3:257–267

Hommel B, Colzato LS, van den Wildenberg WPM (2009) How social are task representations? Psychol Sci 20:794–798

Hong Y-y, Morris MW, Chiu C-y, Martínez V (2000) Multicultural minds: a dynamic constructivist approach to culture and cognition. Am Psychol 55:709–720

Kahneman D (1973) Attention and effort. Prentice Hall, Englewood Cliffs

Kemmelmeier M, Cheng BY-M (2004) Language and self-construal priming: a replication and extension in a Hong Kong sample. J Cross Cult Psychol 35:705–712

Knoblich G, Jordan S (2003) Action coordination in individuals and groups: learning anticipatory control. J Exp Psychol Learn Mem Cogn 29:1006–1016

Knoblich G, Sebanz N (2006) The social nature of perception and action. Curr Dir Psychol Sci 15:99–104

Knoblich G, Sebanz N (2008) Evolving intentions for social interaction: from entrainment to joint action. Philos Trans R Soc Lon B Biol Sci 363:2021–2031

Kramer RM, Brewer MB (1984) Effects of group identity on resource use in a simulated commons dilemma. J Personal Soc Psychol 46:1044–1057

Markus HR, Uchida Y, Omoregie H, Townsend SSM, Kitayama S (2007) Going for the gold: models of agency in Japanese and American contexts. Psychol Sci 17:103–112

Mendes WB, Major B, McCoy S, Blascovich J (2008) How attributional ambiguity shapes physiological and emotional responses to social rejection and acceptance. J Personal Soc Psychol 94:278–291

Mueller JH, Thompson WB (1984) Test anxiety and distinctiveness of personal information. In: Ploeg HM, Schwarzer R, Spielberger CD (eds) Advances in test anxiety research, vol 3. Erlbaum, Hillsdale, pp 21–37

Olivers CNL, Meijer F, Theeuwes J (2006) Feature-based memory-driven attentional capture: visual working memory content affects visual attention. J Exp Psycho Hum Percept Perform 32:1243–1265

Pashler H, Johnston JC, Ruthruff E (2001) Attention and performance. Annu Rev Psychol 52:629–651

Ross M, Xun WQE, Wilson AE (2002) Language and the bicultural self. Personal Soc Psychol Bull 28:1040–1050

Ruby P, Decety J (2001) Effect of subjective perspective taking during simulation of action: A PET investigation of agency. Nat Neurosci 4:546–550

Schuch S, Tipper SP (2007) On observing another person's actions: influences of observed inhibition and errors. Percept Psychophys 69:828–837

Sebanz N, Knoblich G, Prinz W (2003) Representing others' actions: just like one's own? Cognition 88:B11–B21

Sebanz N, Knoblich G, Prinz W (2005) How two share a task: corepresenting stimulus-response mappings. J Exp Psychol Hum Percept Perform 31:1234–1246

Sebanz N, Bekkering H, Knoblich G (2006) Joint action: bodies and minds moving together. Trends Cogn Sci 10:70–76

Shteynberg G (2010) A silent emergence of culture: the social tuning effect. J Personal Soc Psychol 99:683–689

Simon JR (1969) Reactions towards the source of stimulation. J Exp Psychol 81:174–176

Soto D, Heinke D, Humphreys GW, Blanco MJ (2005) Early, involuntary top-down guidance of attention from working memory. J Exp Psychol Hum Percept Perform 31:248–261

Soto D, Humphreys GW, Heinke D (2006a) Dividing the mind: the necessary role of the frontal lobes in separating memory from search. Neuropsychologia 44:1282–1289

Soto D, Humphreys GW, Heinke D (2006b) Working memory can guide pop-out search. Vis Res 46:1010–1018

Soto D, Hodsoll J, Rotshtein P, Humphreys GW (2008) Automatic guidance of attention from working memory. Trends Cogn Sci 12:342–348

Stephan WG, Stephan CW (1985) Intergroup anxiety. J Soc Issues 41:157–175

Tajfel H (1982) Social psychology of intergroup relations. Annu Rev Psychol 33:1–39

Tajfel H, Billig M, Bundy R, Flament C (1971) Social categorization and intergroup behaviour. Eur J Soc Psychol 1:149–178

Tice DM, Butler JL, Muraven MB, Stillwell AM (1995) When modesty prevails: differential favorability of self-presentation to friends and strangers. J Personal Soc Psychol 69:1120–1138

Tong Y-Y, Hong Y-Y, Lee S-L, Chiu C-Y (1999) Language use as a carrier of social identity. Int J Intercult Relat 23:281–296

Triandis HC (1995) Individualism and collectivism. Westview, Boulder

Tsai C-C, Brass M (2007) Does the human motor system simulate Pinocchio's action? Coacting with a human hand versus a wooden hand in a dyadic interaction. Psychol Sci 18:1058–1062

Vohs KD, Baumeister RF, Ciarocco NJ (2005) Self-regulation and self-presentation: regulatory resource depletion impairs impression management and effortful self-presentation depletes regulatory resources. J Personal Soc Psychol 88:632–657

Wegner DM (1986) Transactive memory: a contemporary analysis of the group mind. In: Mullen B, Goethals GR (eds) Theories of group behaviour. Springer, New York, pp 185–208

Wegner DM, Erber R, Raymond P (1991) Transactive memory in close relationships. J Personal Soc Psychol 61:923–929

Welsh TN, Elliott D, Anson JG, Dhillon V, Weeks DJ, Lyons JL, Chua R (2005) Does Joe influence Fred's action? Inhibition of return across different nervous systems. Neurosci Lett 385:99–104

Welsh TN, Lyons J, Weeks DJ, Anson JG, Chua R, Mendoza J, Elliott D (2007) Within- and between-nervous-system inhibition of return: observation is as good as performance. Psychonom Bull Rev 14:950–956

Williams M (2001) In whom we trust: group membership as an affective context for trust development. Acad Manag Rev 26:377–396

Yantis S (1998) Control of visual attention. In: Pashler H (ed) Attention. Psychology Press, Hove, pp 223–256

Zajonc R (1965) Social facilitation. Science 149:269–274