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Avatars and Arrows: Implicit Mentalizing or Domain-General Processing?

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Previous studies using the dot perspective task have shown that adults are slower to verify the number of dots they can see in a picture when a human figure in the picture, an avatar, can see a different number of dots. This "self-consistency effect," which occurs even when the avatar's perspective is formally task-irrelevant, has been interpreted as evidence of implicit mentalizing; that humans can think about the mental states of others via dedicated, automatic processes. We tested this interpretation by giving participants 2 versions of the dot perspective task. In some trials, the avatar was presented as in previous experiments, and in other trials the avatar was replaced by an arrow with similar low-level features. We found self-consistency effects of comparable size in the avatar and arrow conditions, suggesting that self-consistency effects in the dot perspective task are due to domain-general processes such as those that mediate automatic attentional orienting.

Keywords: automatic attentional orienting, dot perspective task, implicit mentalizing, perspective-taking, submentalizing

"Mentalizing," also known as "theory of mind" and "mindreading," is thinking about mental states such as beliefs, desires, and intentions. It has been a major focus of philosophical investigation for centuries, and of scientific enquiry for the last 35 years (Premack & Woodruff, 1978). Mentalizing is of interest because it is thought to play a pivotal role in human social interaction and communication, enabling us to predict, explain, mold, and manipulate each other's behavior in ways that go well beyond the capabilities of other animals.

Traditionally it has been assumed that mentalizing requires conscious deliberation. However, in recent years it has been suggested that infants, children, and adults are capable of "implicit mentalizing;" of representing mental states in an unconscious and automatic way, rather than via controlled processing (Frith & Frith, 2012). Evidence of implicit mentalizing in adults is important for two reasons. First, it supports the theory that humans have two cognitive systems for mentalizing: one early-developing, automatic, or "fast-and-efficient" system (implicit), and a later-developing, controlled "slow-and-flexible" system (explicit; Apperly, 2011; Apperly & Butterfill, 2009). Second, it supports the controversial view (Heyes, in press-a; Moore & Corkum, 1994; Perner & Ruffman, 2005; Perner, 2010), based primarily on eye movement studies, that infants are capable of mentalizing (Baillargeon, Scott, & He, 2010; Onishi & Baillargeon, 2005).

A range of procedures have been used to provide evidence of implicit mentalizing in adults (Heyes, in press-b), testing for automatic representation of what others see (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010; Zwickel, 2009), intend (Sebanz, Knoblich, & Prinz, 2003), and believe (Kovács, Téglás, & Endress, 2010; Senju, Southgate, White, & Frith, 2009). One of these procedures, which we will call the "dot perspective task," has been used in a careful and systematic way to examine "perspective-taking:" automatic representation of what others can see.

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In each trial of the dot perspective task, the participant sees a picture in which a human-like figure, an "avatar," is standing in a room facing to the left or to the right (see Figure 1). There are dots on the wall in front of the avatar, on the wall behind the avatar, or both. A digit (0–3) is presented just before the picture appears. In "self" trials, the participant's speeded task is to confirm whether or not the digit corresponds to the number of dots that she, the participant, can see in the picture; the number of dots in front of the avatar plus the number behind. In "other" trials, the participant's task is to confirm whether or not the digit corresponds to the number of dots that the avatar can see; the number of dots in front of the avatar. Both self and other trials are of two kinds, "consistent" and "inconsistent." In consistent trials, the participant and the avatar can see the same number of dots. For example, there are two dots in the picture, both in front of the avatar. In inconsistent trials the participant and the avatar can see different numbers of dots. For example, there are two dots in the picture, but one is in front and the other is behind the avatar.

The primary result from the dot perspective task—the result suggesting that older children and adults engage in implicit mentalizing—shows that "yes" responses are slower in self-inconsistent than in self-consistent trials (Samson et al., 2010). Thus, in self trials, where participants are not required to take the avatar's perspective into account, they are slower to confirm that the digit represents the number of dots that they (the participant) can see when the number of dots seen by the avatar differs from the number of dots seen by the participant.

This "self-consistency effect" provides evidence of implicit mentalizing if (a) it is due to an automatic, rather than a controlled, process; and (b) this process represents what the avatar can see. The first of these assumptions has been validated in a variety of ways (McCleery, Surtees, Graham, Richards, & Apperly, 2011; Qureshi, Apperly, & Samson, 2010; Samson et al., 2010); the self-consistency effect remained robust to each change in procedure testing for automaticity. Our experiment tested the second assumption against an alternative account suggesting that the self-consistency effect is due to domain-general processing. This alternative "directional hypothesis" suggests that it is the directional, rather than the agentive, features of the avatar that are important, and that they modulate a process that represents the number of dots on one side of the screen, rather than the number that an agent can see. For example, the "front features" of the avatar (forehead, eyes, nose, etc.) automatically trigger a shift of attention to the dots on the left side of the screen, which enhances processing of their number. In inconsistent trials, the number on the left conflicts with the total number on the screen, calculated in parallel and according to task instructions. Before a correct "yes" response can be given, this conflict has to be resolved, and therefore response times are slower in inconsistent than in consistent trials where there is no conflict.

We tested the implicit mentalizing hypothesis against the directional account by giving participants two versions of the dot perspective task. In some trials, the avatar was presented as in previous experiments, and in the other trials the avatar was replaced by an arrow. Arrows have directional but not agentive features, and they are not appropriate targets for the attribution of mental states such as "seeing." However, arrows can produce automatic orienting of attention even when they are uninformative (Tipples, 2002) or counterpredict a target's location (Guzzon, Brignani, Miniussi, & Marzi, 2010; Tipples, 2008). Therefore, the directional account predicts that not only avatars, but also arrows, will produce a self-consistency effect. We tested this prediction in two experiments, modeled on the first and third experiments reported by Samson et al. (2010).

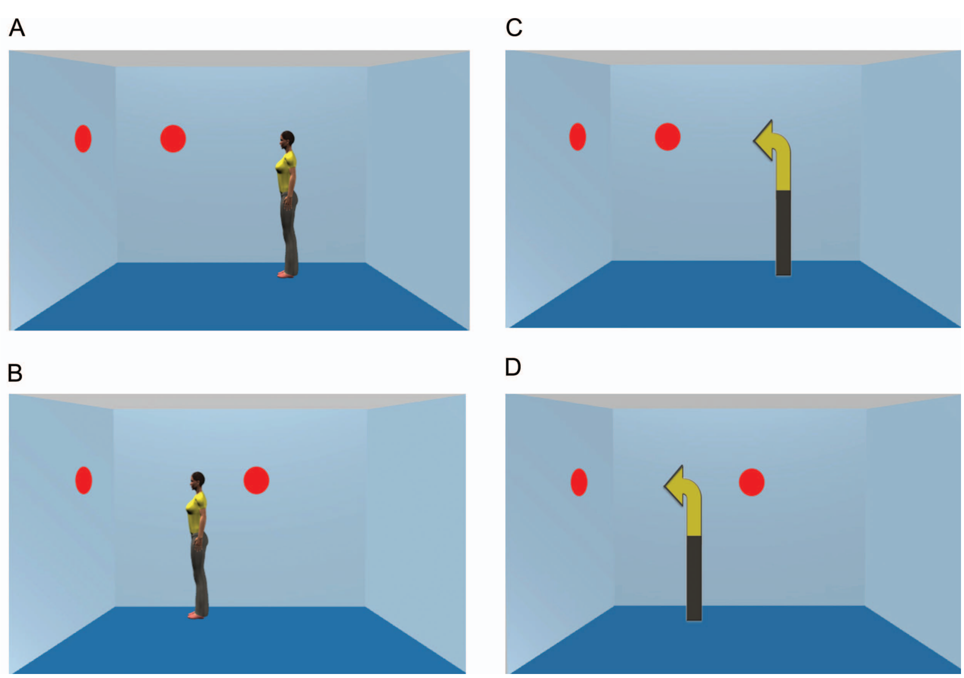

Figure 1. Examples of the stimuli presented in consistent (A) and inconsistent (B) trials with the avatar, and consistent (C) and inconsistent (D) trials with the arrow.

Experiment 1

Method

Participants. Twenty-eight healthy adults (18 males) volunteered to take part in this study. Their age ranged between 19 and 42 years ($M = 29.9$, $SD = 6.1$). The data from two additional participants, with error rates greater than 40%, were excluded from the analysis.

Stimuli and apparatus. Examples of the stimuli are presented in Figure 1. They were produced from the image files used by Samson et al. (2010).[1] Following McCleery et al. (2011), the central stimulus (avatar or arrow) appeared at one of two locations, just to the left or right of the middle of the screen, and faced (front of avatar, point of arrow) to the left or right. There were two tokens of each central stimulus type; a male and a female avatar (presented to male and female participants, respectively), and two arrows with color palettes and color distributions matched to those of the male and female avatars. The arrows also matched the avatars in height (5.84° of visual angle) and area. The points of the arrows, like the noses of the avatars, were aligned on a horizontal plane with the center of the stimulus dots, that is, bright red circles (each 1.15° in diameter) apparently attached to the walls of the stimulus room. The number and distribution of dots in each trial were: (1) in front (F) or behind (B); (2) 2F, 1F,1B, 2B; (3) 3F, 1F, 2B, 2F,1B, 3B. "Yes" responses were made by pressing 1, and "no" responses by pressing 2 on a keypad aligned vertically with the center of the computer screen.

Procedure. The procedure was modeled on that used by Samson et al. (2010, Experiment 1). Each trial began with a fixation cross in the center of the screen (750 ms), which was replaced 500 ms later with a word (750 ms): YOU (Self trials), HE/SHE (Other Avatar trials), or ARROW (Other Arrow trials). After 500 ms, the word was replaced by a digit (0, 1, 2, or 3; 750 ms), and the digit was replaced by an image of the kind shown in Figure 1. The participant's task was to respond "yes" if the digit corresponded to the number of dots "you can see from your perspective" (Self trials), "she/he can see from her/his perspective" (Other Avatar trials), or "to which the arrow is pointing" (Other Arrow trials), and otherwise to respond "no." The next trial began after a response was registered, or, if no response was made, 2,000 ms later.

Each participant completed four consecutive blocks of trials with the avatar stimulus and four consecutive blocks with the arrow stimulus. The order of avatar and arrow conditions was counterbalanced across participants. Each set of four blocks was preceded by 26 practice trials. Accuracy feedback was given during practice trials only. Each block of experimental trials comprised: eight self consistent, eight other consistent, 16 self inconsistent, and 16 other inconsistent trials. In half of the trials of each of these four principal types the avatar/arrow pointed to the left and in half it pointed to the right. Order of presentation was pseudorandomized within each block so that there were no more than three consecutive trials of the same type and direction. Half of the trials of each type required a "yes" response and half required a "no" response.

Thus, our procedure differed from that of Samson et al. (2010, Experiment 1) in three respects: (a) We included an arrow condition as well as an avatar condition; (b) we added inconsistent "no" trials in which the digit did not correspond with the inverse perspective ("noninverse no" trials)[2]; and (c) to ensure that, in spite of this addition, there was an equal number of "yes" and "no" trials within each of the four principal types, we gave participants twice as many inconsistent as consistent trials. All previously published studies using the dot perspective task have analyzed "yes" trial performance only. The second change listed above, which made inconsistent "no" trials more like consistent "no" trials, was implemented to find out whether any information can be derived from "no" trial performance. To equate the number of consistent and inconsistent trials in our "yes" trial analyses, we excluded alternate "yes" trials in the inconsistent condition.

Results and Discussion

Self trial performance was the primary focus of theoretical interest in the present study because it is the self-consistency effect, rather than the other-consistency effect, that is thought to provide evidence of implicit mentalizing. Accordingly, we first analyzed the self trial data in isolation, and then performed more inclusive analyses, incorporating both self and other trials, to check whether our results were broadly compatible with those of previous studies using the dot perspective task. In the focal analyses, we first examined "yes" responses, which were the only responses analyzed in previous dot perspective studies, and then checked whether a similar pattern of results was observed when "noninverse no" responses were also included. Response time (reaction time, RT; Figure 2A) and percentage errors (Figure 2B) were used as the dependent variables throughout.

Self trials. We used a 2 × 2 × 2 mixed-design ANOVA with Consistency (consistent vs. inconsistent) and Stimulus (avatar vs. arrow) as within-subjects factors, and Order (avatar first vs. arrow first) as a between-subjects factor. Response omissions due to the time-out procedure (1.5%) and erroneous responses (4.9%) were excluded from the RT analysis.

As predicted, analysis of RT in self "yes" trials revealed a significant main effect of Consistency, $F_{(1,26)} = 40.33$; $p < .001$; $\eta_p^2 = .61$. RTs were longer in inconsistent ($M = 700.80$ ms, $SEM = 19.38$) than in consistent ($M = 640.81$ ms, $SEM = 17.47$) trials, but there was no evidence that this self-consistency effect varied with the identity of the central stimulus: avatar ($p < .001$), arrow ($p = .001$). No other main effects or interactions were significant (Stimulus $p = .483$, Order $p = .252$, Consistency × Stimulus $p = .842$, Consistency x Stimulus x Order $p = .11$),

[1] We are grateful to Dana Samson for generously providing us with the stimuli used by Samson et al. (2010), and for her very helpful advice on implementation of the dot perspective task.

[2] "Yes" responses were accurate when the digit corresponded to the number of dots visible to the participant (self trials) or in front of the avatar/arrow (other trials). In half of the trials where a "yes" response was accurate, the digit also corresponded with the inverse perspective, that is, the number in front of the avatar/arrow in self trials (self consistent), and the number visible to the participant in other trials (other consistent), and in the other half it did not (self inconsistent and other inconsistent trials). "No" responses were accurate when the digit did not correspond to the number of dots visible to the participant (self trials) or in front of the avatar/arrow (other trials). In consistent trials where a "no" response was accurate, and in half of the inconsistent trials where a "no" response was accurate, the digit also did not correspond with the inverse perspective. In the other half of the inconsistent "no" trials, the digit corresponded with the inverse perspective.

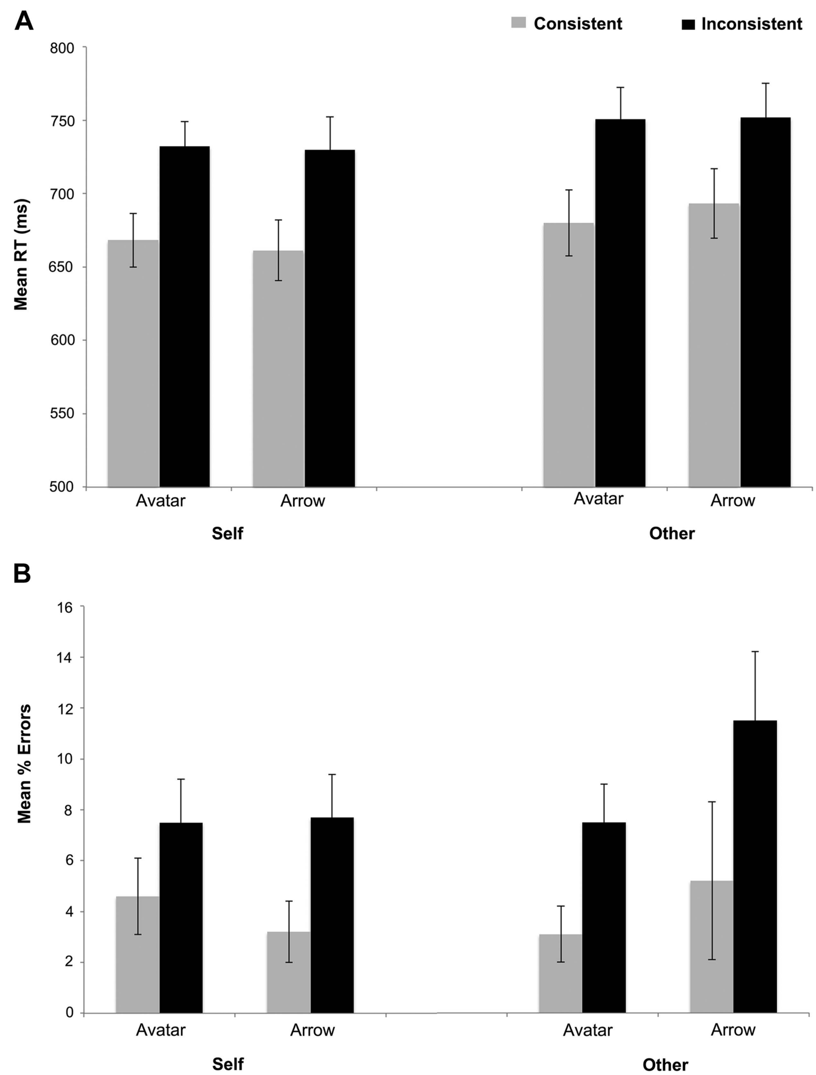

Figure 2. Mean RT (A) and percentage error (B) for all "yes" responses in Experiment 1. Light bars represent consistent trials and dark bars represent inconsistent trials, for the self and other perspective tasks, with avatar and arrow stimuli. Lines represent *SEM.*

except the Stimulus × Order interaction, $F_{(1,26)} = 12.15$; $p = .002$; $\eta^2_p = .32$. Post hoc simple effects analysis showed that responses were significantly slower in the first than in the second stimulus condition when the avatar blocks were presented first (avatar vs. arrow, *M* difference = 59.54 ms, $F_{(1,26)} = 8.81$; $p = .006$; $\eta^2_p = .25$) and a marginally significant trend in the same direction when the arrow blocks were presented first (arrow vs. avatar, *M* difference = 39.35 ms, $F_{(1,26)} = 3.85$; $p = .06$; $\eta^2_p = .13$). Inspection of the means associated with the Consistency × Stimulus × Order interaction indicated a nonsignificant ($p = .11$) tendency for the self-consistency effect to be greater in the first condition completed, regardless of whether that condition involved the avatar or the arrow. Between-subjects analysis confirmed that the self-consistency effect in the arrow condition did not depend on participants having prior experience in the avatar condition. This analysis, which included only data from each participant's first condition (avatar or arrow; see Figure 3), revealed a main effect of Consistency, $F_{(1,26)} = 30.66$; $p < .001$; $\eta^2_p = .54$, no main effect of Stimulus ($p = .452$), and no Consistency × Stimulus interaction ($p = .924$). Again, in this between-subjects analysis the self-consistency effect was significant in both avatar (76.75 ms; $t_{(13)} = 6.2$; $p < .001$; $d = .65$) and arrow (79.47 ms; $t_{(13)} = 3.14$; $p < .001$; $d = .65$) conditions.

The inclusion of "noninverse no" trials in which the digit did not correspond with the inverse perspective allowed us to combine "yes" and "noninverse no" trials of the self task in one analysis (after an initial analysis including Response ("yes" vs. "no") as a factor in the ANOVA revealed that the crucial Response × Stimulus × Consistency interaction was not significant, $p = .99$). The results of the RT analysis showed a similar pattern to "yes" trials. There was a significant main effect of Consistency, $F_{(1,26)} = 23.84$; $p = .001$; $\eta^2_p = .48$, with faster responding in consistent ($M = 664$ ms, $SEM = 18.78$) than in inconsistent ($M = 702$ ms, $SEM = 17.48$) trials. The Stimulus × Order interaction was also

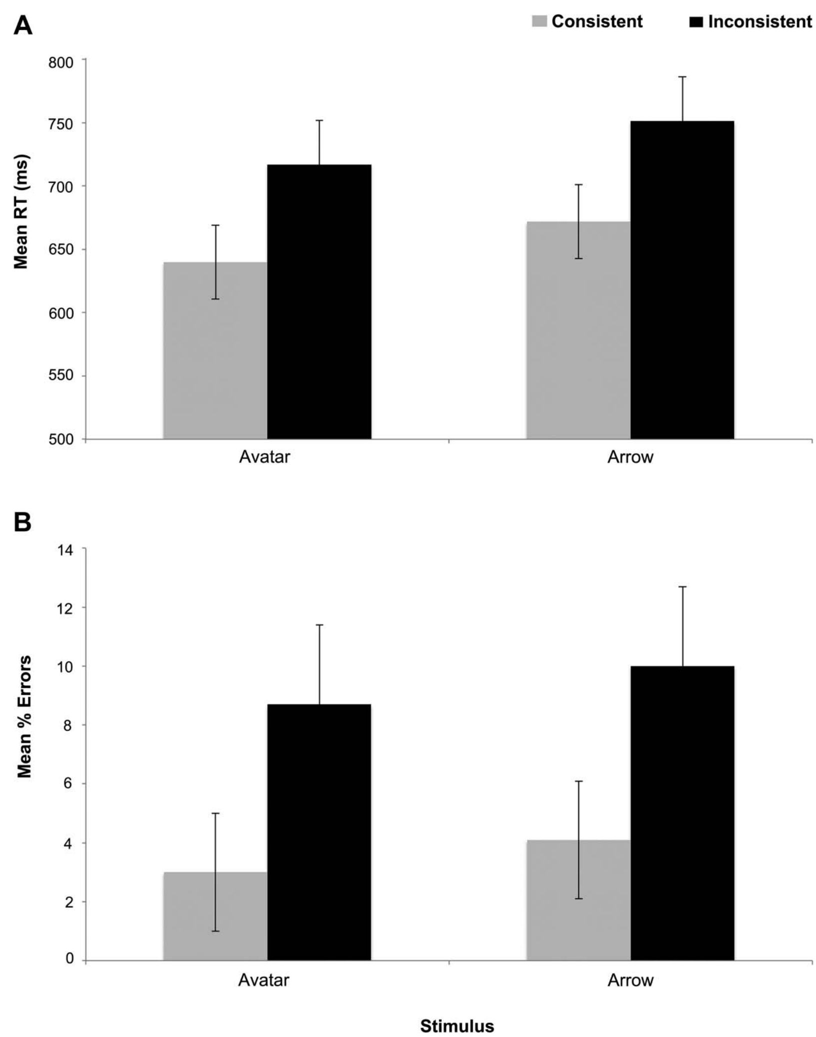

Figure 3. Mean RT (A) and percentage error (B) for "yes" responses in the first stimulus condition completed by participants in Experiment 1. Light bars represent consistent trials and dark bars represent inconsistent trials, for the self perspective task, with avatar and arrow stimuli. Lines represent *SEM*.

significant $F_{(1,26)} = 18.65$; $p = .001$; $\eta_p^2 = .42$. Post hoc simple effects analysis showed that participants responded faster in their second Stimulus condition, regardless of whether the avatar (*M* difference = 59.28 ms, $F_{(1,26)} = 13.71$; $p = .001$; $\eta_p^2 = .35$) or arrow condition (*M* difference = 38.52 ms; $F_{(1,26)} = 5.79$; $p = .024$; $\eta_p^2 = .18$) was completed first. The Consistency × Stimulus × Order interaction also reached significance, $p = .015$. This interaction is illustrated in Figure 4. Simple effects analysis confirmed that both the arrow and the avatar produced a significant consistency effect when they were the first stimulus type presented, Avatar: $t_{(13)} = 6.89$, $p < .001$, $d = .42$; Arrow: $t_{(13)} = 3.29$, $p = .006$, $d = .52$. However, the Consistency × Stimulus × Order interaction indicates that the tendency for a stimulus type to generate a larger consistency effect when it came first rather than second was greater for the arrow (Arrow First: $M = 54.77$ ms; Arrow Second: $M = 12.73$ ms, $p = .04$) than the avatar (Avatar First: $M = 46.89$ ms; Avatar Second: $M = 34.65$ ms, $p = .49$). Thus, the advantage associated with coming first is greater for arrows than for avatars. None of the other effects were significant. As in the case of "yes" self trials, between-subjects analysis including "noninverse no" trials in the first Stimulus condition yielded a main effect of Consistency, $F_{(1,26)} = 32.24$; $p = .001$; $\eta_p^2 = .55$; consistent $M = 681$ ms, $SEM = 20.39$, inconsistent $M = 733$ ms, $SEM = 20.61$, with no main effect of Stimulus ($p = .471$) or Consistency × Stimulus interaction ($p = .713$).

Equivalent analyses of the error data from self trials confirmed that the effects of Consistency on RT were not due to speed–accuracy trade-off. Participants made fewer errors in consistent than in inconsistent trials for "yes" responses (consistent $M = 3.9\%$, $SEM = 1.0$; inconsistent $M = 7.6\%$, $SEM = 1.4$, $F_{(1,26)} = 8.47$; $p = .007$; $\eta_p^2 = .25$), and a similar trend was observed when "noninverse no" responses were included, $F_{(1,26)} = 3.55$; $p = .071$; $\eta_p^2 = .12$ (consistent $M = 4.5\%$, $SEM = 1.0$; inconsistent $M = 6.3\%$, $SEM = 1.3$). Similarly, between-subjects analyses indicated that more errors were made in inconsistent ($M = 9.4\%$, $SEM = 1.9$) than in consistent ($M = 3.5\%$, $SEM = 1.4$) "yes"

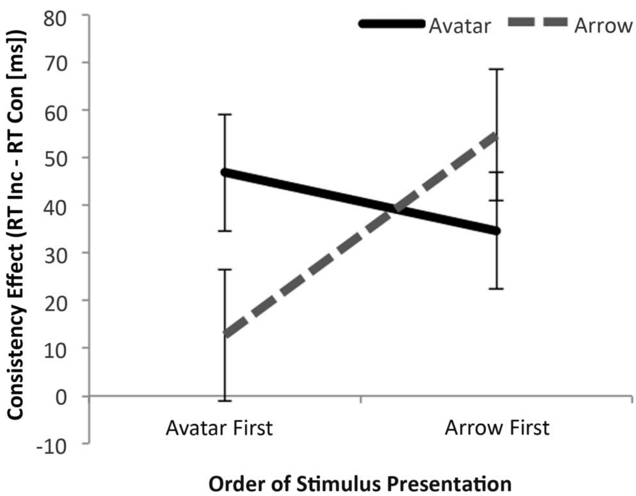

Figure 4. Consistency × Stimulus × Order interaction for the self perspective task in Experiment 1. The dark solid line represents avatar trials and the light dashed line represents arrow trials, for the collapsed "yes"/"noninverse no" trials. Lines represent *SEM.*

trials, $F_{(1,26)} = 9.65$; $p = .005$; $\eta_p^2 = .27$, and in inconsistent (M = 7.4%, $SEM = 1.8$) than in consistent trials (M = 4.4%, $SEM = 1.3$) when "noninverse no" responses were included, $F_{(1,26)} = 4.59$; $p = .042$; $\eta_p^2 = .15$. No other main effects or interactions were significant in any of these error analyses.

Self and other trials. Previous experiments using the dot perspective task compared performance in self and other trials using "yes" responses only. Therefore, to check that the results of our experiment were broadly compatible with those of previous studies, we subjected the RT and error data from "yes" trials to 2 × 2 × 2 repeated measures ANOVA, with Task (self vs. other), Consistency (consistent vs. inconsistent), and Stimulus (avatar vs. arrow) as the within subjects factors. Response omissions due to the time-out procedure (2%) and erroneous responses (4.6%) were excluded from the RT analysis.

When we included both self and other perspective judgments, our RT data replicated the consistency effect found in previous studies, $F_{(1,26)} = 86.34$; $p < .001$; $\eta_p^2 = .76$ (consistent $M = 640$ ms, $SEM = 19.46$; inconsistent $M = 712$ ms, $SEM = 20.65$). Similarly, as in previous studies, there was a consistency effect in both self (62 ms, $t_{(27)} = 6.88$; $p < .001$; $d = .63$) and other (99 ms, $t_{(27)} = 7.64$; $p < .001$; $d = .81$) trials in the avatar condition. Furthermore, in our experiment this effect was also significant in the arrow condition when participants judged their own perspective (58 ms, $t_{(27)} = 3.52$; $p = .002$; $d = .48$) and when they judged the number of dots to which the arrow was pointing (69 ms, $t(_{27}) = 4.33$; $p < .001$; $d = .50$). We did not find an effect of Task ($p = .21$) and the interaction between Task and Consistency showed a trend toward significance ($p = .10$). These effects have been observed in some previous studies using the dot perspective task (e.g., Samson et al., 2010) but not in others (Qureshi et al., 2010). No other main effects or interactions were significant.

Also replicating previous studies, and showing that the RT effect was not due to a speed–accuracy trade-off, inclusive analysis (self plus other trials) yielded a significant main effect of Consistency on percentage error, $F_{(1,26)} = 13.47$; $p = .001$; $\eta_p^2 = .33$, with participants making more errors in inconsistent (8.6%) than in consistent (4%) trials. The Stimulus × Task interaction was also significant in the error analysis, $F_{(1,26)} = 4.78$; $p = .038$; $\eta_p^2 = .15$. Inspection of Figure 3 suggests that there was an effect of Task on errors in the arrow condition but not in the avatar condition, but neither of these simple effects were significant.

Thus, as predicted, the results of Experiment 1 suggest that an arrow is as effective as an avatar in producing a self-consistency effect in the dot perspective task, and that the effectiveness of the arrow does not depend on participants having had prior experience of judging what the avatar can see.

Experiment 2

Experiment 2 was modeled very closely on the third experiment reported by Samson et al. (2010). In that experiment, Samson et al. included only self trials; participants were always asked to confirm whether a digit corresponded to the number of dots that they (the participant) could see, and never asked to confirm whether a digit corresponded to the number that the avatar could see. They also mixed these self avatar trials with self rectangle trials, in which the central stimulus was a rectangle rather than a human-like figure, and found a self-consistency effect only in the avatar trials. The directional hypothesis suggests that this negative result in the self rectangle condition was due to the fact that, although the rectangle stimulus was asymmetric (it had a green line on one side and a purple line on the other), it was not directional. It did not point to the left or the right, and therefore did not induce automatic shifts of attention. To test this hypothesis, in Experiment 2 we replicated exactly the third experiment reported by Samson et al., but replaced the rectangle stimulus with the arrow stimulus used in our Experiment 1. As in Experiment 1, we predicted that self-consistency effects of comparable magnitude would be observed in the avatar and arrow conditions.

Two features of Experiment 2 make it a more decisive test of domain generality than Experiment 1. First, in Experiment 1 the arrow could have induced a self-consistency effect by virtue of transfer from other perspective trials. Completing trials in which they were required to judge the number of dots the avatar could see and/or the number of dots to which the arrow was pointing, could have drawn participants' attention to the arrow stimulus in a way that enabled the arrow to influence performance in self trials. This kind of other-to-self transfer effect could not occur in Experiment 2 because participants were not asked at any stage to make judgments relating to the avatar or arrow. Instead they were told explicitly to ignore the central stimulus. Second, although the methods used in Experiment 1 were very similar to those used in previous dot perspective experiments, some of the details were different. Specifically, participants completed twice as many inconsistent as consistent trials, rather than an equal number, and we added "no" trials in which the digit did not correspond to the inverse perspective. In view of these differences, it is possible that the self-consistency effects observed with avatar and arrow stimuli in Experiment 1 were due to domain-general processes, but that the self-consistency effects observed with avatar stimuli in previous studies were mediated by distinct processes involving implicit mentalizing. To avoid this interpretative problem, the methods used in Experiment 2—including the types and numbers of trials—

were exactly matched to those of the third experiment reported by Samson et al.

Method

Participants. Eighteen healthy adults (11 females) volunteered to take part in this study for a small monetary reward. Age ranged between 20 and 52 years old ($M = 29$, $SD = 7.6$).

Stimuli and apparatus. The stimuli used in Experiment 1 were modified in two ways: the avatar or arrow appeared in the very center of the screen, and the dots appeared on the left and/or right wall, but never on the back wall of the room. The displays showing the avatar were the same image files used by Samson et al. (2010, Experiment 3), and we created the control condition by replacing the avatar with the arrow as described in Experiment 1. As before (Samson et al., Experiment 3 and our Experiment 1), there was a male and a female avatar (presented to male and female participants, respectively), and the arrows were presented in colors matching those of the male and female avatars.

Procedure. The procedure was modeled on the third experiment reported by Samson et al. (2010), with the same number of consistent and inconsistent trials (24 consistent "yes," 24 consistent "no," 24 inconsistent "yes," and 24 inconsistent "no") in each stimulus condition, and the same sequence of events within each trial (as described in Experiment 1). Participants were instructed to judge their own perspective in every trial and to ignore the stimuli in the center of the room. There were four blocks of 48 trials each, with each block containing four additional filler trials in which no dots were presented. The avatar and arrow trials were mixed within each block and, as in Experiment 1, there was a practice block of 26 trials prior to the experimental session.

Results and Discussion

The data were analyzed using a 2 × 2 repeated measures ANOVA with Consistency (consistent vs. inconsistent) and Stimulus (avatar vs. arrow) as the within-subjects factors. RT and number of errors were the dependent variables. Figure 5 shows the RT and error data.

Response omissions due to the time-out procedure (0.3%) and erroneous responses (0.9%) were excluded from the RT analysis. There was a significant main effect of Consistency, $F_{(1,17)} = 12.86$; $p = .002$; $\eta_p^2 = .43$, indicating that responding was faster in consistent ($M = 581$ ms, $SEM = 26.02$) than in inconsistent trials ($M = 615$ ms, $SEM = 32.65$). There was also a significant main effect of Stimulus, $F_{(1,17)} = 6.66$; $p = .019$; $\eta_p^2 = .28$, with more rapid responding in arrow ($M = 588$ ms, $SEM = 29$) than in avatar trials ($M = 608$ ms, $SEM = 29.5$). Like the trend observed by Samson et al. (2010, Experiment 3) toward more rapid responding in rectangle than in avatar trials, the main effect of Stimulus suggests that in addition to any specific effects (inducing attentional orienting or implicit mentalizing), the avatar stimuli may be more distracting than inanimate stimuli. However, as predicted by the directional hypothesis, and in contrast with the results of Samson et al.'s third experiment, the Stimulus × Consistency interaction was not significant ($p = .81$). Furthermore, post hoc analysis confirmed that the consistency effect was significant not only in avatar, 35.40 ms, $t_{(17)} = 3.22$, $p = .004$, $d = .28$, but also in arrow trials, 32.59 ms, $t_{(17)} = 2.94$, $p = .008$, $d = .26$.

As in the third experiment reported by Samson et al., participants made very few errors (0.9%) and neither the main effects nor the interaction were significant in the Consistency × Stimulus analysis (all *p*s $>.17$). Thus, the effects of Consistency on RT were not due to a speed–accuracy trade-off.

General Discussion

Our results replicated those of previous studies using the dot perspective task in showing that, when the central stimulus was an avatar, responding was faster in consistent than in inconsistent trials overall, and that this consistency effect was present both when the participant's task was to verify the number of dots they could see (self task), and to verify the number of dots the avatar could see (other task). As previous studies have found (e.g., McCleery et al., 2011), the self-consistency effect induced by the avatar stimulus is a robust phenomenon. As predicted by the directional account, we extended the results of previous studies by showing that consistency effects of comparable magnitude also occur when the central stimulus is an arrow with low-level features matched to those of the avatar. Crucially, in the context of implicit mentalizing, we found consistency effects with the arrow stimulus when participants were performing the self task; they were slower to verify the number of dots that they (the participant) could see when this number was inconsistent, rather than consistent, with the number to which the arrow was pointing. This finding supports the view that the self-consistency effect in the dot perspective task is due to domain-general processing; to mechanisms that are not specific to the representation of mental states.

It could be argued that the self-consistency effect occurred when the central stimulus was an arrow because, generalizing from the avatar to the arrow stimulus, participants represented the number of dots in front of the arrow as the number of dots that the arrow could "see;" that they engaged in implicit mentalizing in both the avatar and the arrow conditions. However, our results provided no support for this view. The between-subjects analyses of performance in Experiment 1 showed that the arrow produced a self-consistency effect before participants had been tested with the avatar stimulus, and the results of Experiment 2 showed that the arrow produced a self-consistency effect even when participants had been told to ignore the central stimulus, and had not made judgments about the number of dots that the avatar could see. These results suggest that participants were not generalizing from avatar to arrow stimuli on the basis of their experience within the experiment. However, they do not exclude the possibility that participants were generalizing from their preexperimental experience with arrows. Perhaps everyday experience with arrows, in which interesting or important stimuli are more likely to be located near the head than the tail, results in habitual representation of what arrows can "see." This liberal version of the implicit mentalizing hypothesis is coherent but it is not clear whether it is empirically testable. We know that *explicit* mentalizing can be extended to virtually any object. If it is assumed that implicit mentalizing is also promiscuous—and given that we cannot, by definition, use verbal report to assess implicit mentalizing—there is a danger that implicit mentalizing hypotheses will become unfalsifiable. Under these circumstances, the dot perspective task would have no greater claim to demonstrate implicit mentalizing than, for example, the many experiments showing that eye and arrow stimuli induce involuntary shifts of attention (Guzzon et al., 2010).

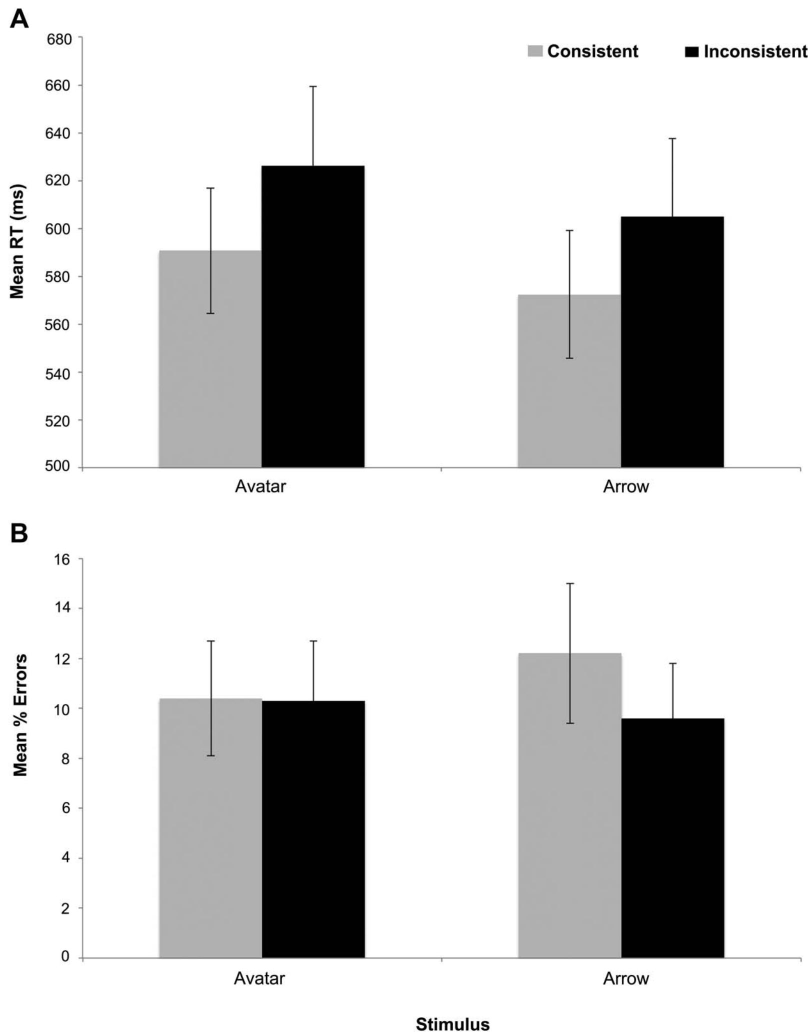

Figure 5. Mean RT (A) and percentage error (B) for "yes" responses in Experiment 2, where participants completed a self perspective task only. Light bars represent consistent trials and dark bars represent inconsistent trials, with avatar and arrow stimuli. Lines represent *SEM.*

Our results indicate that, under identical conditions, an inanimate stimulus, an arrow, can generate a self-consistency effect comparable in magnitude with that generated by an animate stimulus, an avatar. This provides prima facie evidence that the mechanisms mediating the self-consistency effect are domain-general. It is also compatible with the particular domain-general hypothesis we have proposed; with the suggestion that the self-consistency effect is due to the directional, rather than the agentive, features of the stimuli, and that they modulate a process that represents the number of dots on one side of the screen, rather than the number that an agent can see. However, it is possible that other domain-general mechanisms contribute to the self-consistency effect, instead or in addition to the directional account. For example, in all dot perspective experiments to date, the consistency variable has been confounded to some degree by "grouping": the dots appear on one side of the central stimulus, rather than in a spatial array that includes the central stimulus, more often in consistent than in inconsistent trials. Therefore, it is possible that, regardless of its agentive or directional properties, the central stimulus slows responding in inconsistent trials by making it harder to count or to subitize the dots. If this kind of distraction was solely responsible for the self-consistency effect, it should have persisted when Samson et al. (2010, Experiment 3) replaced the avatar with a rectangular central stimulus. However, it remains possible that distraction and other domain-general mechanisms contribute to the self-consistency effect, and further studies would be needed to provide conclusive evidence that the critical domain-general processes are those involved in the directional account.

Our results are congruent with those of other, recent studies questioning evidence of implicit mentalizing in adults (Dolk et al., 2011; Guagnano, Rusconi, & Umiltà, 2010; Heyes, in press-b). By showing that domain-general processes are sufficient to explain behavior that seems to involve mentalizing, these studies support the view that mentalizing—both implicit and explicit—may be less pervasive in human social life than psychologists and philosophers have traditionally assumed (Apperly, 2011).

References

Apperly, I. A. (2011). *Mindreaders: The cognitive basis of "Theory of Mind."* Hove, UK and New York, NY: Psychology Press.

Apperly, I. A., & Butterfill, S. A. (2009). Do humans have two systems to track beliefs and belief-like states? *Psychological Review, 116,* 953–970. doi:10.1037/a0016923

Baillargeon, R., Scott, R. M., & He, Z. (2010). False-belief understanding in infants. *Trends in Cognitive Sciences, 14,* 110–118. doi:10.1016/j.tics.2009.12.006

Dolk, T., Hommel, B., Colzato, L. S., Schütz-Bosbach, S., Prinz, W., & Liepelt, R. (2011). How "social" is the social Simon effect? *Frontiers in Psychology, 2,* 84. doi:10.3389/fpsyg.2011.00084

Frith, C. D., & Frith, U. (2012). Mechanisms of social cognition. *Annual Review of Psychology, 63,* 287–313. doi:10.1146/annurev-psych-120710-100449

Guagnano, D., Rusconi, E., & Umiltà, C. A. (2010). Sharing a task or sharing space? On the effect of the confederate in action coding in a detection task. *Cognition, 114,* 348–355. doi:10.1016/j.cognition.2009.10.008

Guzzon, D., Brignani, D., Miniussi, C., & Marzi, C. A. (2010). Orienting of attention with eye and arrow cues and the effect of overtraining. *Acta Psychologica, 134,* 353–362. doi:10.1016/j.actpsy.2010.03.008

Heyes, C. (in press-a). False belief in infancy: A fresh look. *Developmental Science.*

Heyes, C. (in press-b). Sub-mentalising: I'm not really reading your mind. *Perspectives on Psychological Science.*

Kovács, Á. M., Téglás, E., & Endress, A. D. (2010). The social sense: Susceptibility to others' beliefs in human infants and adults. *Science, 330,* 1830–1834. doi:10.1126/science.1190792

McCleery, J. P., Surtees, A. D. R., Graham, K. A., Richards, J. E., & Apperly, I. A. (2011). The neural and cognitive time course of theory of mind. *The Journal of Neuroscience, 31,* 12849–12854. doi:10.1523/JNEUROSCI.1392-11.2011

Moore, C., & Corkum, V. (1994). Social understanding at the end of the first year of life. *Developmental Review, 14,* 349–372. doi:10.1006/drev.1994.1014

Onishi, K. H., & Baillargeon, R. (2005). Do 15-month-old infants understand false beliefs? *Science, 308,* 255–258. doi:10.1126/science.1107621

Perner, J., & Ruffman, T. (2005). Infants' insight into the mind: How deep? *Science, 308,* 214–216. doi:10.1126/science.1111656

Perner, J. (2010). Who took the cog out of cognitive science? Mentalism in an era of anticognitivism. In P. Frensch & R. Schwarzer (Eds.), *Cognition and neuropsychology: International perspectives on psychological science* (Vol. 1, pp. 241–262). New York, NY: Psychology Press.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences, 1,* 515–526. doi:10.1017/S0140525X00076512

Qureshi, A. W., Apperly, I. A., & Samson, D. (2010). Executive function is necessary for perspective selection, not Level-1 visual perspective calculation: Evidence from a dual-task study of adults. *Cognition, 117,* 230–236. doi:10.1016/j.cognition.2010.08.003

Samson, D., Apperly, I. A., Braithwaite, J. J., Andrews, B. J., & Bodley Scott, S. E. (2010). Seeing it their way: Evidence for rapid and involuntary computation of what other people see. *Journal of Experimental Psychology: Human Perception and Performance, 36,* 1255–1266. doi:10.1037/a0018729

Sebanz, N., Knoblich, G., & Prinz, W. (2003). Representing others' actions: Just like one's own? *Cognition, 88,* B11–B21. doi:10.1016/S0010-0277(03)00043-X

Senju, A., Southgate, V., White, S., & Frith, U. (2009). Mindblind eyes: An absence of spontaneous theory of mind in Asperger syndrome. *Science, 325,* 883–885. doi:10.1126/science.1176170

Tipples, J. (2002). Eye gaze is not unique: Automatic orienting in response to uninformative arrows. *Psychonomic Bulletin & Review, 9,* 314–318. doi:10.3758/BF03196287

Tipples, J. (2008). Orienting to counterpredictive gaze and arrow cues. *Perception & Psychophysics, 70,* 77–87. doi:10.3758/PP.70.1.77

Zwickel, J. (2009). Agency attribution and visuospatial perspective taking. *Psychonomic Bulletin & Review, 16,* 1089–1093. doi:10.3758/PBR.16.6.1089

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