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Submentalizing: Clarifying How Domain General Processes Explain Spontaneous Perspective-Taking

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Demonstrations of spontaneous perspective-taking are thought to provide some of the best evidence to date for "implicit mentalizing"—the ability to track simple mental states in a fast and efficient manner. However, this evidence has been challenged by a "submentalizing" account proposing that these findings are merely attention-orienting effects. The present research aimed to clarify the cognitive processes responsible by measuring spontaneous perspective-taking while controlling for attention orienting. Four experiments employed the widely used dot perspective task, modified by changing the order that stimuli were presented so that responses would be less influenced by attention orienting. This modification had different effects on speed and accuracy of responding. For response times, it attenuated spontaneous perspective-taking effects for avatars as well as attention-orienting effects for arrows. For error rates, robust spontaneous perspective-taking effects remained that were unaffected by manipulations targeting attention orienting, but contingent upon there being two competing active task sets (self- and other perspectives). These results confirm that attention orienting explains response time effects revealed by the original version of the dot perspective task. Error rate results also reveal the crucial role played by domain-general executive processes in enabling selection between perspectives. The absence of independent evidence for implicit mentalizing lends support to a revised submentalizing account that incorporates executive functions alongside attention orienting.

Public Significance Statement

Being able to see things from another person's perspective is vital for communicating with others. This research advances our understanding of this ability. Improved methods reveal that this relies upon shifts in attention resulting from the orientation of another person's head and body. Also, mental effort is required to be able to attend to another's perspective as well as our own. Our findings clarify how these processes work together to make us aware of others' perspectives. This research provides insights into scientific theory, with implications for how perspective-taking differs in clinical conditions such as schizophrenia.

Keywords: perspective-taking, theory of mind, attention orienting, executive functions

Supplemental materials: https://doi.org/10.1037/xhp0001250.supp

Mentalizing, or "theory of mind," involves attributing mental states like beliefs and intentions to oneself and others and plays a pivotal role in understanding and predicting human behavior. While there is consensus about the existence of a late-developing, slow, effortful system for deliberate mentalizing, an ongoing debate questions whether there is additionally an early-developing, fast, automatic system for tracking simple mental states (Heyes & Frith, 2014; Phillips, 2021). This debate hinges on whether spontaneous perspective-taking primarily relies on domain-general attentional processes, triggered by stimulus directionality like a person's head or body orientation, or on domain-specific social processes, allowing observers to monitor implicitly mental states of others (Cole & Millett, 2019; Heyes, 2014). The contribution of this article to this debate is to measure systematically spontaneous perspective-taking while controlling for attention orienting, thus evaluating the role of domain-general processes. Establishing this has methodological implications, questioning the validity of existing experimental procedures for investigating altered mentalizing in conditions such as schizophrenia (Kronbichler et al., 2019; Simonsen et al., 2020; see also Gardner & Buchanan, 2023), psychopathy (Drayton et al., 2018), and autism spectrum disorder

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(Doi et al., 2020; Schwarzkopf et al., 2014; Tei et al., 2019). It also has theoretical significance, questioning the proposal there are two dedicated systems for the theory of mind, one implicit and the other explicit (Apperly & Butterfill, 2009; Frith & Frith, 2008).

Spontaneous perspective-taking measured by the "dot perspective task" (Samson et al., 2010) is considered to provide important evidence of implicit mentalizing (Frith & Frith, 2012; Kampis & Southgate, 2020). In this task, participants judge the number of dots seen from their own perspective ("self-perspective") or from that of an avatar ("other perspective") while the avatar is facing either a consistent or inconsistent number of dots. A digit is presented immediately before this scene, and participants make speeded responses indicating whether the two quantities match. The key finding is that response times (RTs) are elevated by approximately 50 ms during inconsistent relative to consistent self-perspective trials, even though the participant is responding from their own perspective and the avatar's perspective is not relevant. This is referred to as an "altercentric intrusion" effect. The original "implicit mentalizing" interpretation was that altercentric intrusions provide evidence for a specialized cognitive process that automatically computes what the avatar sees. Thus, during inconsistent trials, the automatically computed number of dots seen by the avatar interferes with the participant's ability to report the number of dots seen from their own perspective, leading to longer RTs. Automaticity is indicated by this effect occurring even though the other perspective is formally task irrelevant during self-perspective trials, and because it is not suppressed either by demands of a secondary task (Qureshi et al., 2010), or by time pressure (Todd et al., 2017).

The rival "submentalizing" account is that the altercentric intrusion effect in the dot perspective task is the result of domain general cognitive processes for controlling attention (Heyes, 2014). Specifically, it was proposed that the avatar serves as a directional cue that shifts the participant's attention prior to responding (Heyes, 2014; Santiesteban et al., 2014). For consistent trials, this attention shift is to the location of all the target dots and is thus beneficial. For inconsistent trials, this attention shift prevents the participant from readily attending to all the target dots, thus slowing responding. Consistent with this account, eye-tracking data reveal more fixations during inconsistent trials than consistent (Ferguson et al., 2017). The avatar stimuli used have also been found to result in attention-cueing effects in Posner tasks (Bukowski et al., 2015; Cole et al., 2017; Gardner et al., 2018). In addition, comparable consistency effects were found in the dot perspective task when the avatar figure was replaced by arrows—symbolic cues known to direct attention that are inanimate (Nielsen et al., 2015; Santiesteban et al., 2014). The unlikely possibility that this was the result of mental state attribution to anthropomorphized arrows seems to be ruled about by the finding that even the direction of orientation of a desk fan can yield consistency effects (Vestner et al., 2022). Therefore, there is good converging evidence that attention orienting can produce altercentric intrusion effects in the dot perspective task, but not that it alone is necessary and sufficient; implicit mentalizing and attention orienting might both independently yield similar results.

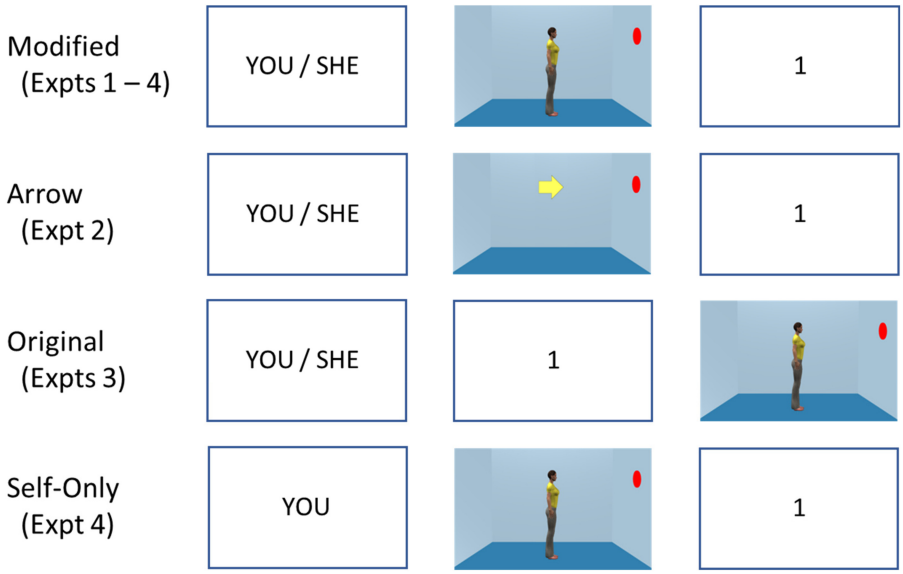
Attempts to adjudicate between these rival accounts are inconclusive because they have yielded mixed findings. These studies typically are designed to test predictions of the mentalizing account by assessing whether the altercentric intrusion effect is selective to a "seeing" condition where the avatar has visual access to the dots (i.e., absent when the avatar does not have visual access). One approach is to introduce transparent or opaque barriers between the avatar and the dots. Using this approach, some studies have found that the altercentric intrusion effect is selective to the seeing condition, supporting the implicit mentalizing account (Baker et al., 2016), but others show an altercentric intrusion effect that is not selective, supporting the submentalizing account (Cole et al., 2016; Langton, 2018). Another approach is to manipulate participants' beliefs about whether the avatar can see through prior direct experience with types of opaque or transparent goggles worn by the avatar. Again, some studies have found that the altercentric intrusion effect is selective to the seeing condition, supporting the implicit mentalizing account (Furlanetto et al., 2016; see also Fan et al., 2021). However, other studies show an altercentric intrusion effect that is not selective, consistent with the submentalizing account (Conway et al., 2017). It has been proposed these mixed findings suggest that implicit mentalizing and attention orienting might both occur (Capozzi & Ristic, 2020; Michael & D'Ausilio, 2015) and that procedural differences between studies may contribute to the different outcomes (O'Grady et al., 2020). Therefore, a promising alternative approach may be to isolate these processes by assessing spontaneous perspective-taking while controlling for the effects of attention orienting.

One prior attempt to measure spontaneous perspective-taking while controlling for attention orientating has been interpreted as providing separable mentalizing and submentalizing effects (Pesimena & Soranzo, 2023). In this experiment, avatars were replaced by fantasy characters. For one group, this was a dragon that faced either to the left or to the right and provided an unambiguous directional cue (confirmed by the presence of attention cueing in a Posner test). This was analogous to the avatar in the original study, in that mentalizing and directional cues were confounded. For a second group, the dragon image had been edited so that it possessed an arrow-like tail, such that its directionality was ambiguous (e.g., facing left, tail pointing right; confirmed by the absence of attention cueing in the Posner test). Altercentric intrusions measured by RTs were found to be restricted to the group presented with characters that had unambiguous directionality, thus implying that attention orienting contributes to this effect. By contrast, altercentric intrusions measured by error rates persisted for both groups, including, crucially, the ambiguous directionality group, implying that this effect was not dependent on attention orienting. This intriguing finding was interpreted by the authors as measuring an additional independent mentalizing effect. However, it is unclear whether the directionally ambiguous stimuli served to attenuate the effects of attention orienting, as intended, or make these effects more variable. For instance, these stimuli may have triggered attention shifts based on the dragon's head on some trials, and the tail-arrow on others.

Similarly, the aim of the current study was also to assess spontaneous perspective-taking while controlling for attention orienting in a modified dot perspective task. However, original avatar stimuli were used, rather than fantasy characters, to enhance the generalizability of this work to human social cognition, and to the body of literature using these and similar human characters as stimuli (Cole & Millett, 2019). Here, the approach taken was to reorder the sequence in which stimuli were presented within each trial so that the scene containing the avatar and dots precedes, rather than follows, the digit (see Figure 1). That way, when participants assess whether a digit matched the number of dots just presented they are responding to a centrally presented stimulus not containing any attention-orienting cues. A spontaneous perspective-taking effect

Figure 1

Schematic Illustration of the Modified Trial Structure Employed in All Four Experiments Compared With the Trial Structure Additionally Employed in Experiments 2–4



Note. These are all examples of "match" trials in which correct response was "yes" because the number of dots visible from the cued perspective corresponded to the digit. Each is also an example of a "consistent" trial—the avatar/arrow is oriented toward the same number of dots as those visible to the participant (here, 1). Expt = Experiment. See the online article for the color version of this figure.

found under these conditions could indicate an additional independent implicit mentalizing effect, implying that the new trial sequence would be a useful adaptation.

In overview, Experiment 1 assessed spontaneous perspective-taking in this modified task. Experiment 2 assessed whether this modification fully controlled attention orienting by using arrows to assess any residual attention orienting. Experiment 3 assessed the contribution of attention orienting to the original Samson et al. (2010) task by comparing effects for the modified and original trial sequences. Finally, Experiment 4 assessed the role of task switching by comparing performance when judgments were made just from the self-perspective to performance when judgments were made from both the self- and avatar perspectives. Effects were assessed separately for speed and accuracy of responding, in light of Pesimena and Soranzo's (2023) finding that these measures were differentially affected by a putative attention-orienting manipulation.

Experiment 1

Experiment 1 assessed spontaneous perspective-taking in a modified dot perspective task designed to control attention orienting. In each trial, participants were presented with a perspective prompt (self vs. other), followed by the scene containing the avatar and dots, and finally by a digit. Participants were asked to judge whether the digit matched the number of dots seen from the cued perspective, and, like the original task, consistency effects during self-perspective trials would indicate spontaneous perspective-taking. To the extent that this modification controls attention orienting, the rival accounts generate different predictions. The mentalizing account predicts preserved spontaneous perspective-taking. This is because interference from the automatically computed number of dots seen by the avatar should result in a less reliable representation of the number of dots seen from the participants' own perspective irrespective of when this stimulus is presented. By contrast, the submentalizing account predicts diminished spontaneous perspective-taking, particularly for RT, because the imperative stimulus (digit) does not contain attention-orienting cues.

Method

Participants

An opportunity sample of 83 adults from the university community and their acquaintances volunteered to take part. Of these, six were excluded for high error rates (percentage errors [PEs] greater than 30%). The remaining 77 participants (49 female, 28 male) were aged between 19 and 65 years ($M = 30.01$, $SD = 10.08$). A minimum target sample size was set at $N = 60$, which was 3.75 times the size of the original experiment (Samson et al., 2010, Experiment 1, $n = 16$). This would detect an altercentric intrusion effect for RT of the size originally reported (self-perspective: consistent vs. inconsistent, $d_z = 0.89$) with 99% power at $\alpha = .05$ (calculated by G*Power; Faul et al., 2007). The study was highly powered given that the original experiment may not be a good guide to effect sizes under a modified procedure.

Materials

Original stimuli from Samson et al. (2010) were employed. These depicted female avatars facing either to the left or right in the center of a simple virtual room. Discs were presented on side walls that

were behind and/or in front of the avatar so that in half the trials the participant could see the same number of discs as the avatar ("consistent" condition), and in the remainder, the participant could see a different number of discs ("inconsistent" condition).

Stimulus presentation and data collection were controlled on the participant's own computer using the Testable online testing platform (https://www.testable.org; Rezlescu et al., 2020); participation via a tablet or phone was not permitted.

Procedure

As illustrated in Figure 1, each trial commenced with the presentation of a fixation cross, followed by a perspective prompt (YOU/SHE), then by an image of the avatar with a variable number of discs (0–3), and finally by a digit (0–3). The participant's task was to assess whether the digit corresponded to the number of discs from the cued perspective, in common with the original version of the dot perspective task (Samson et al., 2010, Experiment 1). The key difference was that the order in which the final two stimuli were presented in each trial was reversed so that the imperative stimulus was a centrally presented digit rather than the image of the avatar.

Stimuli were presented for 750 ms with an interstimulus interval of 500 ms, apart from the final stimulus which was presented until a response was detected, up to a maximum of 2,000 ms. Participants responded "yes" (J key) or "no" (K key).

After providing informed consent (ETH1920-0827), participants were led through instructions on how to carry out the task. They then completed a short practice block with feedback (26 trials), followed by 208 experimental trials without feedback across four blocks in a pseudorandom order (constrained so that there were no more than three consecutive trials of the same type and an equal number of trials preceded by the same perspective as those preceded by a different perspective). These were of the standard composition—24 of each combination of Consistency × Perspective × Match/No-Match, plus 16 "filler" trials in which no dots were presented.

Transparency and Openness

Other sections of this article describe how the sample size was determined, along with all data exclusions, all manipulations, and all measures that were recorded. Data and research materials are available at https://researchbox.org/2304. Data were analyzed using IBM SPSS Version 25. The design, hypotheses, and analysis plan for this experiment were preregistered, and are available at https://aspredicted.org/5qz4k.pdf. All departures from the preregistration plan are clearly discussed in the article, and analyses that were not preregistered are identified as exploratory. This includes Bayesian tests calculated using JASP Version 0.18.3 for one-tailed paired t tests with default settings that were unplanned and carried out to help interpret theoretically relevant null results. Bayes factors (BFs) for all tests are reported in the online supplemental materials.

Results

The preregistered plan specified inverse efficiency scores (IESs) as the key dependent variable. However, the ensuing analysis focused on the separate RT and PE components of IESs, originally planned as secondary analyses. There were two reasons for this departure. First, PE remained unexpectedly high and variable, even after exclusions, particularly for the other-inconsistent condition ($M = 9.58\%$, $SD = 13.84$). Such high rates of errors make IESs unstable due to nonlinearity (Bruyer & Brysbaert, 2011). Second, the value of separate analyses of speed and accuracy of responding came to light only after the analysis plan was preregistered—evidence suggesting that attention orientation contributes to consistency effects measured by RT, but not PE (Pesimena & Soranzo, 2023).

RT Analysis

The mean RT for correct responses was computed for each condition. Following convention (Samson et al., 2010), data were excluded from trials considered "fillers" (no dots presented) and where the number of dots did not match the digit (i.e., where "no" was the correct response).

Figure 2 illustrates the RT data and indicates that RTs tended to be elevated for inconsistent relative to consistent trials for both perspectives, but particularly when participants respond from the other's perspective. These impressions were examined using a 2 × 2 within-subjects analysis of variance (ANOVA) in which the factors were perspective (self vs. other) and consistency (consistent vs. inconsistent). This revealed a main effect of consistency, $F(1, 76) = 19.39$, $p < .001$, $\eta_p^2 = .203$, but not of perspective, $F(1, 76) = 0.00$, $p = .979$, $\eta_p^2 = .000$. A statistically significant interaction confirmed that a stronger consistency effect occurred during other-perspective trials, $F(1, 76) = 5.63$, $p = .020$, $\eta_p^2 = .069$. Nonetheless, related t tests showed that a consistency effect was present both for self-perspective trials, indicating altercentric intrusions, $M_{\text{difference}} = 14.81$ ms, $t(76) = 2.59$, $p = .012$, $d_z = 0.30$, and for other-perspective trials, indicating egocentric intrusions, $M_{\text{difference}} = 39.81$ ms, $t(76) = 3.99$, $p < .001$, $d_z = 0.45$.

Error Analysis

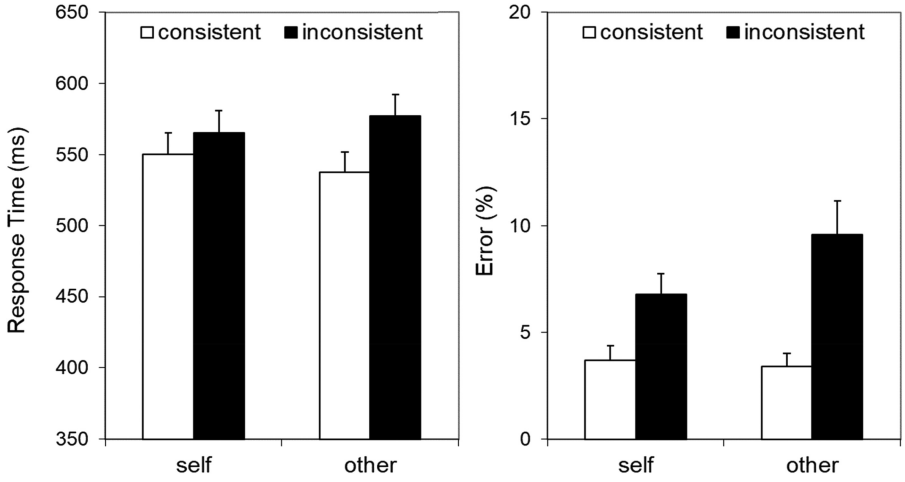
Figure 2 appears to indicate that both types of consistency effect were also present for PE, and that the magnitudes of these effects were similar. This impression was confirmed by ANOVA, which revealed a main effect of consistency, $F(1, 76) = 24.47$, $p < .001$, $\eta_p^2 = .244$, that was not moderated by perspective, $F(1, 76) = 3.23$, $p = .076$, $\eta_p^2 = .04$. The main effect of perspective was also not statistically significant, $F(1, 76) = 2.18$, $p = .144$, $\eta_p^2 = .028$. Related t tests confirmed both altercentric intrusion, $M_{\text{difference}} = 3.08$ percentage points, $t(76) = 3.62$, $p = .001$, $d_z = 0.41$, and egocentric intrusion effects, $M_{\text{difference}} = 6.17$ points, $t(76) = 3.91$, $p < .001$, $d_z = 0.45$.

Discussion

Altercentric intrusion effects were found for both speed and accuracy in this modified dot perspective task, thus providing evidence of spontaneous perspective-taking. The effect for error rates is consistent with that previously found for characters with ambiguous directionality, previously interpreted as capturing a mentalizing effect dissociable from attention orienting (Pesimena & Soranzo, 2023). While statistically significant, the size of the effect for RT (15 ms) appears smaller in magnitude than those previously reported for the same avatar stimuli. For the original trial sequence, a difference of 48 ms was found under laboratory conditions (Samson et al., 2010, Experiment 1), while a difference of 51 ms has been recently

Figure 2

Data From Experiment 1



Note. RTs (left) and PEs (right) as a function of whether the number of discs visible to the participant and avatar were consistent and whether judgments were made from the self- or other perspective. Error bars indicate 1 *SEM*. RT = response time; PE = percentage error.

reported using the same online Testable platform (Gardner & Buchanan, 2023). If confirmed, an attenuation in effect size would be consistent with the modification having reduced the influence of attention orienting, as well as attention orienting contributing to the size of altercentric intrusion effects measured by RT when the avatar is presented last. Therefore, the modified procedure holds promise as a valid test of spontaneous perspective-taking that potentially controls for the effects of attention orienting.

To clarify these matters, Experiment 2 assessed any residual effects of attention orienting, by comparing performance under the modified trial sequence for both avatars and arrows. Arrows are directional cues known to elicit attention-orienting effects (Chica et al., 2014; Tipples, 2002). So, any residual contribution of attention orienting to altercentric intrusion effects measured by RT should be similarly present for the arrow stimulus as well as the avatar. This comparison also enables the cause of the altercentric intrusion effect for PE to be examined. If this were due to mentalizing, the effect should be restricted to avatars and not present for arrows; an effect for arrows would implicate submentalizing.

Experiment 2

Method

Participants

Sample size was determined to detect with 80% power at $\alpha = .05$ a small to medium effect size for a Group × Consistency (between–within) interaction, $\eta_p^2 = .027$, which is smaller than those previously reported for Group × Consistency interactions using similar mixed designs (Baker et al., 2016, Experiment 3, $\eta_p^2 = .089$; Furlanetto et al., 2016, $\eta_p^2 = .426$). Power calculation was conducted using G*Power with scores for repeated measures assumed to be moderately correlated, $r = .50$, based on data from Experiment 1. On this basis, the stopping rule specified minimum group sizes of $n = 36$.

Anticipating that approximately 15% of data would need to be excluded, 86 adult participants were requested from the "Testable Minds" participant pool for $4 remuneration. In fact, 93 adults took part in March 2022 because some were not credited by Testable Minds nor included in running totals. Of these, 10 were excluded on the basis of preregistered criteria (PE > 30%), yielding group sizes exceeding the target of $n = 36$ (avatar, $n = 43$; arrow, $n = 40$), thus satisfying conditions of the stopping rule. The remaining 83 participants (29 female, 54 male) were aged between 18 and 60 years ($M = 29.95$, $SD = 9.69$), with the two groups comparable in age (avatar, 11 female, $M = 30.65$ years, $SD = 10.06$; arrow, 18 female, $M = 29.20$ years, $SD = 9.35$). The preregistered design, hypotheses, and analysis plan is available at: https://aspredicted.org/ug2st.pdf.

Materials and Procedure

Participants were randomly allocated to "directional stimulus" groups. Those allocated to the avatar group were presented with the same avatar within a virtual room throughout, consistent with the procedure used in Experiment 1. For the remainder, those allocated to the arrow group, the directional stimulus was a centrally presented arrow pointing to the left or to the right also located within the virtual room. These stimuli were digitally edited from the originals, and have previously been used as a symbolic directional cue to which mental states would not be ascribed (Gardner et al., 2018).

In all other respects, materials and procedure were the same as those employed in Experiment 1.

Results

Unexpectedly, the planned exclusion criterion based on overall error rates missed a number of participants that had very high levels of errors in one or more cells of the design indicating probable misunderstanding of the task and/or deliberate stereotyped response

strategies (see the online supplemental materials). Therefore, a slightly more restrictive inclusion criterion was adopted, that is, no more than 30% errors overall, and no more than 40% in any cell of the design (Consistency × Perspective). This resulted in the exclusion of data from a further 13 participants (eight male; avatar group, $n = 2$; arrow group, $n = 11$). For transparency, results are also provided in the online supplemental materials for the planned exclusion criteria, and any discrepancies between analyses are briefly noted.

RT Analysis

The RT data illustrated in Figure 3 appear to indicate that any consistency effects for either directional stimulus were restricted to those made from the "other" perspective, referred to as egocentric intrusions. This was examined by a 2 × 2 × 2 mixed ANOVA in which the between-subjects factor was directional stimulus (avatar vs. arrow), and within-subjects factors were perspective (self vs. other) and consistency (consistent vs. inconsistent). This revealed that neither the main effect of perspective, $F(1, 68) = 0.66$, $p = .420$, $\eta_p^2 = .010$, nor that of directional stimulus were statistically significant, $F(1, 68) = 1.89$, $p = .174$, $\eta_p^2 = .027$. Crucially, there was a statistically significant main effect of consistency, $F(1, 68) = 11.80$, $p < .001$, $\eta_p^2 = .148$, that was indeed moderated by perspective, $F(1, 68) = 5.31$, $p = .024$, $\eta_p^2 = .072$. This interaction was examined further with related t tests. These revealed that there were consistency effects during "other" trials, indicating egocentric intrusions, and that these occurred irrespective of the type of stimulus: avatar, $M_{difference} = 31$ ms, $t(40) = 3.36$, $p = .002$, $d_z = 0.53$; arrow, $M_{difference} = 41$ ms, $t(28) = 2.04$, $p = .050$, $d_z = 0.38$. By contrast, no consistency effects were found during the "self" trials that would have indicated altercentric intrusions: avatar, $M_{difference} = 6$ ms, $t(40) = 0.76$, $p = .451$, $d_z = 0.12$; arrow, $M_{difference} = 11$ ms, $t(28) = 0.77$, $p = .446$, $d_z = 0.14$.

No other interactions were significant, apart from that between perspective and directional stimulus, $F(1, 68) = 5.53$, $p = .022$, $\eta_p^2 = .075$, consistent with RTs being higher for the arrow stimulus than the avatar, particularly during self-perspective trials.

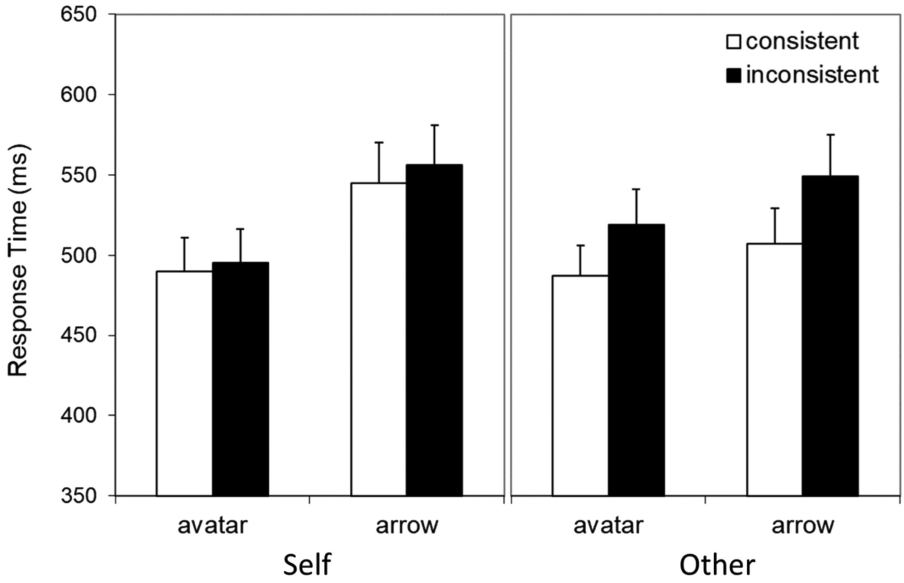
To help interpret the null results obtained for altercentric intrusion effects, exploratory Bayes factors were calculated for one-tailed paired t tests (self-perspective: consistent < inconsistent). By convention $BF_{0-} > 3$ is taken as evidence supporting the null hypothesis. These revealed only anecdotal evidence for no effect for both avatars, $BF_{0-} = 2.94$, and arrows, $BF_{0-} = 2.51$.

Equivalent analyses for data after only planned exclusions generally yielded the same statistical inferences (see the online supplemental materials). There were only two exceptions: one t test demonstrating a statistically significant consistency effect during self-trials for the arrow stimulus, and the absence of the Consistency × Perspective interaction.

Error Analysis

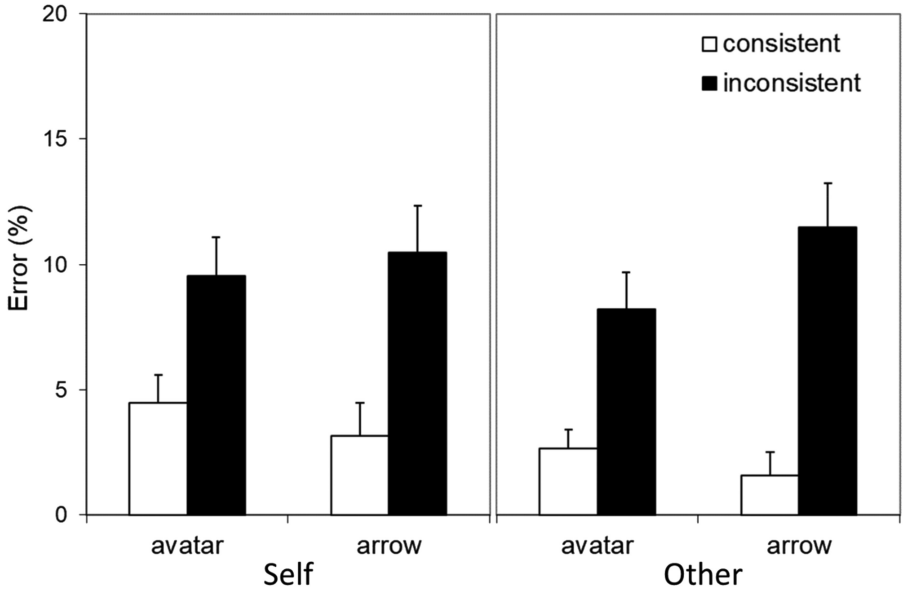
PE data presented in Figure 4 appear to indicate the presence of consistency effects for both types of stimulus during self- and other-perspective trials. The three-factor mixed ANOVA confirmed this impression, with a statistically significant main effect of consistency, $F(1, 68) = 61.00$, $p < .001$, $\eta_p^2 = .473$, and no interactions. Neither the main effect of perspective, $F(1, 68) = 1.40$, $p = .241$, $\eta_p^2 = .02$, nor that of directional stimulus was significant, $F(1, 68) = 0.12$, $p = .734$, $\eta_p^2 = .002$. Related t tests confirmed that altercentric intrusions assessed by PE were present during self-perspective trials for both directional stimuli: avatar, $M_{difference} = 5.08$ percentage points, $t(40) = 3.61$, $p = .001$, $d_z = 0.56$; arrow, $M_{difference} = 7.33$ points,

Figure 3
RT Data From Experiment 2



Note. RTs as a function of consistency (between the number of discs visible to the participant and the number orientated to by the stimulus), directional stimulus (avatar vs. arrow), and perspective (self vs. other). Error bars indicate 1 *SEM*. RT = response time.

Figure 4
Error Data From Experiment 2



Note. PEs as a function of consistency (between the number of discs visible to the participant and the number orientated to by the stimulus), directional stimulus (avatar vs. arrow), and perspective (self vs. other). Error bars indicate 1 *SEM*. PE = percentage error.

$t(28) = 4.05, p < .001, d_z = 0.75$. These occurred in addition to egocentric intrusions (other-perspective trials): avatar, $M_{\text{difference}} = 5.59$ points, $t(40) = 3.47$, $p = .001$, $d_z = 0.54$; arrow, $M_{\text{difference}} = 9.91$ points, $t(28) = 5.10$, $p < .001$, $d_z = 0.95$.

Corresponding analyses for data after only planned exclusions led to various additional statistically significant effects being present for the ANOVA: main effects of both perspective and directional stimulus, and interactions between Consistency × Stimulus and Perspective × Directional Stimulus. These potentially spurious findings likely represent bias from the stereotyped responding of the additional 13 participants excluded from the main analysis. Crucially, the inferences drawn from all *t* tests were identical, so the evidence for altercentric intrusions for directional stimuli was robust across analyses. These analyses are reported in the online supplemental materials.

Discussion

An altercentric intrusion effect was found for the avatar stimulus, providing evidence for spontaneous perspective-taking and confirming the validity of the modified task. However, while the effect for PE found in Experiment 1 was replicated, a similar effect for RT was absent. Crucially, the same pattern of results—a consistency effect during self-trials for PE but not for RT—was found when the directional stimulus was an arrow. These findings have at least three implications. First, the absence of a consistency effect measured by RT during self-trials for both directional stimuli (avatar and arrow) indicates that there was little or no residual effect of attention orienting on this measure under the modified procedure. The Bayesian analyses do not allow a small residual effect to be ruled out. Second, the presence of a consistency effect measured by PE during self-trials for arrows, which was similar to that for avatars, suggests that both may be due to submentalizing. That is because it is implausible to imagine participants were attributing mental states to these inanimate directional cues. This would challenge the idea that a separable mentalizing effect may be captured by PE (Pesimena & Soranzo, 2023). Third, the diverging results for the two measures (i.e., altercentric intrusions for RT, not PE) suggest that they may be measuring different processes: they imply that attention orienting influences RT, but that PE effects capture something different. If not mentalizing (due to the similarity of the results for arrows), PE may be sensitive to a different domain-general process, perhaps executive control processes engaged in selecting between self- and other perspectives. This hypothesis was examined by Experiment 4.

Experiment 3 was designed to assess formally the contribution of attention orienting to altercentric intrusion effects measured by the original version of the dot perspective task. This compared altercentric intrusions for the modified version with those for the original version in which the attention-orienting stimulus, the avatar, is presented last and immediately prior to responding. If attention orienting contributes to such effects in the original version, an interaction between consistency and version would be expected during self-perspective trials. The foregoing account predicts that this interaction would be found only for RT, and not for PE.

Experiment 3

Method

Participants

Minimum group sizes of $n = 36$ were set in order that the present experiment was powered to detect the same small to medium effect

size for a between–within interaction as Experiment 2, $\eta_p^2 = .027$ with 80% power at $\alpha = .05$. This was based on the previous power analysis because our estimation of the hypothesized effect size was not altered by the results of Experiment 2. Allowing for anticipated 15% exclusions, 86 adult participants were again requested from the "Testable Minds" participant pool for $4 remuneration, but 91 ultimately took part in May 2022 (five were not included in the running totals and not credited due to a software issue). Of these, six were excluded on the basis of preregistered criteria (PE > 30%), yielding group sizes exceeding the target of $n = 36$ (modified, $n = 42$; original, $n = 43$), thus satisfying the stopping rule. The remaining 85 participants (28 female, 57 male) were aged between 19 and 67 years ($M = 30.46$, $SD = 9.79$) and the two groups were comparable (modified: 12 female, $M = 29.62$ years, $SD = 8.71$; original: 16 female, $M = 31.28$ years, $SD = 10.77$). The preregistered design, hypotheses, and analysis plan is available at: https://aspredicted.org/s9p3x.pdf.

Materials and Procedure

Participants were randomly allocated to an independent group for one of the two versions of the dot perspective task. Those allocated to the "modified" group were presented with stimuli within each task in the modified sequence, such that the digit appeared last, consistent with the procedure used in Experiments 1 and 2. For those allocated to the "original" group, stimuli were presented in the original sequence, such that the image containing the avatar oriented to the left or to the right appeared last, consistent with Samson et al. (2010) and, to the best of our knowledge, all previous studies using this task. Both versions included a mixture of "self" and "other" trials (see Figure 1). Thus, the only differences between the two versions were the order of the final two stimuli within each task (digit and image containing the avatar) and whether participants were instructed to compare a digit with a number of discs presented in the preceding stimulus or instructed to compare a number of discs with a digit presented as the preceding stimulus. Thus, a directional stimulus that may orientate attention was presented as the imperative stimulus for the original version, but not for the modified. In all other respects, materials and procedure were the same as those employed in Experiments 1 and 2.

Results

The same exclusion criteria as used in Experiment 2 were applied because the preregistered criterion failed to exclude stereotyped responding. This resulted in the exclusion of data from a further six participants (three male; modified group, $n = 4$; original group, $n = 2$). Any differences between these results and those for the planned exclusion criteria (the online supplemental materials) are briefly noted.

Analyses focused on self-perspective trials because these were relevant to the current hypotheses about the relative size of altercentric intrusion effects. This was specified in the preregistered plan.

RT Analysis

Figure 5 illustrates RT data and appears to indicate the presence of an altercentric intrusion effect that was restricted to the original version. This impression was assessed by a 2 × 2 mixed ANOVA in which the within-subjects factor was consistency (consistent vs. inconsistent), and the between-subjects factor was version (modified vs. original). This revealed a main effect of version, $F(1, 77) = 46.85$, $p < .001$, $\eta_p^2 = .378$, indicating that RTs were shorter for the modified than the original version. While there was also a main effect of consistency, $F(1, 77) = 20.50$, $p < .001$, $\eta_p^2 = .210$, this should be interpreted in light of a statistically significant interaction with version, $F(1, 77) = 29.14$, $p < .001$, $\eta_p^2 = .275$. Related t tests indicated the presence of an altercentric intrusion effect only for the original version: original version, $M_{difference} = 83$ ms, $t(40) = 6.03$, $p < .001$, $d_z = 0.94$; modified version, $M_{difference} = -7$ ms, $t(37) = 0.81$, $p = .425$, $d_z = -0.13$. In an exploratory analysis, Bayes factors provided moderate support for the absence of altercentric intrusions in the modified version, $BF_{0-} = 9.62$.

All statistical inferences were identical when these analyses were repeated for only planned exclusions (see the online supplemental materials).

Error Analysis

By contrast, the PE data illustrated in Figure 5 appear to indicate the presence of altercentric intrusion effects in both versions of the task. This impression was evaluated by the equivalent mixed ANOVA, which revealed a main effect of consistency, $F(1, 77) = 27.8$, $p < .001$, $\eta_p^2 = .266$, but no main effect of version, $F(1, 77) = 1.57$, $p = .215$, $\eta_p^2 = .020$, and crucially no interaction, $F(1, 77) = 1.14$, $p = .289$, $\eta_p^2 = .015$. Related t tests confirmed the presence of an altercentric intrusion effect for both versions: original, $M_{difference} = 5$ points, $t(40) = 4.34$, $p < .001$, $d_z = 0.68$; modified, $M_{difference} = 4$ points, $t(37) = 3.11$, $p = .004$, $d_z = 0.51$.

Equivalent analyses for PE after only planned exclusions generally yielded the same statistical inferences (see the online supplemental materials), with one exception. The t test assessing an altercentric intrusion effect for the modified version was nonsignificant, attributed to bias from stereotyped responding of the excluded participants.

Discussion

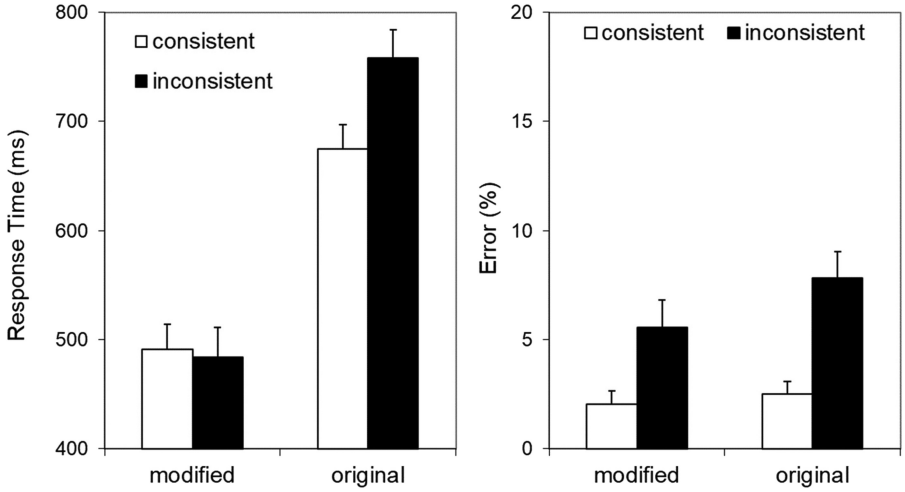
Results from Experiment 3 confirm that modification to the trial sequence attenuated altercentric intrusions measured by RT, but not those measured by PE. For RT, this effect was 76 ms smaller, indicating that presenting the avatar last and immediately prior to responding in the original version leads to attention orienting making a substantial contribution to altercentric intrusion effects (here, ~92%). For PE, the finding that this effect occurred similarly in both versions indicates that altercentric intrusions measured by PE are unlikely to rely on attention orienting.

In addition, the modified version resulted in generally quicker responding. This difference is likely to be due to simpler stimulus encoding and discriminability of the digits compared to the visual scenes employed as imperative stimuli in the two versions.

The presence of an altercentric intrusion effect for PE in the modified version requires explanation. This occurs for inanimate arrows (Experiment 2) as well as avatars (Experiments 1–3). One possibility is that this reflects the demands of task switching between self- and other trials (Westra et al., 2021). Westra et al. found that an altercentric intrusion effect for "novel entity" stimuli with minimal directional properties occurs provided that participants perform a mix of self- and other trials, as was the case here. When participants in their

Figure 5

Data for Self-Perspective Judgments From Experiment 3



Note. RTs (left) and PEs (right) as a function of whether the number of discs visible to the participant and avatar were consistent and version of the dot perspective task (modified vs. original). Error bars indicate 1 *SEM*. RT = response time; PE = percentage error.

experiment responded from the self-perspective throughout, no altercentric intrusion effect was found for these novel entity stimuli measured by IESs, which combines RT and PE. Thus, the altercentric intrusion effect for PE found here when attention orienting had been controlled may reflect carryover from other trials, similar to that occurring for novel entities also designed not to direct attention intrinsically. For instance, increased errors when taking one's own perspective during inconsistent compared to consistent trials might occur because participants sometimes fail to track the trial type in mixed blocks and erroneously make what would be a correct response for the other perspective. Experiment 4 assesses a task-switching account for the present results by comparing performance for the modified task for participants that need to switch from self- and other perspectives to those that perform from the self-perspective throughout. According to the task-switching hypothesis, the altercentric intrusion effect for error would be restricted to the group performing from both self- and other perspectives. According to the alternate implicit mentalizing hypothesis (Pesimena & Soranzo, 2023), this effect would be present for both groups.

Experiment 4

Method

Participants

Consistent with Experiments 2 and 3, minimum group sizes of $n =$ 36 were set in order that the present experiment was also powered to detect a small to medium effect size for a between–within interaction, $\eta_p^2 = .027$, with 80% power at $\alpha = .05$ based on the power analysis for Experiment 2. Our estimation of the hypothesized effect size was not altered by the results of Experiment 3 because the observed effect size $\eta_p^2 = .275$ fell within the range ($.089 < \eta_p^2 < .426$) reported by previous research using a similar design (Baker et al., 2016; Furlanetto et al., 2016). Allowing for estimated ∼15% exclusions, 86 adult participants were requested from the "Testable Minds" participant pool for $4 remuneration. Data for only six participants were excluded based on preregistered criteria (PE > 30%, or >40% in any cell of the design), resulting in group sizes that exceeded the target thus satisfying the stopping rule (mixed, $n = 40$; self-only, $n = 40$). The remaining 80 participants (36 female, 42 male, two nonbinary) were aged between 21 and 62 years ($M = 33.10$, $SD = 9.50$). The preregistered design, hypotheses, and analysis plan is available at: https://aspredicted.org/9bz3t.pdf.

Materials and Procedure

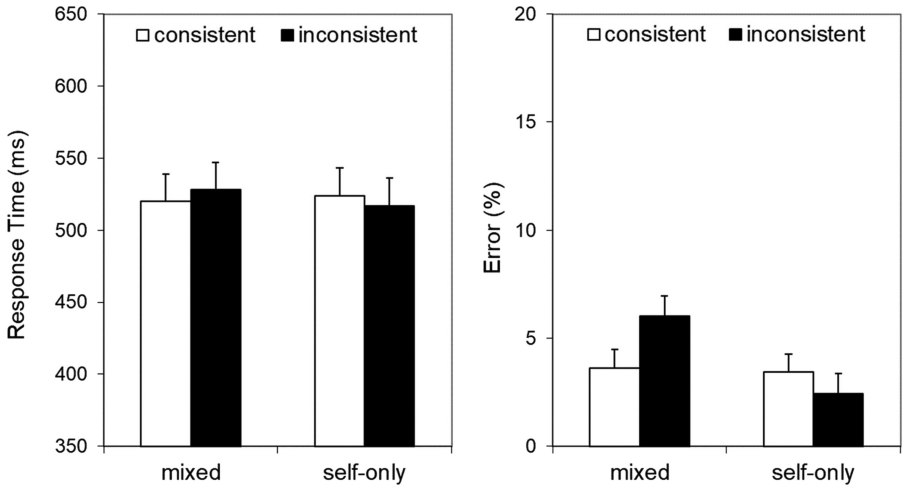
Participants were randomly allocated to one of two independent groups. Those allocated to the "mixed" group experienced the standard mixture of self- and other-perspective trials presented in a pseudorandom order, consistent with the modified procedure used in Experiments 1–3. Those allocated to the "self-only" group experienced an identical number of trials, composed of the same stimulus materials. However, these participants were asked to take the self-perspective throughout, cued by the perspective prompt "YOU." To ensure that an equal number of self-perspective trials would be amalgamated for each group, half the experimental trials were preselected for analysis, yoked to those present in the "mixed" group by type and ordinal position. In all other respects, materials and procedure were the same as those employed in Experiments 1–3.

Results

Error Analysis

In line with the task-switching hypothesis, PE data illustrated in Figure 6 appear to indicate an altercentric intrusion effect that was present only for the "mixed" group (self-perspective trials presented alongside other-perspective trials); for the "self-only" group, error rates were at a similarly low level for inconsistent as for consistent

Figure 6
Data for Self-Perspective Judgments From Experiment 4



Note. RTs (left) and PEs (right) as a function of whether the number of discs visible to the participant and avatar were consistent and perspectives taken (mixed vs. self-only). Error bars indicate 1 *SEM*. RT = response time; PE = percentage error.

trials. These impressions were assessed using a 2×2 mixed ANOVA in which the within-subjects factor was consistency (consistent vs. inconsistent), and the between-subjects factor was perspectives-taken (mixed vs. self-only). This revealed that neither the main effect of consistency, $F(1, 78) = 1.59$, $p = .221$, $\eta_p^2 = .020$, nor that of perspectives-taken, $F(1, 78) = 2.91$, $p = .092$, $\eta_p^2 = .036$, were statistically significant. Crucially, there was an interaction between these factors, $F(1, 78) = 8.92$, $p = .004$, $\eta_p^2 = .103$. Related t tests confirmed that the altercentric intrusion effect was present only when self-perspective trials were mixed with other-perspective trials: mixed, $M_{\text{difference}} = 3$ points, $t(39) = 2.79$, $p = .008$, $d_z = 0.44$; self-only, $M_{\text{difference}} = -1$ point, $t(39) = 1.33$, $p = .192$, $d_z = -0.21$. An exploratory Bayesian comparison provided strong support for the absence of altercentric intrusions for the self-only group, $BF_{0-} = 12.66$.

RT Analysis

As expected, RT data illustrated in Figure 6 appear to show little evidence of an altercentric intrusion effect for either group. The equivalent 2×2 mixed ANOVA applied to these data revealed no statistically significant main effects: Consistency, $F(1, 78) = 0.02$, $p = .877$, $\eta_p^2 = .000$; Perspectives-taken, $F(1, 78) = 0.02$, $p = .879$, $\eta_p^2 = .000$. The interaction was also not statistically significant, $F(1, 78) = 1.52$, $p = .221$, $\eta_p^2 = .019$. Exploratory Bayesian analyses revealed strong evidence for no altercentric intrusion effect for the self-only group, $BF_{0-} = 10.69$, but not the mixed group, $BF_{0-} = 2.67$.

General Discussion

The present study aimed to clarify the cognitive processes underlying spontaneous perspective-taking by controlling for attention orienting in a modified dot perspective task. The dot perspective task was modified by changing the order that stimuli were presented so that participants respond to a centrally presented stimulus not containing directional cues that could orient attention. Across four experiments, dissociable effects were found for speed and accuracy of responding. Manipulations targeting attention orienting were found to influence response latencies but not error rates. By contrast, the requirement to switch between self- and other perspectives was only found to affect error rates. These results indicate that spontaneous perspective-taking relies upon attention orienting, but that attention orienting alone is not sufficient to explain all these findings.

More specifically, RT data showed a fragile spontaneous perspective-taking effect in the modified task (Experiment 1) that did not replicate (Experiments 2, 3, and 4). Bayesian analyses found moderate/strong support for no effect for two out of four comparisons and anecdotal support for the remainder. Such an effect was similarly absent for arrows (Experiment 2), employed as inanimate directional cues known to orient attention. These effects were smaller in magnitude than that for "egocentric intrusions" (Experiments 1 and 2), which capture interference from what participants know, and are thus not mediated by attention orienting. Crucially, this effect was also smaller in magnitude than for the original version in which participants respond to the number of dots alongside an attention-orienting avatar (Experiment 3). Taken together, these results indicate that attention orienting from directional cues contributes substantially to spontaneous perspective-taking effects measured by RTs and that the modification to the trial sequence attenuated these effects by successfully controlling for attention orienting.

The current evidence therefore suggests that attention orienting may underlie robust spontaneous perspective-taking effects indicated by RTs in earlier studies employing the original version of the dot perspective task. This proposal is consistent with a preliminary meta-analysis of several previous experiments indicating that these effects were found to be primarily predicted by attention orienting when attention orienting and mentalizing were coded

separately (Holland et al., 2021). It is also consistent with evidence that susceptibility to consistency effects for an inanimate desk fan correlates with susceptibility to consistency effects for photographs of a human model (Vestner et al., 2022). Furthermore, this proposal helps explain between-study variation in the size of reported spontaneous perspective-taking effects by taking into account variables that affect attention orienting, including salience (Bukowski et al., 2015) and task context (Westra et al., 2021). Similarly, attenuated or absent altercentric intrusion effects have been reported for RTs when stimuli are less intrinsically directional, such as Lego figures (O'Grady et al., 2020), or human figures embedded within complex natural scenes (Del Sette et al., 2022). This is particularly the case when participants respond exclusively from the self-perspective (Del Sette et al., 2022; O'Grady et al., 2020); when self-perspective trials are mixed with other-perspective trials, altercentric intrusion effects may be acquired during the course of the experiment even for stimuli with ambiguous directionality (Westra et al., 2021). Collectively, this evidence suggests that attention orienting accounts for spontaneous perspective-taking effects measured by the speed of responding to avatars and human figures.

By contrast, error data showed a robust spontaneous perspective-taking effect in the modified task (Experiment 1), which was replicated three times (Experiments 2–4). The size of this effect was comparable to that for the original version (Experiment 3), implying that it was unaffected by a manipulation that affected attention orienting. It was also comparable to the size of the effects for "egocentric intrusions" (Experiments 1 and 2) and for arrows (Experiment 2), suggesting a common type of interference effect that does not rely on attention orienting. Crucially, this effect was found to be restricted to a mixed testing procedure combining both self- and other-perspective trials; it was found to be absent for the self-only condition (Experiment 4) with Bayesian analysis providing strong support for the null hypothesis. Taken together, these results provide evidence for a separate cognitive process contributing to spontaneous perspective-taking alongside attention orienting. The current results indicate that this is an interference effect that is contingent on there being two competing active task sets (self- and other perspectives), not dependent on attention orienting, and not specific to current perspective (self or other), stimulus (avatar or arrow), or version (modified or original).

These results have relevance to previous findings for the dot perspective task when self- and other perspectives are mixed. Accordingly, increased errors when taking one's own perspective during inconsistent compared to consistent trials occur due to erroneously making what would be a correct response for the other perspective. This is consistent with earlier evidence that the magnitude of altercentric intrusion effects varies according to procedure, with larger effects occurring when other-perspective trials are included and interspersed with self-perspective trials (Holland et al., 2021; O'Grady et al., 2020). In experimental design terms, this could be construed simply as a "carryover" effect. For instance, because of lapses in executive control, participants may sometimes fail to track the trial type in mixed blocks and occasionally encode dots from the wrong perspective resulting in an error in inconsistent trials.

However, executive control processes are also likely to play a more intrinsic role in moment-by-moment perspective selection in everyday life as well as in the laboratory. This is implied by larger altercentric intrusion effects occurring when executive resources are depleted due to dual task conditions (Qureshi et al., 2010), or time pressure (Todd et al., 2017). Drawing on the task-switching literature (Monsell, 2003), perspective selection may be considered in terms of choosing between competing "task sets" by dynamically increasing the activation of the task set for the desired perspective, while inhibiting that for the unwanted perspective. In the current context, "task set" may involve retrieving appropriate goal states (e.g., "I can see …" vs. "she can see") and shifting attention to relevant stimulus features (set of dots; ignore/attend to the avatar).

A potential problem with this account is that the time between the presentations of the perspective cue and the avatar in the present experiments is 1,250 ms, which is easily sufficient for asymptotic endogenous task-set reconfiguration to occur (Rogers & Monsell, 1995). Nevertheless, a residual cost of mixing tasks remains that is known to be influenced by factors such as their relative familiarity (Yeung & Monsell, 2003). Thus, errors at response selection due to residual activation of the unwanted task set can account for altercentric intrusion effects measured by error rates when self- and other perspectives are mixed. Evidence accumulation models may provide a useful way to elucidate these mechanisms in future research (e.g., Schmitz & Voss, 2012).

The present study therefore provides evidence for how two submentalizing processes integrate to account for spontaneous perspective-taking measured by the dot perspective task. It refines the current submentalizing account by showing that attention orienting primarily explains altercentric intrusion effects measured by RTs. Furthermore, it elaborates this account by identifying explicitly the intrinsic role of executive functions in perspective selection, and how this contributes to altercentric intrusion effects measured by error rates. Our novel submentalizing account provides an alternative explanation for findings previously interpreted as evidence for implicit mentalizing (Pesimena & Soranzo, 2023). It also may help to explain inconsistencies in the literature, such as opposing effects in psychopathology. For instance, reports of decreased perspective-taking in schizophrenia (Kronbichler et al., 2019), can be reframed as due to deficits in social attention (Dalmaso et al., 2013) rather than deficits in mentalizing. Whereas reports of increased perspective-taking in schizophrenia (Simonsen et al., 2020) can be reframed as a consequence of depleted executive functions (Fioravanti et al., 2005; Westerhausen et al., 2011) rather than depleted self–other control. Thus, our submentalizing account may help to reconcile these apparently contradictory results (Gardner & Buchanan, 2023).

Some limitations should be considered. First, we acknowledge that some of the reported analyses deviate slightly from preregistered plans. For Experiment 1, separate analyses were reported for RTs and error rates rather than the planned dependent variable, IESs, which is a composite of these measures. Also, Experiments 2 and 3 employed slightly stricter exclusion criteria in order to reject data from participants who adopted stereotyped responding strategies. We have reported the results for both exclusion criteria for the purposes of transparency, and note that the findings were broadly similar. Second, a relatively large proportion of participants were excluded from Experiment 2 (25%), particularly from the group presented with the arrow. This was to prevent bias from stereotyped responding strategies, such as ignoring the perspective prompt and consistently responding either from the self- or other perspective. We speculate that online testing exacerbated misunderstandings for the slightly less natural arrow condition (e.g., no opportunity for clarification of instructions), and paid online participants may have been relatively prone to adopt strategic shortcuts.

In conclusion, the current experiments provide evidence for two domain-general processes that contribute to spontaneous perspective-taking in the dot perspective task through dissociable effects on RTs and error rates. Consistent with previous work, attention shifts were found to contribute to RT effects in the original dot perspective task when participants were required to respond to a directional avatar. Additionally, domain-general executive processes that control selection of competing task sets appear to enable selection between perspectives and contribute to altercentric intrusion effects measured by error rates. This evidence has three main implications. First, the current modified procedure provides a useful means to control for effects of attention orienting, where this is considered to be a nuisance variable. Second, submentalizing accounts need to incorporate executive functions alongside attention orienting. Third, such an account may provide a better understanding of previous findings, including altered spontaneous perspective-taking in psychopathology, thus casting further doubt upon the dot perspective task as a source of evidence for implicit mentalizing.

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