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Attentional interference is modulated by salience not sentience

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ABSTRACT

Spatial cueing of attention occurs when attention is oriented by the onset of a stimulus or by other information that creates a bias towards a particular location. The presence of a cue that orients attention can also interfere with participants' reporting of what they see. It has been suggested that this type of interference is stronger in the presence of socially-relevant cues, such as human faces or avatars, and is therefore indicative of a specialised role for perspective calculation within the social domain. However, there is also evidence that the effect is a domain-general form of processing that is elicited equally with non-social directional cues. The current paper comprises four experiments that systematically manipulated the social factors believed necessary to elicit the effect. The results show that interference persists when all social components are removed, and that visual processes are sufficient to explain this type of interference, thus supporting a domain-general perceptual interpretation of interference.

1. Introduction

Spatial cueing of attention occurs when attention is oriented by the onset of a stimulus at a specific location or by a cue that signals a location and therefore creates an expectation that a stimulus will appear in that location (Posner, 1980). Certain cues such as eyes or arrows have been known to orient attention towards target stimuli due to their social or biological relevance (Ristic & Kingstone, 2012). However, there is debate as to whether socially- or biologically-relevant cues are special when it comes to triggering reflexive shifts in attention (Langton, Watt, & Bruce, 2000; Ristic, Friesen, & Kingstone, 2002). In other words, it is not clear whether all cues belong to the same category, or whether social information has a distinct functional role in cueing attention. In this paper, we study a specific phenomenon of spatial cueing: how cueing affects the speed and accuracy at reporting what the observer sees in the scene.

A number of studies have shown that the presence of a cue in the visual scene can interfere with participants' reporting of what they see – slower reaction times and higher error rates – if the number of stimuli that the cue points to is different from the overall number of stimuli visible to the participant (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010). Samson et al. (2010) introduced a type of spatial cueing paradigm (sometimes referred to as the 'dot perspective task'; Cole, Atkinson, Le, & Smith, 2016) consisting of a visual scene with a cue pointing towards some target stimuli. Participants were requested to report either the target stimuli that they could see (i.e. participants were adopting a first person-perspective) or the target stimuli that were in the direction of the cue (i.e. participants were adopting a third person-perspective). Based on Vogeley et al. (2004), we refer to the first-person perspective as 1PP and to the third-person perspective as 3PP.

In the dot perspective task, the stimuli are presented on a computer screen and trials begin with the presentation of a perspective prompt on the screen ("YOU" or "S/HE"). After the presentation of the prompt, a number is presented (e.g., 1). This is followed by the experimental scene, which consists of a three-dimensional room with a female or male avatar placed in the middle. The avatar faces to the left, so that it can "see" only the left wall of the room, or to the right, facing the right wall. In the experimental trials, discs are displayed on the left or right wall creating conditions where either the participant and avatar can see the same number of discs (consistent condition) or where the participant can see more discs than the avatar (inconsistent condition). When the scene appears, participants confirm whether the number shown previously is equal to the number of discs visible from the prompted perspective ("YOU" or "S/HE", see Fig. 1).

Samson et al. (2010) found that participants were slower and less accurate when there was inconsistency between the cued targets and the visible targets. This effect has been observed in a number of subsequent studies; however, it is debated whether the interference that occurred when adopting first-person perspective (1PP-interference) is

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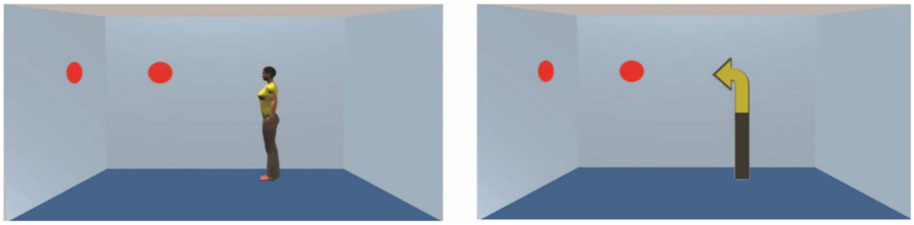

Fig. 1. Sketch of the experimental design employed by Samson et al. (2010) and replicated in the current study.

modulated by social factors such as visual perspective attribution. Two positions have been advanced: one position argues that perceptual factors of the cueing task are sufficient to explain 1PP-interference (e.g. Cole et al., 2016; Cole, Smith, & Atkinson, 2015; Santiesteban, Catmur, Hopkins, Bird, & Heyes, 2014), whilst the other argues that perceptual factors are not sufficient on their own and that additional social factors are necessary (e.g. Baker, Levin, & Saylor, 2016; Capozzi, Cavallo, Furlanetto, & Becchio, 2014; Furlanetto, Becchio, Samson, & Apperly, 2016; Nielsen, Lance, Levy, & Amanda, 2015; Samson et al., 2010). For the sake of consistency, these positions will now be referred to as the perceptual interpretation and the social interpretation, respectively.

Generally speaking, the perceptual interpretation is that 1PP-interference emerges because attention is oriented towards the stimulus in the cued location. This leads to interference when there is inconsistency between what is present at the cued location and what the participant is asked to attend to (e.g. Cole et al., 2015; Cole et al., 2016; Green & Woldorff, 2012; Posner, Snyder, & Davidson, 1980). The social interpretation of 1PP-interference is that attentional orientation is modulated by social factors: visual state attribution to the cue, social-relevance of the cue and social-perspective-taking. As such, 1PP-interference either does not occur, or is lessened when these social factors are not present (Baker et al., 2016; Capozzi et al., 2014; Furlanetto et al., 2016; Nielsen et al., 2015; Samson et al., 2010). The next sections outline the two interpretations in more detail and discuss the conflicting evidence for the social interpretation.

1.1. *The perceptual interpretation of 1PP-interference*

The perceptual interpretation of 1PP-interference argues that the effect can be attributed to the directional features, and not social relevance, of the cue. In consistent conditions, there is a shift in attention towards the cued location that facilitates the processing of the target stimuli. In inconsistent trials there is a conflict between the number of target stimuli pointed to by the cue and the total number on screen. These two pieces of information need to be calculated simultaneously so that the conflict can be resolved before a response is given, leading to slower response times and reduced accuracy (Cole et al., 2015; Santiesteban et al., 2014). If this is the case, it follows that the effect should occur for any cue where the directional features are unambiguous and salient enough to orient attention.

Indeed, there is a strong similarity between the dot-perspective task described earlier (Baker et al., 2016; Capozzi et al., 2014; Furlanetto et al., 2016; Nielsen et al., 2015 and Samson et al., 2010) and the experimental paradigm traditionally employed in spatial cueing studies (e.g. Posner, 1980; Qian, Feng, Yong, & Miao, 2015; Ristic & Kingstone, 2012). In both cases participants react to the onset of a target that appears to the left or right of a central fixation point. Spatial cueing studies have found similar results to 1PP-interference studies: faster reaction times and higher accuracy when targets appear in the cued location and slower responding when there are target/cue conflicts (Green & Woldorff, 2012; Qian, Shinomori, & Song, 2012; Qian et al., 2015). These studies do not use socially-relevant cues.

1.2. *The social interpretation of 1PP-interference*

A body of research has emerged on social perspective-taking, which argues that 1PP-interference is an intrinsically social process (Nielsen et al., 2015). This social interpretation accepts that attentional cueing plays a part in eliciting the 1PP-interference "[…] attention is spontaneously drawn to where someone else is looking […] this is typically observed in a spatial cuing paradigm" (Samson et al., 2010, p. 1264). However, it is argued that additional social factors modulate the effect. From the literature, we have identified three separate social factors that are argues to influence 1PP-interference: visual perspective attribution, social-relevance of the cue and social perspective-taking.

1.2.1. *Visual perspective or mental state attribution*

Visual perspective attribution is the idea that, when a participant engages in the dot-perspective task, the cue itself is considered to have a point of view. The occurrence of 1PP-interference is dependent on the participant perceiving the cue as being able to see: "participants might not experience interference from the presence of the avatar if they thought that the avatar could not see" (Samson et al., 2010, page 1263). The necessity of visual perspective attribution is further emphasised by the authors "[…] it is not only the object seen by the other person that is easily available to participants to process (as demonstrated previously in the spatial cueing paradigms) but also the fact that this object is seen by the other person" (Samson et al., 2010, p. 1264). Referred to in some cases as mental state attribution, it has been suggested that participants' belief that the cue is actually able to perceive, is either necessary for the cueing to occur or that it enhances the cueing effect (e.g. Furlanetto et al., 2016; Nuku & Bekkering, 2008; Teufel, Alexis, Clayton, & Davis, 2010).

However, a number of studies have recently begun to test this contention and found that the same level of cueing and interference emerge without visual perspective attribution (e.g. Cole et al., 2016; Cole et al., 2015). Previous studies that have examined this aspect have used different approaches. Cole et al. (2016) and Baker et al. (2016) obscured/opened the view of the avatar with a physical obstruction, whilst Furlanetto et al. (2016) used different coloured goggles to denote "seeing" and "non-seeing" avatars. These studies found opposite results: whilst in Cole et al. (2016)'s study 1PP-interference occurred regardless of whether or not the avatar could see the targets, in both Baker et al. (2016) and Furlanetto et al. (2016)'s studies, 1PP-interference emerged only when visual perception was attributed to the avatar, in particular when the participants believed that the avatar could actually see the scene. Specifically, Baker et al. (2016) concluded that "self-judgment interference is elicited by another's conflicting visuo-spatial access calculated from their line of sight" (page 931).

1.2.2. *Social relevance of the cue*

This is the idea that the magnitude of 1PP-interfernece depends upon the amount of social characteristics that the cue has. For example, when comparing three cues in a dot-perspective task, Nielsen et al. (2015), suggested that a human avatar produces stronger 1PP-interference when compared to an arrow, and the arrow, at its turn, produces stronger 1PP-interference when compared to a dual-coloured block. They argue that the amount of interference is "determined by the extent to which the task was social in nature; the more social the task, the stronger the […] intrusion effect" (page 15).

However, it could be argued that this interpretation of the findings is flawed in two ways: the labelling of arrow cues as "semi-social" and the fact that the avatar and arrow cues are never directly compared. In the study, the authors attributed different levels of social-relevance to each of the cues, describing the avatar as social, the arrow as semi-social and the dual-coloured block as non-social. It is worth considering whether the distinction between the cues is valid, because the conclusion that 1PP-interference demonstrates an intrinsically social process stems from how the cues were labelled and the conclusion that the so-called social cue (the avatar) elicited stronger interference effects than either of the other two cues.

Nielsen et al. (2015) describe the arrow cue as "semi-social" based on a study by Kingstone, Tipper, Ristic, and Ngan (2004). This study found that human eyes and arrows are both able to trigger a shift in attention. In itself this does not make the arrow a semi-social cue. Where social cues, such as faces, have been found to differ considerably from other cues, the effect has been attributed to specific social-cognitive abilities, such as attributing intention to the face cue, which is not applicable to arrow cues (Wiese, Wykowska, Zwickel, & Müller, 2012). Indeed, in studies on cueing, arrows have been used specifically to provide a non-social baseline and it has generally been found that gaze direction of avatars trigger reflexive shifts of attention towards the gazed-at location, equivalent to the effect elicited by arrows (Bayliss, Paul, Cannon, & Tipper, 2006; Ristic et al., 2002). This is supported by neurological findings by Brignani, Guzzon, Marzi, and Miniussi (2009) who studied the attentional shift produced by arrows and eye-gaze and measured event-related potentials. They found that arrows and gaze produced similar behavioural and neurophysiological responses. This is also consistent with Santiesteban et al. (2014)'s findings that both arrows and avatars elicited similar levels of 1PP-interfernece. They suggest that the effects are due to automatic attentional orienting.

Moreover, from a visual inspection of the results reported by Nielsen et al. (2015; page 9) it seems that similar levels of 1PP-interference were elicited by the avatar and the arrow. However, when comparing effects of the cues, the results of the arrow and dual-coloured block were collapsed and compared with the avatar, meaning no explicit comparison between the effects of the arrow and avatar were made. This calls into question the conclusion that social relevance of the cue was important in eliciting 1PP-interference.

1.2.3. Social perspective taking

Social perspective-taking is the idea that, when asked what is visible to another, the participant attempts to adopt their perspective. In the context of the dot-perspective task, Nielsen et al. (2015) suggested that the use of personal pronouns for both the participant and the cue induces or modulates social perspective-taking. In their study, the authors "[…] modified the instructions for selecting perspective across conditions by employing personal pronouns in the social cue condition but replacing them in the other conditions" (Nielsen et al., 2015; page 4). The authors concluded that there is a stronger 1PP-interference when social pronouns are used. This is consistent with Samson et al. (2010)'s assertion that the interference may be specific to the social domain and the contention by Capozzi et al. (2014) that in instances where 1PP-interference did not occur, it was because "[…] the process of perspective calculation was not initiated" (page 11), due to the absence of a socially relevant prompt.

The role of social perspective-taking, and personal pronouns, in 1PP-interference is unclear. In studies where it is discussed, it has either not been manipulated or it has been manipulated at the same time as other variables. As such, it is difficult to ascertain the exact impact that this specific component has on the strength of 1PP-interference.

1.3. The current research

In outlining the two interpretations of 1PP-interference, the preceding sections have identified confounds in previous research that call into question the robustness of the social interpretation. To test the theory that 1PP-interference is initiated by perceptual and not social features of the cueing task, the current project systematically manipulates perspective attribution, social-relevance of the cue and social perspective-taking and examines whether each one modulates the 1PP-interference effect. Consistent with the interpretation that this is a lower-level perceptually-driven effect, we developed the following hypotheses:

1. 1PP-interference persists even when perspective is not attributed to the cue;

2. 1PP-interference persists even when the cue does not have social-relevance;

3. 1PP-interference persists even when the first-person perspective is not induced by a social prompt;

4. 1PP-interference persists even when the third-person perspective is not induced by a social prompt.

2. General method

Here we present a description of the procedural aspects common to each of the four experiments, followed by the general analytic approach adopted across all experiments.

2.1. Participants

For each experiment participants were staff members, undergraduate and postgraduate students at Sheffield Hallam University. The participants were naïve to the purpose of the study and received no remuneration for taking part. Written informed consent was obtained from each participant in accordance with the University's ethical procedures.

Each experiment in the current research used 16 new participants per independent group. The chosen sample size was based on previous research that employed this experimental paradigm (Samson et al., 2010). This was supported by a prospective power analysis which indicated that this sample size would provide strong power (0.8) to detect the expected effects. Sample size was decided in advance and data collection was stopped when the predetermined number of participants had been reached.

2.2. Stimuli and procedure

Stimuli were similar to those employed by Samson et al. (2010) and consisted of a 3D model of a room presented so that the back, left and right walls were visible to participants. In the centre of the room a cue[1] (e.g. a human avatar) was present, facing towards either the right or left wall.

The stimuli were created using SketchUp (www.sketchup.com). During experimental trials, red discs were displayed on either the left, right or both walls. As the participant could see both walls, s/he could always see all of the discs. However, since the cue was always pointing towards either the left or right wall it could only face the discs placed on one of the walls. In consistent trials, the number of discs visible to the participant and faced by the cue was the same. In inconsistent trials, the participant could see some discs that the cue was not facing.

Stimulus presentation was controlled and responses recorded using DMDX software (Forster & Forster, 2003). The stimulus presentation sequence was identical to Samson et al. (2010). Trials began with a fixation cross presented for 750 ms. After 500 ms the pronoun "YOU" or "SHE"/"HE" appeared on-screen and remained for 750 ms. The prompt "YOU" indicated to the participant that they should adopt a first-person perspective (1PP) and the prompt "HE" or "SHE" indicated that they

[1] The type of cue that was presented was dependent upon the experimental manipulation that took place in the study.

should adopt a third-person perspective (3PP).

After another gap of 500 ms, a number (1–3) was presented for 750 ms. This number represented the number of discs that the participant needed to verify were visible from their perspective (1PP) or faced by the cue (3PP). The image of the room with the cue in the centre was then presented on screen until the participant responded by pressing the right SHIFT key for yes (the stated number of discs visible from the participant perspective or faced by the cue) or the left SHIFT key for no (the stated number of discs is not visible from the participant perspective or not faced by the cue). If the participant did not respond within 2000 ms, the next trial started.

The combination of stimulus presentation (consistent vs. inconsistent) and perspective adopted (1PP vs. 3PP) options meant that there were four basic trial types in the experiment. Importantly though, trials can also be further divided based on the correct response (Yes vs. No). Whilst all consistent yes, inconsistent yes and inconsistent no trials require the participant to evaluate at least one perspective to assess whether the number presented in the trial matches the number of discs on screen, a potential confound arises from all consistent no trials, as the number presented to the participant does not match the number of discs visible from either perspective. For this reason, only the “yes” trials are included in analysis and “no” trials are used as catch trials to assess adherence to the experimental task. In total 208 trials were presented to each participant. These comprised 96 Yes response trials and 96 No response trials with equal representation of consistency (consistent/inconsistent) and perspective (1PP/3PP). A further 16 trials were included where 0 discs displayed on-screen, also with equal representation of consistency (consistent/inconsistent) and perspective (1PP/3PP). The presentation of trials was randomised.

2.3. General analytic approach

Interference is measured across all experiments by examining the difference between consistent and inconsistent trails on RT and error rates. To test the aforementioned hypotheses, each experiment introduced specific manipulations of cue type and/or prompt type variables to examine whether these also had an effect on interference. In Experiments 1 and 2 the effect of cue type was examined. In experiments 3 and 4 the effect of the perspective prompt was examined.

The current research is concerned primarily with 1PP-interference. As the experimental task required participants to switch perspectives (1PP and 3PP) between trials, perspective was included as a variable in the analysis to differentiate between these two trial-types.

To this end, analysis of variance (ANOVA) was used with consistency (consistent and inconsistent) and perspective (1PP and 3PP) as within-subjects variables and cue type or perspective prompt as between groups variables, where appropriate. Separate analyses were conducted on response time and error rates.

Finally, for each experiment a measure of the 1PP-interference magnitude was obtained by subtracting the mean in inconsistent 1PP trials from the mean in consistent 1PP trials. Again, separate analyses were conducted on response time and error rates.

3. Experiment 1

Experiment 1 tested Hypothesis 1 that 1PP-interference persists when a mental state - in the sense of having a visual representation of the scene - is not attributed to the cue. There have been conflicting findings in relation to this point but the results are difficult to compare directly due to different approaches used to manipulate the “seeing” of the cue (Teufel et al., 2010; Nuku & Bekkering, 2008). Moreover, in the process of this manipulation, each study introduced additional elements into the dot perspective task that may have affected the results. Firstly, the use of coloured goggles by Furlanetto et al. (2016) introduces a potential confound, as the participants need to be told which type of goggles the avatar had to wear to be able to see. The meaning of the colours of the goggles does not convey any perceptually relevant information; rather, it needs to be learned, potentially impacting response time. The use of a physical barrier by Cole et al. (2016) and Baker et al. (2016) overcomes this problem. However, it also introduces an extra component into the visual scene that adds complexity in comparison with the other dot perspective tasks. Another problem in both studies is that the experiment employed a within-groups design to alternate between “seeing” and “non-seeing” conditions. This could impact 1PP-interference as alternating between conditions may indicate to participants that they have to do something different in each condition and the resulting effect could be due to expectation rather than interference. To address these concerns, Experiment 1 employed two between-groups conditions: a blindfolded avatar and a sighted avatar. Thus, in this study there was one between-subjects variable: cue type (with two levels: sighted avatar and blindfolded avatar); and two within-subjects variables: consistency (with two levels: consistent and inconsistent); and perspective (with two levels: 1PP and 3PP). The dependent variables considered were RTs and error rates.

3.1. Method

The experimental setup and procedure are described in the General method section. Thirty-two participants took part to this experiment, 16 per each of the cue type variable. The manipulation specific to Experiment 1 was the comparison of a blindfolded avatar with a seeing avatar (see Fig. 2).

3.2. Results

A three-way mixed analysis of variance (ANOVA) was conducted in which cue type was a between-subjects variable (sighted avatar and blindfolded avatar) whilst both perspective (1PP and 3PP) and consistency (consistent and inconsistent) were within-subjects variables.

3.2.1. Reaction time analysis

The analysis revealed a significant effect of consistency, $F(1,30) = 55.18$ $MSE = 363{,}318.46$; $p < 0.01$, $\eta^2 = 0.65$, with inconsistent trials showing slower RT (M = 843 ms, SD = 259 ms) than consistent trials (M = 736 ms, SD = 257 ms) as well as the interaction between consistency and perspective, $F(1,30) = 8.84$, $MSE = 62{,}871.27$, $p \le 0.01$ $\eta^2 = 0.23$; indicating smaller effects of consistency for 1PP trials (see Fig. 3, top row). A post-hoc analysis however revealed the

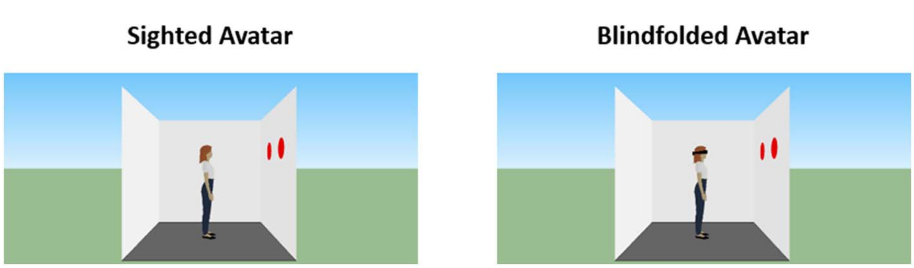

Fig. 2. Example of the sighted avatar and blindfolded avatar cues in Experiment 1.

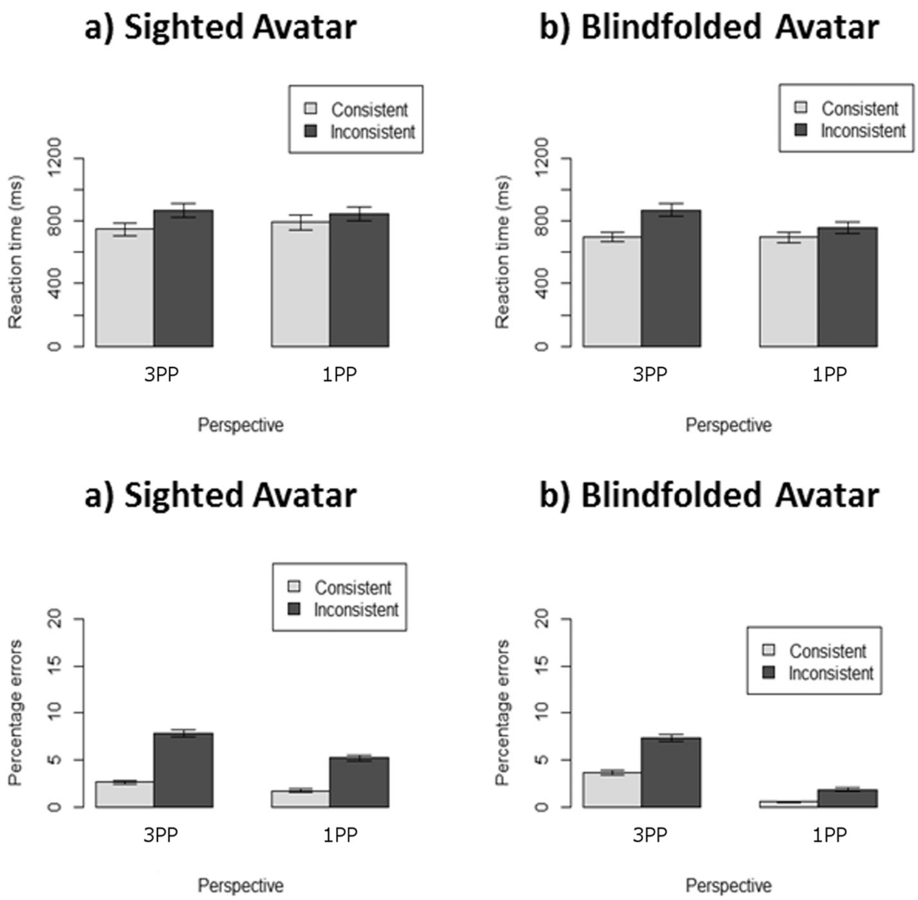

Fig. 3. Experiment 1 reaction times (upper row) and error rates (bottom row) for the: a) sighted avatar condition; (b) blindfolded avatar condition. Bars indicate standard errors of the mean.

effect of consistency was present in both the 3PP and 1PP levels of the perspective variable, at differing magnitudes; t(31) = 6.06; $p < 0.01$, and 1PP t(31) = 4.08; $p < 0.01$, respectively.

The mean RTs were 722 ms and 873 ms for the consistent and inconsistent conditions, respectively, of the 3PP level of the perspective variable; and they were 751 ms and 813 ms for the consistent and inconsistent conditions, respectively, of the 1PP level of perspective.

There was no significant effect of perspective ($p = 0.16$) and of cue type ($p = 0.39$). Finally, no significant interactions were found between cue type and both consistency ($p = 0.46$) and perspective ($p = 0.28$) variables.

3.2.2. Error rate analysis

The analysis revealed a significant effect of consistency, F (1, 30) = 4.29, MSE = 0.12, $p < 0.05$, $\eta^2 = 0.13$, with the inconsistent trials eliciting higher error rates than consistent trials; and a significant effect of perspective, F (1,30) = 30.78, MSE = 0.15; $p < 0.01$, $\eta^2 = 0.5$, with a lower error rate in 1PP trials (4.6%) compared to 3PP trials (10.67%), see Fig. 3, bottom row. The interaction between consistency and perspective was also statistically significant, F (1,30) = 50.75, MSE = 0.013, $p < 0.05$; $\eta^2 = 0.16$, with smaller effect of consistency in 1PP trials. The effect of the cue type variable was not statistically significant ($p = 0.57$) as well as non-significant interactions with the consistency ($p = 0.39$) and perspective ($p = 0.14$) variables.

3.2.3. 1PP-interference magnitude analysis

A measure of the 1PP-interference magnitude was obtained for both RT and error rates. This was done by subtracting the mean in inconsistent 1PP trials from the mean in consistent 1PP trials and carrying out an independent measures *t*-test. The analysis revealed a non-significant effect of cue type on the magnitude of RT and error rates ($p = 0.45$ & 0.37, respectively). This indicates that both cues were equally strong in eliciting 1PP-interference.[2]

4. Experiment 2

Experiment 2 tested Hypothesis 2, that 1PP-interference persists even when the cue does not have social-relevance. Historically, arrows have been used a non-social baseline when examining cueing effects of social cues such as eyes, faces or avatars (Bayliss et al., 2006; Ristic et al., 2002). In relation to 1PP-interference, Santiesteban et al. (2014) compared the effects of arrows and avatars and found similar levels of 1PP-interference from both cues. They concluded in favour of the perceptual interpretation of 1PP-interference; specifically, that the effects are due to “domain-general processes such as those that mediate automatic attentional orienting” (page 929). However, a later study by Nielsen et al. (2015) argued in favour of the social interpretation. Specifically, that the level of interference is “determined by the extent to which the task was social in nature; the more social the task, the stronger the […] effect” (page 15).

However, both studies contain potential confounds regarding the distinction between arrow and avatar cues. Santiesteban et al. (2014) used an arrow designed to have similar features to a human avatar (i.e. vertical orientation, matching colours, point of arrow in head position:

[2] This result is further supported by the analysis of the catch trials. As mentioned above, the “no” trials were not included in the analysis, as the number presented to the participants did not match the number of discs visible from either perspective (based on Samson et al., 2010). However, if interference was found even in “no” trials – where the cueing was invalid – this could suggest that attention is automatically oriented by the cue. Supplementary analysis of the “no” trials, comparing conditions where discs were present, with conditions where no discs were present, showed slower RTs when target discs were present, t(31) = 5.35; $p < 0.01$; Cohen's d = 1.07. This, considered alongside the results of experiment 1, seems to provide further evidence in favour of the perceptual interpretation of 1PP-interference.

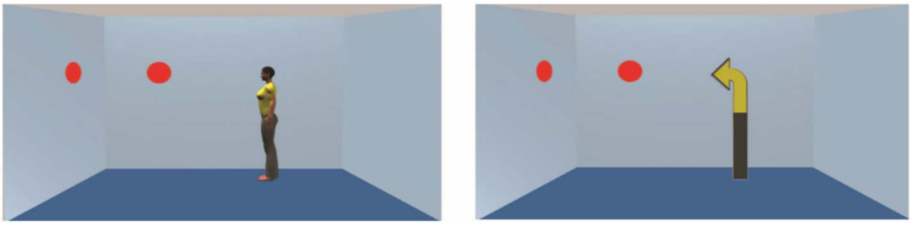

Fig. 4. Example of the avatar and arrow cues used in Santiesteban et al. (2014).

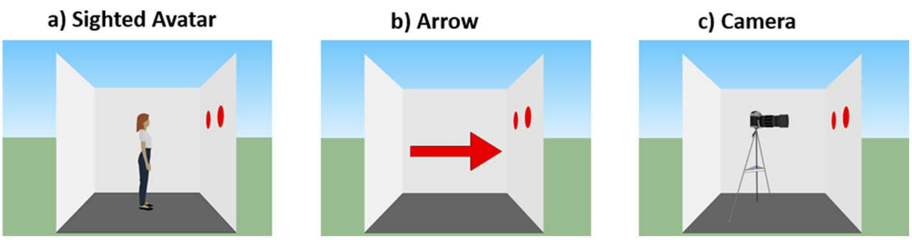

Fig. 5. Example of the sighted avatar, arrow and camera cues used in Experiment 2.

Fig. 4), making it difficult to distinguish whether the effect is elicited by the "human-like" social nature of the arrow cue. Nielsen et al. (2015) combined the results of arrows and avatars – despite arrows traditionally being used as a non-social baseline cue – and compared them to a dual coloured block cue, which was labelled as non-social, meaning no direct comparison of arrow and avatar was made. In addition, Nielsen et al.'s use of a dual-coloured block as a control introduced a potential confound, since the directional meaning of the colours on the cue is ambiguous and needs to be learned. Previous research has indicated that the visual salience of cues affects how effectively they orient attention, regardless of experimenter instruction (Tipples, 2002).

The aims of this experiment were threefold: firstly, to compare an arrow and an avatar cue; secondly, to address a potential confound in previous studies which used block type cues as these cues did not provide a clear direction; thirdly, to separate visual similarity and social relevance of the cue. To address these aims, Experiment 2 compared an arrow, an avatar and a camera. In this experiment, the camera serves two functions: it addresses the limitations of the dual-coloured block control because, as a difference from the dual-coloured block it has an explicit direction, and it is visually similar to the human avatar, without having social relevance. Thus, the experimental design consisted of one between-subjects variable: cue type (with three levels: sighted avatar, arrow, and camera); and two within-subjects variables: consistency (consistent and inconsistent); and perspective (1PP and 3PP).

4.1. Method

The experimental setup and procedure are described in the General method section. Forty-eight new participants took part to this experiment, 16 per each of the cue type variable. The central cues used in this experiment are represented in fig. 5. The on-screen prompt to elicit 3PP trials was "SHE[3]". The manipulation specific to Experiment 2 was the comparison of three cue types: sighted avatar, arrow, and camera (see Fig. 5).

4.2. Results

A three-way mixed ANOVA was conducted in which the variable cue type (with three levels: sighted avatar, arrow, and camera) was as a between-subjects factor whilst both perspective (1PP and 3PP) and consistency (consistent and inconsistent) were within-subject variables.

4.2.1. Reaction time analysis

The ANOVA revealed a significant effect of consistency, $F(1,45) = 54.68$, $MSE = 670{,}107.45$, $p < 0.01$, $\eta^2 = 0.55$, with slower RT for inconsistent trials ($M = 851$ ms, $SD = 237$ ms) than consistent trials ($M = 733$ ms, $SD = 222$ ms). The interaction between consistency and perspective was almost significant, $F(1,45) = 4.03$, $MSE = 46{,}483.542$, $p = 0.051$. This marginal effect seems to indicate that the effect of consistency was slightly smaller in 1PP trials than 3PP trials (see Fig. 5, top row).

The analyses were not significant for the perspective variable ($p = 0.09$), the cue type variable ($p = 0.12$) and the interactions between cue type and both the consistency ($p = 0.3$) and perspective ($p = 0.18$) variables.

4.2.2. Error rate analysis

An ANOVA revealed a significant effect of consistency, $F(1,45) = 56.13$, $MSE = 0.58$, $p < 0.01$, $\eta^2 = 0.55$, with lower accuracy for inconsistent trials (17%) than consistent trials (6%) and a significant interaction between consistency and perspective, $F(1,45) = 6.47$, $MSE = 0.065$, $p = 0.01$; $\eta^2 = 0.13$ (see Fig. 6, bottom row).

There was no effect of perspective ($p = 0.8$), cue type ($p = 0.38$) and the interactions between cue type and both the variables consistency ($p = 0.5$), and perspective ($p = 0.1$).[4]

4.2.3. 1PP-interference magnitude analysis

A one-way between-subjects ANOVA revealed a non-significant effect of the cue type variable on the magnitude of RT and error rates ($p = 0.65$ & $p = 0.82$).

5. Experiment 3

Experiment 3 tested Hypothesis 3 that 1PP-interference persists when first-person perspective is not induced by a social prompt. Nielsen

[3] The use of the pronoun "SHE" for the Arrow and the Camera conditions might seem arbitrary. This choice has been taken for the sake of consistency with previous research. In Samson et al. (2010) the avatar was a Female (prompted with "SHE") for female participants and a Male (prompted with "HE") for male participants. Presumably, the choice of matching participant's sex with the avatar's sex was taken to favour participants' identification with the avatar. Whilst the role of identification with the other individual remains to be tested, the paradigm assumes that the two individuals are distinct, and in this sense, it should not be necessary to match the sex of participant and avatar. Experiment 4 tests the role of pronouns in the instructions and the effect of using "SHE" in this experiment will be compared with the use of non-social pronouns such as "Arrow" and "Camera".

[4] It is interesting that, although not statistically different, Fig. 6b (bottom) shows that there are higher mean error rates for inconsistent trials in the arrow condition than in the sighted avatar or camera conditions. It is possible that the directional features of the cue affected the responses. This issue is further considered in the discussion.

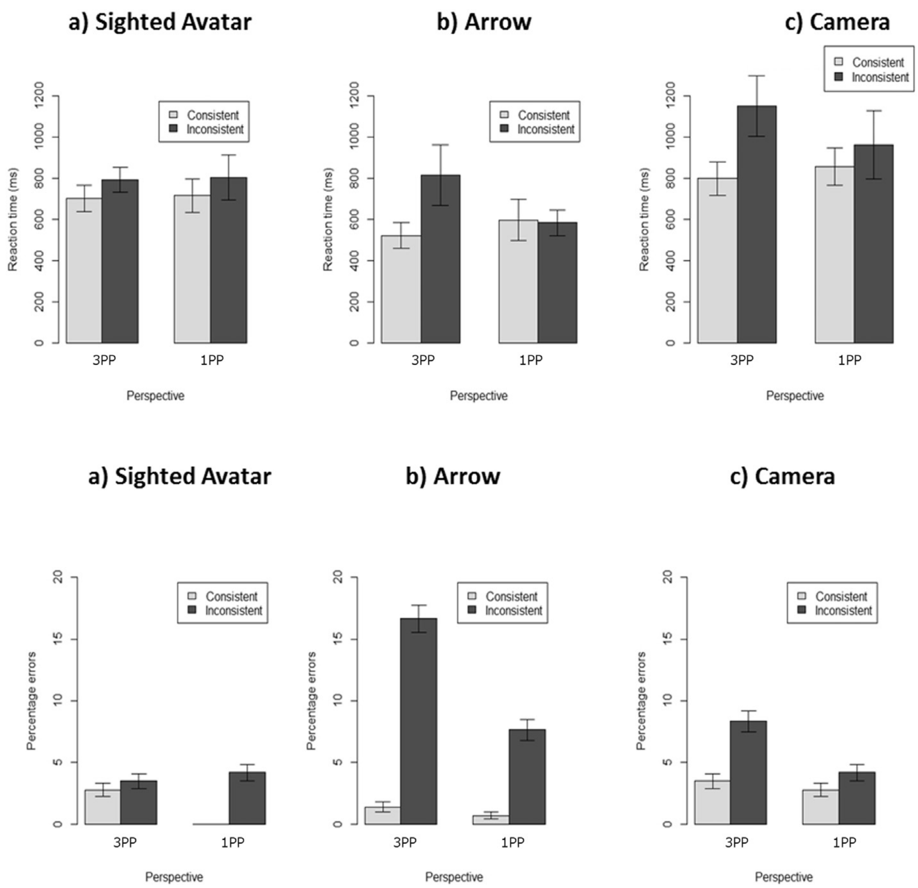

Fig. 6. Experiment 2 reaction times (upper row) and error rates (bottom row) for the: a) sighted avatar condition; (b) arrow condition; and (c) camera condition. Bars indicate standard errors of the mean.

et al. (2015) suggested that personal pronouns modulate social perspective-taking and this contributes to 1PP-interference. They examined this by manipulating the perspective prompt to be either a social pronoun (YOU) or a non-social prompt (ROOM) and found that 1PP-interference was weaker in non-social conditions. However, it is problematic that both the social relevance of the cue (e.g. Arrow/Avatar) and the social nature of the prompt (e.g. "He"/"Arrow", "You/Room") were manipulated at the same time. In addition, there was no condition where a non-social prompt was used with a human avatar cue. Because the prompt was not manipulated in isolation, it is difficult to discern whether the use of social pronouns had any unique contribution to the 1PP-interference effect.

In Experiment 3, the sighted avatar Condition of Experiment 1 (see fig. 2, left) was replicated and an additional 1PP condition was included where the prompt used in the instructions was "TOTAL". Participants were instructed that in the "YOU" trials, they should refer to the number of discs they can see from their own perspective. In the "TOTAL" trials, participants were instructed to confirm the total number of discs on the screen. There were, therefore, two within-subjects variables: consistency (consistent and inconsistent); and prompt ("YOU" and "TOTAL").

5.1. Method

The experimental setup and procedure are described in the General method section. Sixteen new participants took part to this experiment. The cue used in this study was the same as the sighted avatar from Experiment 1. The manipulation specific to Experiment 3 was the comparison of two perspective prompts: "YOU" and "TOTAL".

5.2. Results

A 2 × 2 repeated measures ANOVA was performed, with prompt (YOU vs. TOTAL) and consistency (consistent vs. inconsistent) as within-subjects variables.

5.2.1. Reaction time analysis

The ANOVA revealed a significant effect of consistency, F (1,15) = 9.23, MSE = 51,179.5, $p < 0.01$, $\eta^2 = 0.38$, with slower RT for inconsistent trials (M = 928 ms, SD = 281 ms) than consistent trials (M = 756 ms, SD = 224 ms), see Fig. 7, top row. There was no significant effect of perspective ($p = 0.37$) nor of the interaction between consistency and perspective ($p = 0.77$).

5.2.2. Error rate analysis

The ANOVA revealed a significant effect of consistency, F (1,15) = 7.1, MSE = 0.109, $p < 0.05$, $\eta^2 = 0.32$, with higher error rate for inconsistent trials (11%) than consistent trials (7%). There was no significant effect of perspective ($p = 0.52$), and nor of the interaction between consistency and perspective ($p = 0.74$); see Fig. 6, bottom row.

5.2.3. 1PP-interference magnitude analysis

A paired samples t-test revealed a non-significant effect for prompt on the magnitude of RT and error rates ($p = 0.77$ & $p = 0.3$, respectively).

6. Experiment 4

Experiment 4 tested Hypothesis 4 that 1PP-interference persists when the third-person perspective is not induced by a social prompt. Following from the previous experiment, to isolate any unique contribution of social pronouns to the 1PP-interference effect, Experiment 4 replicated Experiment 2 but the prompts used in the instructions for the third-person perspective were changed from the social pronouns "S/HE" to the following non-social prompts: "FIGURE", "CAMERA", "and

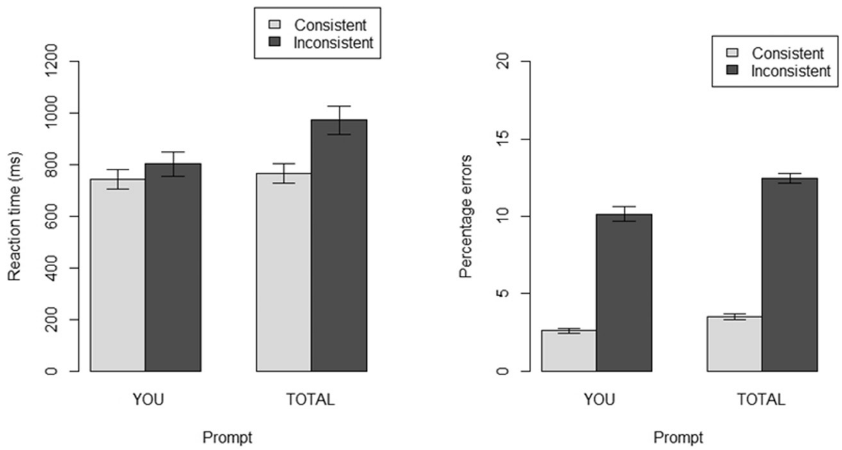

Fig. 7. Experiment 3 reaction times (left) and error rates (right) for the YOU and TOTAL prompts. Bars indicate standard errors of the mean.

"ARROW" for the sighted avatar, camera, and arrow conditions, respectively. The experimental design consisted of one between-subjects variable: cue type (with three levels: sighted avatar, arrow, and camera); and two within-subjects variables: consistency (consistent and inconsistent); and perspective (1PP and 3PP).

6.1. Method

The experimental setup and procedure are described in the General method section. Forty-eight new participants took part to this experiment, 16 per each level of the between-groups variable. The cues used in this study were the same as Experiment 2 (see Fig. 5, above). The manipulation specific to Experiment 4 was the comparison of the perspective prompts "S/HE" with the prompts "FIGURE", "CAMERA", "and "ARROW" for the sighted avatar, camera, and arrow conditions, respectively.

6.2. Results

A three-way mixed ANOVA was conducted in which the variable cue type was between-subjects whilst both consistency and perspective were within-subject variables.

6.2.1. Reaction time analysis

The ANOVA revealed a significant effect of consistency, F (1,45) = 52.64, MSE = 1.291,010.8, $p < 0.01$, $\eta^2 = 0.54$, with slower RT for inconsistent (M = 960 ms, SD = 249 ms) than for consistent trials (M = 796 ms, SD = 204 ms); see Fig. 8, top row. There was no significant effect of perspective ($p = 0.69$), and no interaction effect between consistency and perspective ($p = 0.56$). There was no significant effect of the cue type ($p = 0.1$) as well as no significant effect of the interactions between cue type and both consistency ($p = 0.74$) and perspective ($p = 0.2$).

6.2.2. Error rate analysis

The ANOVA revealed a significant effect of consistency, F (1,45) = 49.12, MSE = 1.422, $p < 0.01$, $\eta^2 = 0.47$, with lower accuracy for inconsistent trials (21%) than for consistent trials (4%); see Fig. 8, bottom row. There was also a significant effect of perspective, F (1,45) = 6.07, MSE = 0.077; $p < 0.05$; $\eta^2 = 0.12$, and a significant interaction effect between consistency and perspective, F (1,45) = 4.75, MSE = 0.069, $p < 0.05$; $\eta^2 = 0.01$. A post-hoc analysis revealed that the effect of consistency was present in both the 3PP and 1PP levels of the perspective variable; t(47) = 6.20; $p < 0.01$, and 1PP t(47) = 5.43; $p < 0.01$, respectively. The proportion of errors means were: 2.17% and 9.5% for the consistent and inconsistent condition, respectively of the 3PP level of perspective; and they were 1.16% and 6.4% for the consistent and inconsistent condition, respectively, of the 1PP level of perspective.

Cue type was not significant ($p = 0.21$) and there were non-significant interactions between cue type and both the variables perspective ($p = 0.26$) and consistency ($p = 0.06$).

6.2.3. 1PP-interference magnitude analysis

A one-way between-subjects ANOVA revealed a non-significant effect of the cue type variable on the magnitude of RT ($p = 0.42$) and a marginal effect on the magnitude of error rates ($p = 0.06$).

6.2.4. Comparison between the perspective prompts in experiments 2 and 4

To further test the effects of the perspective prompts, we conducted two two-way between subject ANOVAs on RT and on error rates, using the cue type and prompt type as factors. Results were not statistically significant ($ps > 0.05$) indicating that the magnitude of 1PP-interference does not depend on the prompt used in the instructions.

7. General discussion

The aim of this project was to test the theory that 1PP-interference is initiated by perceptual and not social features of the dot-perspective cueing task. More specifically, whether visual perspective attribution or social relevance of the cue modulates the interference effect (e.g. Capozzi et al., 2014; Furlanetto et al., 2016; Nielsen et al., 2015 and Samson et al., 2010) or whether the effect occurs independently of such factors (e.g. Cole et al., 2015; Santiesteban et al., 2014).

Over four experiments, we systematically manipulated different aspects of visual perspective attribution or social relevance. Experiment 1 explored whether 1PP-interference is affected by the visual perspective of the cue. Experiment 2 was designed to test whether 1PP-interference is affected by the social-relevance of the cue. Experiments 3 and 4 examined the role of social perspective-taking, believed to be invoked by the use of social pronouns, in 1PP-interference. The pattern of results strongly supports the theory that 1PP-interference is not dependent on social factors and is more likely linked to lower-level domain general processing (Cole et al., 2015; Santiesteban et al., 2014). Consistency effects were observed in each experiment, in agreement with previous findings. Crucially, the effects were maintained with similar levels of magnitude, independent of social relevance or visual perspective attribution.

In accounting for the 1PP-interference effect that has been observed, one explanation is the "directional hypothesis" posited by Santiesteban et al. (2014). They argue 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" (p. 930). In

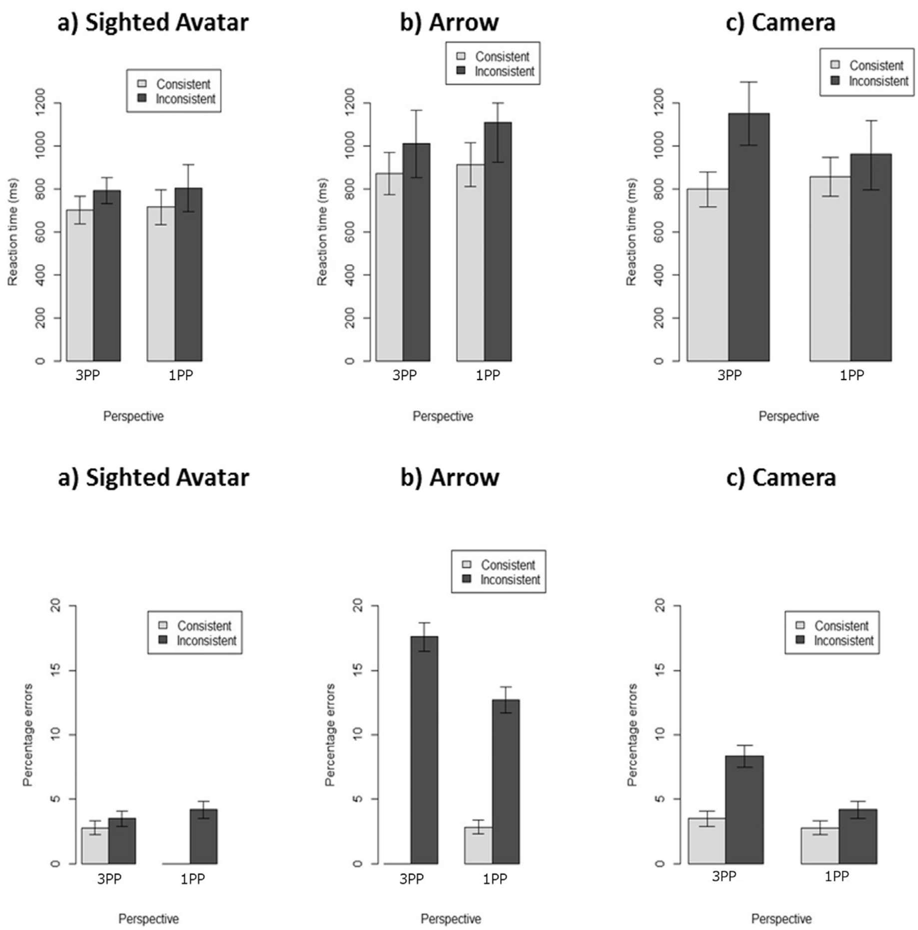

Fig. 8. Experiment 4 reaction times (upper row) and error rates (bottom row) for the: (a) Sighted Avatar (prompted as "Figure") group; (b) Arrow (prompted as "Arrow") group; and (c) Camera (prompted as "Camera") group. Bars indicate standard errors of the mean.

the case of human avatars, facial features act as a directional cue that automatically trigger a shift of attention to the dots on one side of the screen, which makes their processing more efficient. However, in inconsistent trials there is a conflict between the number of dots pointed to by the avatar and the total number on screen. These two pieces of information need to be calculated simultaneously so that the conflict can be resolved before a response is given, leading to slower response times. This theory is supported by analysis of the catch-trials ("no" trials) in the current research, discussed following Experiment 1, which show that the effect of the cue on inconsistent trials was significantly stronger when the cue was directed towards targets – requiring these targets to be included when computing the answer; compared to when the cue faced no targets – less stimuli to compute.

As to role that the salience of the cue's directional features might play in this process, this idea has been suggested previously (Tipples, 2002) and is potentially supported by the trend of results observed in Experiment 2 and a near-significant interaction in Experiment 4, of the current paper, which indicates that arrow cues, which have more salient directional features than the other cues used, seem to elicit stronger interference effects – however further work is needed to confirm these results.

The directional hypothesis provides a parsimonious explanation for some of the apparent inconsistencies between the current research and previous findings that were outlined in the introduction. For example, it seems clear why experiments that compared human avatars to control stimuli lacking clear directional features would find stronger 1PP-interference effects in the avatar condition (Samson et al., 2010). Similarly, where 1PP-interference was weakened or reduced when multiple avatars orientations were gradually diverged, it seems more likely that the decreasing directional clarity of the cue was the cause, rather than a failure to initialize social perspective-taking (Capozzi et al., 2014).

A strength of the current research is the systematic isolation and examination of the social factors that were previously considered to be requirement of 1PP-interference. Although the findings of these experiments indicate that the effects were not socially-driven, that does not mean that there is no relationship between attention and socially-relevant stimuli (e.g. Birmingham & Kingstone, 2009). Rather, it is worth considering that the findings might be linked to the paradigm employed. For example, if social cueing effects, including 1PP-interference, are dependent upon the attribution of visual perspective (Baker et al., 2016), mental state (Furlanetto et al., 2016) or intentional stance (e.g., Wiese et al., 2012; Wykowska, Wiese, Prosser, & Müller, 2014), then perhaps the paradigm employed was simply ineffective at encouraging participants to view the human avatar cue in this manner. Wiese et al. (2012) found that when an avatar was referred to as "a human-like mannequin", cueing facilitation effects were absent but when participants believed the avatar was controlled by a human, the cueing effects were present. This type of manipulation was tested to some extent in Experiments 2 and 4, which found no difference between instances where the cue was referred to "S/HE" or "Figure". However, a more explicit manipulation of the participants' belief in the agency of the avatar might have had a stronger effect than seen in the current research.

On the other hand, the current research is directly comparable to previous work that has employed the same paradigm and stimuli, some of which has reported socially-modulated 1PP-interference effects and some of which has not (Baker et al., 2016; Capozzi et al., 2014; Cole et al., 2015; Furlanetto et al., 2016; Nielsen et al., 2015; Samson et al., 2010 and Santiesteban et al., 2014). In comparing the current research to this body of work, it is reasonable to assume that the previous point does not account for the difference in results. If the avatar stimuli were not capable of triggering social-cueing, due to lack of realism, then the findings of the previous studies should be attributed to perceptual factors. On the other hand, if the avatar is capable of triggering social-cueing, then the results of the current research suggest that it does not modulate interference. In either case, there is sufficient evidence to re-evaluate the theory that 1PP-interference effects, observed in the dot-perspective paradigm, are socially-modulated.

The current paper extends previous work on 1PP-interfernce by systematically testing the theory that this effect is driven by the directional, rather than social or agentive, features of the cue that modulate the effect. The results suggest that 1PP-interference, as assessed with the dot-perspective task is not indicative of a “specialised role for perspective calculation within the social domain” (Nielsen et al., 2015, p 16). After isolating each of the social factors that were said to contribute to 1PP-interference, the results showed that the effect was still present and appeared to be dependent on the visual salience of directional features the cue (Cole et al., 2015; Santiesteban et al., 2014). We therefore conclude that directional information of the cue detected directly by perceptual mechanisms (Massironi, 2002) is sufficient to orient attention and generate interference effects. The domain-general nature of spatial cueing should remain as the most parsimonious theory given the available evidence.

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