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I've got your number: Spontaneous perspective-taking in an interactive task

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ABSTRACT

Thinking about how other people represent objects in the world around them is thought to require deliberate effort. In recent years, interactive "joint action" paradigms have shown how social context can affect our cognitive processing. We tested whether people would represent their partner's point of view in a simple team game. Participants played a game in which they had to judge the magnitude of a number either sat alone, or opposite a partner. Importantly they were never asked to judge their partner's point of view. Remarkably, when playing the game as a team, people were better when their partner happened to share their view of the number, such as when seeing a number 8, than when their partner viewed the number to be different, such as when seeing a number 6 that looked like a number 9 to their partner. In two further experiments, we identified the conditions under which the effect was present. Experiment two showed that the effect was only present after observing the prior involvement of one's partner in the task. Experiment 3, showed that the aspect of the stimulus (its magnitude) that participants were sensitive to did not need to be the aspect of the stimulus to which their partner was paying attention.

1. Introduction

Human beings have evolved to live in complex social worlds and we rely on our ability to cooperate to achieve common goals (Tomasello, 2008). We are naturally predisposed towards teaching and learning important information from others (Csibra & Gergely, 2009) and show continued sensitivity to their belief-like states from infancy (Kovacs, Teglas, & Endress, 2010; Onishi & Baillargeon, 2005; Schneider, Bayliss, Becker, & Dux, 2012). These propositions imply a sensitivity to the points of view of other people, which under some circumstances may be detrimental to focusing on our own perspective. Research on joint action has focussed on how we incorporate another's goals with our own (Sebanz, Knoblich, & Prinz, 2003). Research on perspective-taking has focussed on how we represent the perspectives of others when they are different from our own (Flavell, Everett, Croft, & Flavell, 1981; Keysar, Lin, & Barr, 2003; Samson, Apperly, Braithwaite, Andrews, & Scott, 2010). In this paper, we combine these strands and use an interactive task to test whether we compute other people's perspectives even when there is no explicit goal to do so. The rationale behind this is that if joint task contexts predispose us to be aware of other people's perspectives, it should affect us *regardless* of whether we have an explicit goal to take into account how they see the world.

1.1. Perspective-taking

Even if two people jointly attend to a single object, they may see the object in different ways (Piaget & Inhelder, 1956). Developmental psychologists consider this to be level-2 perspective-taking, as distinct from level-1 perspective taking, which is the ability to know if another person can see a given object or not (Flavell et al., 1981; Masangkay et al., 1974). The distinction between level-1 and level-2 perspective-taking has regularly been proposed to mark a significant landmark in our perspective-taking abilities (Apperly & Butterfill, 2009; Flavell et al., 1981; Surtees, Apperly & Samson, 2016; Surtees, Butterfill, & Apperly, 2012). Children's level-2 perspective-taking develops relatively late, at around the age of 4 (Flavell et al., 1981; Masangkay et al., 1974). Interestingly, level-2 abilities develop at the same age at which children first begin to understand about false beliefs on standard tasks (Wimmer & Perner, 1983) and the difference between appearance

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and reality (Flavell, 1986). Level-2 perspective-taking has yet to be shown in non-human animals (Call & Tomasello, 2008), adding further weight to the notion of it being a cognitively effortful activity, or requiring complex concepts. In two previous studies, we tested whether children and adults automatically take other people's level-2 perspectives (Surtees et al., 2012; Surtees et al., 2016). When presented with stimuli of an avatar in a room, children and adults showed no systematic detrimental effect in self-perspective performance when the avatar saw a numeral to be different to how they, themselves, saw it (for example a 6 which appears as a 9 for the avatar; Surtees et al., 2012). This contrasts with findings from level-1 perspective-taking, which show children and adults to be automatically influenced by how many objects an avatar can see when making judgements about how many objects they, themselves, can see (Samson et al., 2010; Surtees & Apperly, 2012). This suggests that level-2 perspective-taking requires controlled processing, using executive resources (Surtees et al., 2012). However, even if level-2 perspective-taking is not automatic, and requires costly executive resources, people clearly do engage in this form of perspective-taking when necessary. The current study looks at whether situations involving joint goals and joint attention provide sufficient circumstances for adults to adopt someone else's perspective spontaneously.

1.2. Social facilitation

Whilst developmental psychologists identified an inherent difficulty for individuals in explicitly judging the perspectives of other people, social psychologists have for more than a century identified ways in which people adapt their performance in the presence of others without any obvious reason for doing so (Triplett, 1897; Zajonc, 1965). In Triplett's (1897) seminal studies, the mere presence of another person was shown to cause participants to perform better than when they were alone. Such *facilitation* is not limited to humans, with rats (Zentall & Levine, 1972) and chickens (Tolman, 1967) actively pursuing food more persistently when in the presence of others, suggesting that this is not the result of higher order social reasoning. Social presence does not always improve performance; in fact it can directly hinder it. Individual performance has been shown to get worse (Social loafing) when it is evaluated on whether participants complete a joint goal or when they complete a more complex task (Aiello & Douthitt, 2001). The most influential explanation of this pattern of performance has been through Zajonc's (1965) proposal that social presence increases drive or arousal and that this improves performance of dominant actions and reduces performance of non-dominant actions. Alternative proposals have been that social presence facilities through behavioural imitation or mimicry (Cheng & Chartrand, 2003), through social comparison (Cottrell, 1972) or through cognitive appraisal (Baron, 1986). Whilst research on social facilitation has taken place for more than a hundred years, early interest failed to make a distinction between the effect of the presence of an audience and another active participant (Zajonc, 1965). Most relevantly to research on perspective-taking, social facilitation theories have tended to investigate solely the magnitude of performance, rather than whether social facilitation can prompt social understanding between people. As regards to this, recent research on joint action and joint attention has looked more specifically at how the goals and intentions of active partners can influence one another.

1.3. Joint action/perception

When people interact with others towards a common goal, they often perform differently to when they complete a task independently (Richardson, Dale, & Kirkham, 2007; Sebanz et al., 2003; Shteynberg & Galinsky, 2011; Spivey, 2007). Sebanz et al. (2003) demonstrated this in "the Social Simon effect". In a classic Simon task (Simon, 1969), people respond to a visual dimension of a stimulus (its colour) whilst ignoring the spatial dimension of the stimulus (its appearance on the left or right side of the screen). Participants are affected by the spatial dimension of the task when they make a left–right choice response, but not when they respond (go) to one colour and withhold a response (no-go) to the other. In the Social Simon, participants perform the go/no-go version of the Simon task with a partner, each responding to a different colour. In these conditions, the influence of the spatial dimension reappears, suggesting that people represent the goal of the task as a joint goal, rather than merely representing their own part of the task.

The effect of social interaction on cognitive and perceptual processing has also been noted when people engage in conversation. Richardson et al. (2007) and Richardson et al. (2012) have shown that individuals adjust their visual experience to maximise the common ground between them. Long a central component of social theories of language and communication (Clark, 1996; Sperber & Wilson, 1986), the pervasiveness of common ground has been challenged by work suggesting people don't have immediate access to the referents of others (Keysar et al., 2003). However, work examining the looking behaviour of adults has suggested a remarkable convergence between the eye gaze patterns of communication partners (Richardson & Dale, 2005). Groups of participants will look at a relevant individual when a stereotyped trait is mentioned by another communicator, but only if they believe that person can also hear the comment (Crosby, Monin, & Richardson, 2008). Similarly, people coincide in their eye gaze to well-known characters being described by a partner (Richardson & Dale, 2005). Shteynburg et al. have made similar progress in discerning how and when an individual will adapt their aims and goals to that of a similar other. Pairs of participants who believe that they have experienced instructions in common with similar others will learn to adapt their conversational style (Shteynberg & Apfelbaum, 2013) and will adjust their aims to a more cautious miss-reduction strategy or more speculative hit-maximisation strategy when they believe that a similar other has also received that instruction (Shteynberg & Galinsky, 2011). Shteynberg and colleagues' results (Shteynberg & Apfelbaum, 2013; Shteynberg & Galinsky, 2011) suggest that, not only do we look to minimise discrepancies between the experience of ourselves and similar others, but that we will actively adopt a strategy in common with a partner's even if we do not have a common goal. However, evidence that individuals look to increase common ground (Garrod & Pickering, 2009), maximise shared experience and adopt joint strategy and learning opportunities does not address the question of how people deal with situations in which ground, experience or strategy are not in common; that is to say, when partners differ in their perspectives. Thus, this literature also leads to the question of the conditions under which partners are sensitive to each other's perspectives.

Böckler, Knoblich, and Sebanz (2011), Böckler and Sebanz (2012) and Böckler and Zwickel (2012) extended the methods of joint action studies to consider joint perception. Böckler et al. (2011) presented participants with pictures of two hands sequentially. Participants were asked whether the second hand was the same (left or right) hand as the first. Crucially, for half of the trials (the alone condition), the partner closed their eyes. For the other half, they had their eyes open (the joint condition). When the second hand was 120–180° rotated away from the participant's own body orientation, performance was better in the joint than the alone condition. At 0–60° performance was better in the alone condition. This pattern suggested that participants were shifting towards more allocentric than egocentric encoding when another person was present. Joint perception has also been found to modulate neural activity; Böckler and Zwickel (2012) identified significantly increased N170 and N250 effects when participants sat opposite a partner whilst viewing pictures of faces. Modulation of the N170 and N250 is typically associated with the recruitment of extra resources for face processing. This suggests that the mere presence of a partner who sees an inverted face may require extra effort to process stimuli that look the right way up. Taken together, these studies imply that the presence of another person can change how we encode a stimulus. In all cases, participants seemed to encode stimuli less egocentrically: losing the advantage for upright faces (Böckler & Zwickel, 2012) and for hands presented aligned with their own body (Böckler et al., 2011). Importantly, these tasks did not test whether participants were sensitive to the content of their partner's perspective. In all cases, regardless of orientation, partners shared a perspective: both partners saw the same hand or the same face. Therefore, they are informative about how others influence whether we adopt allocentric or egocentric spatial encoding strategies, but do not address the kind of perspective conflict highlighted by Piaget and Inhelder (1956) and others as being indicative of social understanding.

1.4. The current work

Our interest was to investigate whether adults would spontaneously adopt a partner's level-2 perspective when working together in an interactive task setting. To do this, we used simple numerals. If a number 6 is looked at upside down it appears to be a number 9. We were interested in whether participants' own performance at processing the number would be affected by a partner who saw the same stimulus to be the same number or to be a different number. In order to produce a cooperative context participants were cued to make eye contact before every trial (Csibra, 2010 notes that eye contact is a strong cue that an interactive situation is about to take place), and told that they were working as a team.

As level-2 perspective taking has been found to be effortful (Surtees et al., 2012; 2016), we might expect the other person's perspective to have no impact on participants' processing of the stimuli, for the other person's perspective is not relevant to their task at hand. Alternatively, because we require participants to actively engage with another person, one might predict participants to show a performance pattern consistent with being sensitive to the other's point of view. Specifically, in this case, numbers such as 6 and 9, which appear different to their partner in the task, should be more difficult to judge than numbers such as 8 and 5 that look the same to their partner in the task.

2. Experiment 1

2.1. Method

2.1.1. Participants

Thirty-two students at the Université catholique de Louvain, Belgium, participated for a small honorarium. The sample included 21 females and had an average age of 21.7. The majority of participants were white European. One pair of participants was tested, but not included in the final sample because of equipment failure.

2.1.2. Design and procedure

Participants took part in one of two conditions (Alone, Joint). Within each condition, participants were further divided into groups (Red, Blue). In the alone condition, participants sat on one side of a flat-lying monitor facing an empty chair that faced away from them. In the joint condition, two participants faced one another from either side of the screen (see Fig. 1). In both conditions, participants responded only to the relevant coloured numbers for their condition (red or blue), with both participants data used in the final analysis. In all conditions, participants' tasks were the same: they had to judge whether a number presented on the screen was bigger than, or smaller than 7. Participants in the red group responded with a computer mouse placed on their lap and clicked the left mouse button to respond that the number on the screen was smaller than 7 and the right mouse button to respond that the number on the screen was bigger than 7. Participants in the blue group had a keyboard placed on their lap. They clicked the "d" key for smaller than 7 and the "k" key for larger than 7. In both cases participants responded to smaller numbers with a left response and larger numbers with a right response. Most important to note, though, is that in all cases response type was entirely balanced across the alone and joint conditions. Regardless of whether participants found it easier to respond for one method of responding, or to one colour of stimuli, these effects would be balanced across our conditions of interest. Participants' holding the mouse/keyboard on their laps meant that the other participant did not see their responses, so there could be no contamination from observing the spatial responses of the partner.

Participants viewed 16 practice trials, followed by 256 experimental trials, divided into 4 blocks. On each trial, participants first of all saw a fixation cross and heard two beeps. A high frequency beep cued them to look up from the screen. Participants in the joint condition made eye contact with their partner, participants in the alone condition looked at a coloured star placed at eye level. A low frequency beep cued them to look back at the fixation cross. Following this, a number appeared on the screen and participants made their response. Each number (5, 6, 8, 9) was presented equally often, half the time in each colour (Red, Blue). The number 8 and the number 5 (in the chosen fonts) appear to be the same number if viewed from the opposite direction- so were considered *Consistent*. The number 6 and the number 9, however, look like one another if viewed upside down- so were considered *Inconsistent*. Each condition contained one number only 1 place away from the reference number 7 and one number 2 places away, so the discrepancy between stimulus and reference numbers was equal across all conditions. Regardless of when a response was made, the number disappeared after one second. This ensured that participants in all conditions were exposed to the stimuli for an equal length of time.

2.2. Results

Response Times and Accuracy of both participants were analysed.

For the Alone condition, the stimuli were never "Consistent" or "Inconsistent" as such, so these condition labels refer to the consistency of the number if viewed by a person opposite. A main effect of Condition represents the consequences of the presence of a partner. A main effect of Consistency represents a basic difference in the ease of judging the different numbers. Our critical interest was in whether we observed an interaction between Consistency and Condition, which would suggest that the presence of a partner altered the processing of consistent versus inconsistent stimuli.

2.2.1. Response times

Only correct responses were included in the analysis of response times. A 2 (Condition) × 2 (Consistency) ANOVA revealed a main effect of Condition, $F(1, 30) = .34$, $p = .54$, $\eta p^2 = .011$, and no main effect of Consistency $F(1, 30) = 1.83$, $p = .19$, $\eta p^2 = .057$. Crucially, there was an interaction between Consistency and Condition $F(1, 30) = 8.95$, $p = .006$, $\eta p^2 = .23$, see Fig. 2. Follow up *t*-tests

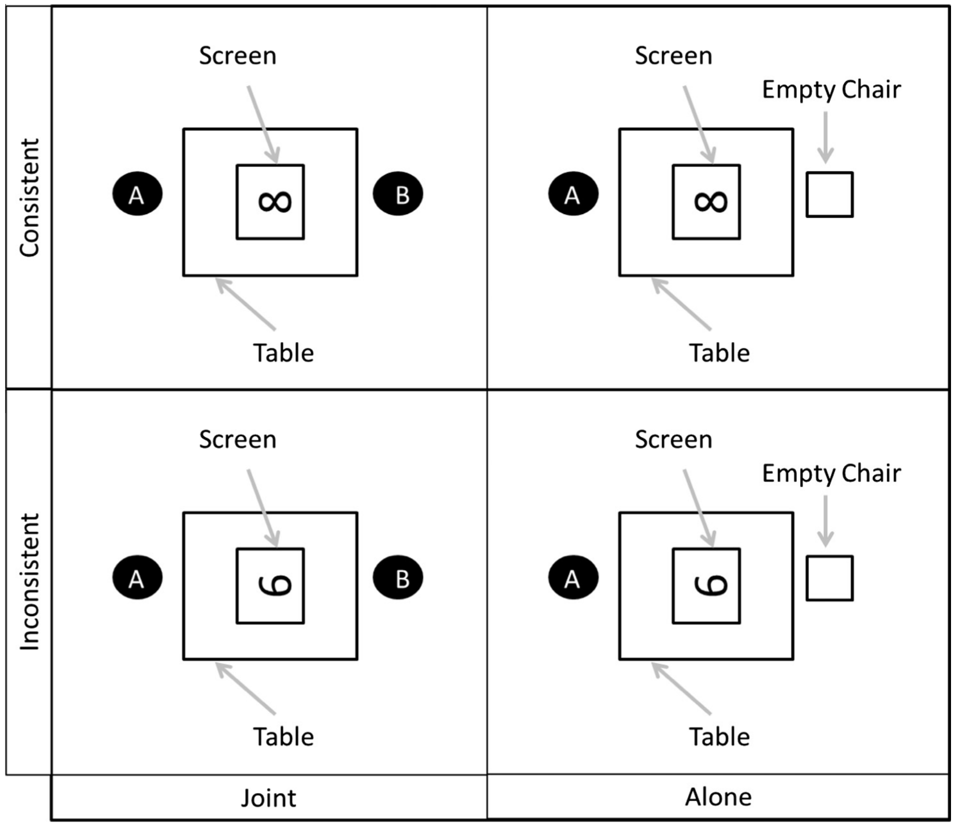

Fig. 1. Representation of the method of Experiment 1. Only in Inconsistent-Joint trials is there a perspective discrepancy: Partner A sees a 9, whilst Partner B sees a 6. For Consistent-Joint, both A and B see an 8. For Consistent-Alone, Partner A sees an 8, whilst in the Inconsistent-Alone, Partner A sees a 9.

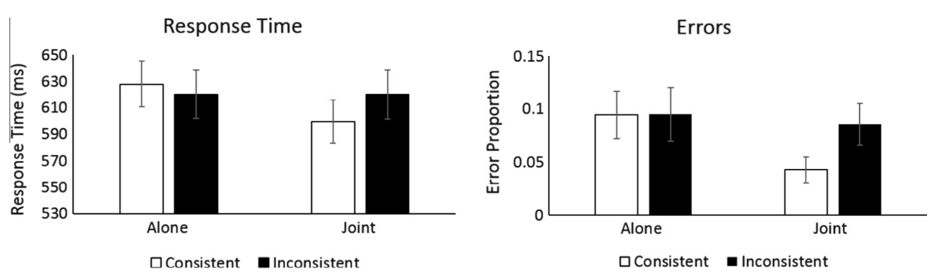

Fig. 2. Results of Experiment 1. Response times and error proportions across the alone and joint condition as a function of perspective consistency. Error bars represent the standard error of the mean.

showed this interaction to reflect a significant effect of Consistency in the Joint Condition, $t(15) = 2.66$, $p = 0.018$[1]; Consistent < Inconsistent, but no significant effect in the Alone condition, $t(15) = 1.42$, $p = .18$.

To review whether the difference was more likely to reflect *facilitation* or *interference* we further analysed the data by comparing mean response time for each of the groups within Consistent and Inconsistent conditions. This revealed no effect in either the Consistent, $t(30) = 1.19$, $p = .24$, or the Inconsistent, $t(30) = .007$, $p = .994$, condition.

2.2.2. Errors

For this analysis, responses where participants did not respond within the time limit were coded as incorrect. A logistic regression was undertaken in line with Jaeger (2008), to model Accuracy, with Condition, Consistency, Participant (nested within Condition) and the interaction between Consistency and Condition being entered as predictors. The model differed significantly from a constant only model, $\chi^2(33, N = 32) = 303.74$, $p < .001$. The Wald Criteria for Consistency, $Z = 10.17$, $p = .001$, Consistent < Inconsistent, Condition, $Z = 4.82$, $p = .028$, Consistent < Inconsistent, and the Consistency by Condition interaction, $Z = 9.55$, $p = .002$, were significant. The interaction was understood by the odds ratio for the effect of Consistency in the Alone condition being 1.01 and in the joint condition being 2.22, meaning that there was little effect of Consistency on Accuracy when completing the task alone, but errors being more than doubled for Inconsistent trials when completing the task with a partner.

Experiment 1 produced an intriguing novel finding. When participating alone, there was no difference in performance between

[1] The data were further analysed to investigate whether the effect was modulated by the pairing in which they participated to consider the alternative hypothesis that effect sizes were increased by a small number of pairs in which both partners showed a large consistency effect. The effect of Consistency remained when the pairing in which each person participated was included in a further analysis, $F(7, 8) = 9.168$, $p = .666$. There was no main effect of Pairing, $F(1, 8) = 2.276$, $p = .136$, $\eta p^2 = .534$ and no interaction between Pairing and Consistency, $F(7, 8) = 1.629$, $p = .254$, $\eta p^2 = .588$.

numbers that looked the same if inverted and numbers that looked different. When working opposite a partner, however, performance was worse for those numbers that looked different from a partner's point of view. We propose that participants were spontaneously sensitive to their partner's perspective and that this made judging the value of the number easier when this was consistent and more difficult when it was inconsistent. This novel finding is consistent with a range of work showing the influence of other people on how we process information (Böckler & Sebanz, 2012; Böckler & Zwickel, 2012; Böckler et al., 2011; Richardson et al., 2012). Further analysis could not determine whether this effect was better described as poor performance on inconsistent trials resulting from interference (Samson et al., 2010) or better performance on consistent trials resulting from facilitation (Shteynberg, 2010).

Experiment 1 leaves open questions about the conditions under which this perspective-taking takes place. Participants never responded to the same trial since each only responded to the stimuli of a specific pre-assigned colour. Thus perspective-taking occurred even though the stimulus was not relevant to the other partner. However, both participants participated within the same block of trials and were thus both actively engaged in the task. The first question this raises is whether it is enough just to have another person present whose view differs from our own? Or, does the other person have to be actively involved in the task? Experiment 2 addresses this first issue by having participants perform the task sequentially across blocks of trials, rather than simultaneously within blocks of trials. Secondly, in Experiment 1, both partners share the same task goal, namely judging the number magnitude. However, does the other person need to share the same goal as us? Experiment 3 addresses this second issue by having pairs of participants with different goals, because their task was to judge different aspects of the stimuli.

3. Experiment 2

One interpretation of the findings of Experiment 1 is that participants "got their partner's number" simply because there was someone sat opposite them who saw the stimulus the same or differently from how they did. Tversky and Hard (2009) found that even in simple picture stimuli, people's responses about spatial locations were changed by the irrelevant presence of another person. By this view, the mere presence of another, even if that person is not actively involved in the task, should be enough to promote spontaneous perspective-taking. In Experiment 2 we examined this hypothesis by having pairs of participants complete the same task as in Experiment 1, but in distinct halves, where one's partner was present, but did not act on the stimuli during the entire half of the task. By the *mere presence* hypothesis, we should replicate the consistency effect of Experiment 1 in both partners of the task. In contrast, if the partner needs to be actively and concurrently involved in the task (*simultaneous involvement* hypothesis), then we should not find the consistency effect in any of the partners. We also considered an intermediate hypothesis according to which the prior experience of the other person's involvement in the task rather than the partner's actual concurrent involvement in the task may suffice. On this account, spontaneous perspective-taking could be triggered by the mere observation of another person performing the joint task. As long as the other has not yet performed the task, there would be no perspective-taking. By this *observation* account, we should only find a consistency effect in the partner who performs the task second as this is the only partner who observed the other performing the task before.

3.1. Method

We tested pairs of participants who completed the same basic task as in Experiment 1 sequentially, with one participant responding in the first half of the experiment and another in the second. We also tested participants individually so as to have a statistical comparison for any joint action effects.

3.1.1. Participants

48 students at the Université catholique de Louvain, Belgium, participated for a small honorarium, none of whom had participated in Experiment 1. The sample included 35 females and had an average age of 20.81. The majority of participants were white European.

3.1.2. Design and procedure

The basic procedure here was identical to that in Experiment 1. Sixteen participants took part alone, whilst 32 formed pairs. In this case the pair were further divided such that one member of each pair was allocated to the Joint-First condition and one to the Joint-Second condition. As in Experiment 1, participants were further divided, equally, on whether they would make judgements about red or blue numbers. In the Alone condition participants saw 8 practice trials followed by 128 experimental trials. Unlike in Experiment 1, they only saw numbers of the appropriate colour, so responded to every number they saw, so as to match the demands in the joint condition. In every other way, this condition matched the alone condition of Experiment 1. The paired participants were instructed that they were working as a team, but would take turns being the player and the observer. The first player (in the Joint-First condition) completed 8 practice trials followed by 128 experimental trials. These trials showed only one colour, but in all other ways matched the joint condition of Experiment 1 (beeping, eye contact, etc.). Following this, the second player (in the Joint-Second condition) completed 8 practice trials followed by 128 experimental trials of the other colour. Note that as in Experiment 1, the examined trials were identical for all conditions. Our design meant an equal number of participants responded to each colour and with each response map in each of the three conditions and responded to an equal number of consistent and inconsistent numbers.

3.2. Results

We completed separate analyses of Response Times and Errors. For the Alone condition, the stimuli were never "Consistent" or "Inconsistent" as such, so these condition labels refer to the consistency of the number if it had been viewed by a person opposite.

3.2.1. Response times

Only correct responses were included in the analysis of response times. A 3 (Condition) × 2 (Consistency) ANOVA revealed a main effect of Consistency, $F(1, 45) = 5.91$, $p = .019$, $\eta p^2 = .12$, but no main effect of Condition $F(2, 45) = 1.33$, $p = .27$, $\eta p^2 = .056$. Crucially, there was an interaction between Consistency and Condition $F(2, 45) = 4.48$, $p = .017$, $\eta p^2 = .17$, see Fig. 3. Follow up t-tests showed this interaction to reflect a significant effect of Consistency in the Joint-Second Condition, $t(15) = 4.07$, $p = .001$; Consistent < Inconsistent, but neither in the Alone condition $t(15) = .099$, $p = .929$, nor in the Joint-First condition, $t(15) = .44$, $p = .67$.

Further analysis to examine whether the effects were more likely the result of facilitation or interference evidenced no difference between conditions in either Consistent, $F(2, 45) = .72$, $p = .49$, or Inconsistent $F(2, 45) = 2.23$, $p = .120$, conditions.

3.2.2. Errors

As for Experiment 1, responses where participants did not respond within the time limit were coded as incorrect. Accuracy rates were generally high (ranged between 95% and 97%). A logistic regression was undertaken, to model Accuracy, with Condition,

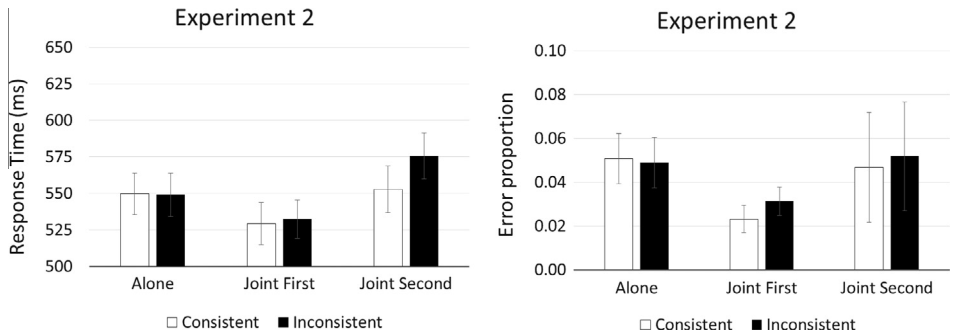

Fig. 3. Results of Experiment 2. Response times and error proportions across the alone and joint conditions as a function of perspective consistency. Error bars represent the standard error of the mean.

Consistency, Participant (nested within Condition) and the interaction between Consistency and Condition being entered as predictors. The model differed significantly from a constant only model, $\chi^2(50, N = 48) = 338.68$, $p = .001$. The Wald Criterion was not significant for Condition, $Z < .001$, $p = 1.00$, Consistency, $Z = .92$, $p = .34$, nor the interaction between the two, $Z = 1.06$, $p = .59$.

In Experiment 2, we advanced our knowledge of the scope of spontaneous perspective-taking. Completing the task in separate halves, rather than simultaneously, changed the effect in that the first member of the team to undertake the task was no longer sensitive to their partner's perspective, instead performing as if they were alone. However, when the second member of the team participated, the effect of consistency was restored. This pattern suggests that the mere presence of another person is not enough to evoke spontaneous processing of the partner's perspective. It also shows that the simultaneous involvement of the partner is not necessary to trigger spontaneous perspective-taking as long as the partner has played an active role before. These results suggest that *observation* of a partner in a joint task can be enough to activate a joint-task context.

4. Experiment 3

Experiment 3 examined whether partners need to share the same task goal for spontaneous perspective-taking to occur. Thus, in the critical condition, pairs of participants completed different tasks with the same stimuli. One partner judged number magnitude (as in the previous experiments) and the other judged a surface feature (spotted or plain) of the numbers presented. Note that, although the number identity was sometimes different depending on which partner looked at it (i.e., this was the case for the inconsistent numbers 6 and 9), the surface feature of the numbers (spotted or plain) was *always* the same from both points of view. This means that the consistency factor used throughout this series of experiments was directly relevant to the judgement made in the magnitude task, but not the features task.

4.1. Predictions for magnitude judgments

If the team member judging magnitude (Partner A) shows no consistency effect (meaning that she finds it as easy to judge 8 and 5 relative to 7, as 6 and 9 relative to 7), then this means that there is no evidence of spontaneous perspective-taking, and indicates that spontaneous perspective-taking necessitates that both partners share the same goal (e.g. evaluating number magnitude, like in Experiments 1 and 2). On the other hand, if the consistency effect persists, then this means that spontaneous perspective-taking occurs even for stimulus aspects that are not part of the other person's task goal.

4.2. Predictions for judging surface features

Perspective consistency (for Partner B) was also defined in terms of the magnitude of the number seen, irrespective of the fact that Partner B judged the surface features of the stimuli, not number magnitude. Someone showing this consistency effect would, for example, demonstrate better performance at judging the spottiness of a number 8 than a number 6. In this case an effect of consistency of perspective regarding number magnitude would therefore, show that participants compute others' perspectives on aspects of a stimulus that are irrelevant to their own task goal. The absence of an effect of consistency of perspective regarding number magnitude would be more difficult to interpret. One interpretation would be that we only take other people's perspectives spontaneously on aspects that are relevant to our own task. Another is that we always take other people's perspective in joint tasks, but our responses are only affected if they relate to the aspect that may produce conflict.

4.3. Method

Participants either participated alone, or opposite a partner. The key difference from Experiments 1 and 2 was that here participants in the joint condition completed different tasks. Partner A judged the magnitude of the number, whilst Partner B judged a superficial feature of the stimulus (whether it was spotted or plain, see Fig. 4). Partners were aware that they would each be paying attention to a different stimulus feature.

4.3.1. Participants

48 students at the Université catholique de Louvain, Belgium, participated for a small honorarium. The sample included 28 females and had an average age of 22.5. None of the participants had taken part in Experiment 1 or 2. The majority of participants were white European. Two pairs of participants were tested but not included in the final sample as one of the pair performed below chance.

4.3.2. Stimuli

Half of the stimuli used were identical to those used in Experiments 1 and 2, red and blue numbers {5, 6, 8, 9}. The other half of the stimuli were created by adding a number of small white circles to each of the numbers (see Fig. 4). This led to a final total of 16 picture stimuli.

4.3.3. Design and procedure

One third of participants completed the task alone, completing the same basic task as in Experiment 1. This meant seeing 256 stimuli, 128 of which required a response. The other two thirds took part in pairs. One member of each pair (Partner A) was put

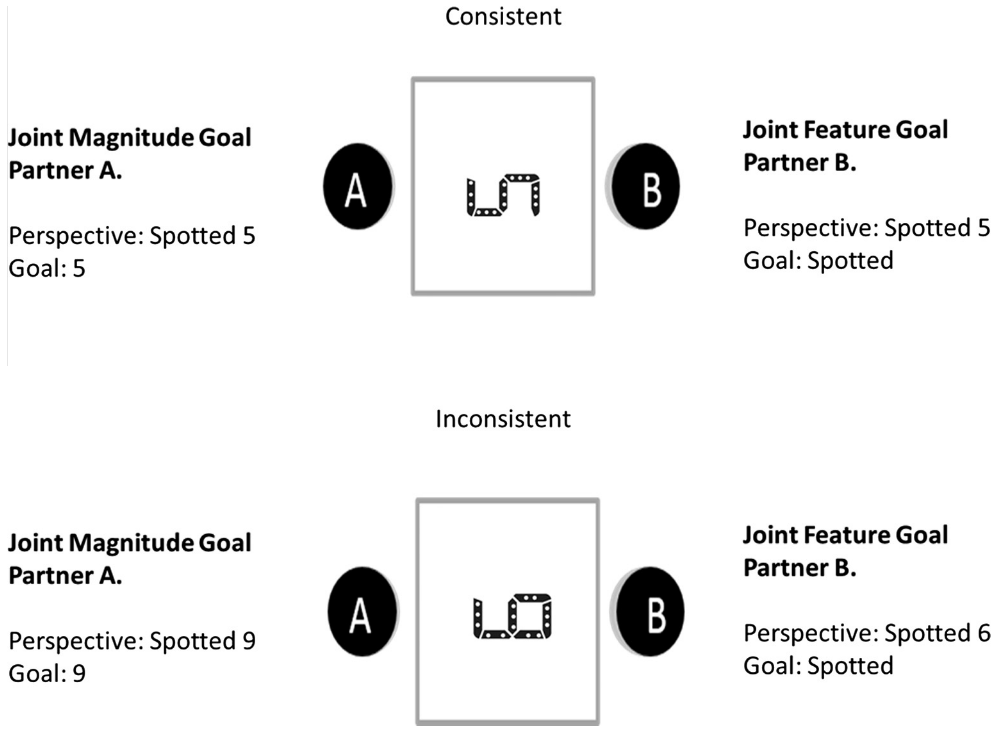

Fig. 4. Method for Experiment 3. "Consistency" relates only to the number magnitude since the pattern feature is always consistent across perspectives. Partner A (in the Joint-Magnitude condition) has to judge whether the stimulus is smaller or larger than 7; Partner B's perspective on the magnitude of the number may be consistent with or inconsistent with that of Partner A. Partner B (in the Joint-Feature condition) has to judge whether the stimulus is spotted or plain; Partner B's perspective on the number magnitude may be different from that of Partner A, but both partners have an equivalent view on the surface features of the number.

in the Joint-Feature condition and the other (Partner B) in the Joint-Magnitude condition. A pair of participants saw 256 trials. As in Experiment 1, each participant was given a colour of number to respond to (red or blue). Participants in the Joint-Magnitude condition completed the task in the same way as Experiment 1, responding if the number was bigger or smaller than 7. Participants in the Joint-Feature condition completed a new task requiring them to respond as to whether the number was spotty or plain (see Fig. 4). This meant that, for example, Partner A might be judging whether the red numbers were bigger or smaller than 7 and working with Partner B who was judging if the blue numbers were spotty or plain. As in the previous experiments, colour of number and response method were controlled across conditions.

4.4. Results

As in Experiments 1 and 2, the crucial test was the interaction between Consistency and Condition in the analysis of Response Times and Errors.

4.4.1. Response times

Only correct responses were included in the analysis of response times. A 3 (Condition) $\times$ 2 (Consistency) ANOVA revealed a main effect of Consistency, $F(1, 45) = 6.33$, $p = .015$, $\eta p^2 = .12$, but no main effect of Condition $F(2, 45) = .097$, $p = .91$, $\eta p^2 = .004$. Crucially, there was an interaction between Consistency and Condition $F(2, 45) = 3.33$, $p = .045$, $\eta p^2 = .13$, see Fig. 5. Follow up t-tests showed this interaction to reflect a significant effect of Consistency in the Joint-Magnitude Condition, $t(15) = 2.84$, $p = .012$; Consistent < Inconsistent, but neither in the Alone condition $t(15) = .56$, $p = .58$, nor in the Joint-Feature condition, $t(15) = .38$, $p = .71$.

As with Experiments 1 and 2, further analysis to examine whether the effects were more likely the result of facilitation or interference evidenced no difference between conditions in either Consistent, $F(2, 45) = .18$, $p = .84$, or Inconsistent $F(2, 45) = .28$, $p = .76$, conditions.

4.4.2. Errors

For this analysis, responses where participants did not respond within the time limit were coded as incorrect. Accuracy rates were generally high (Ranged between 90% and 96%). A logistic regression was undertaken to model Accuracy, with Condition, Consistency, Participant (nested within condition) and the interaction between Condition and Consistency being entered as predictors. The model differed significantly from a constant only model, $\chi^2(50, N = 48) = 395.42$, $p < .001$. The Wald Criterion for Consistency, $Z = 4.31$, $p = .038$, Consistent < Inconsistent was significant, but for Condition was not, $Z = 3.35$, $p =.187$. The interaction effect was significant, $Z = 9.01$, $p = .011$. The interaction was understood by the odds ratio for the effect of Consistency in the Joint Numerical condition implicating that errors were 72% more likely on Inconsistent trials, OR = 1.72; in the Alone condition, errors were 39% more likely on Inconsistent trials, OR = 1.39; in the Joint Features condition errors were 17% less likely on Inconsistent trials.

Ours results suggest that spontaneous perspective-taking *does* occur for stimulus aspects relevant to our own goal, even when our partner's goal is not the same as ours. For example, when we see a spotted number 9, it is harder to judge that the number is bigger than 7 when our partner sees the number to be a 6 rather than a 9, despite the fact that magnitude is irrelevant to their task. As highlighted earlier, the absence of an effect of consistency of perspective (regarding number magnitude) on the partner in the joint

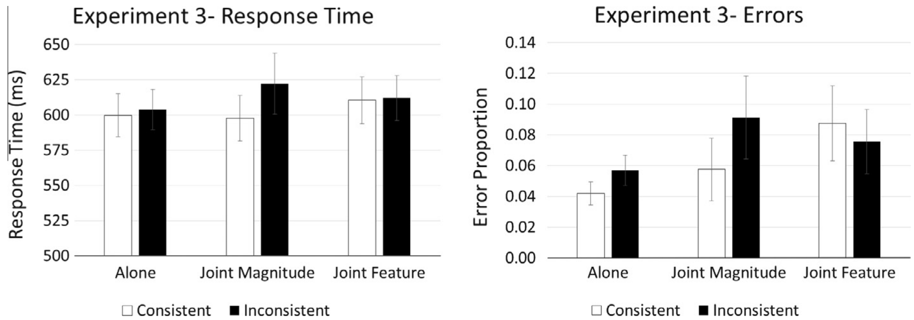

Fig. 5. Results of Experiment 3. Response times and error proportions across the alone and joint conditions as a function of perspective consistency. Error bars represent the standard error of the mean. "Consistency" refers to whether partners had the same perspective on the magnitude of the number. The superficial features of the number, directly relevant to the Joint Feature condition, were *always* consistent to both participants.

features condition (Partner B) is less straightforward to interpret and we will return to this issue in the General Discussion.

5. General discussion

We tested the degree to which adults were spontaneously sensitive to the perspective of how an object looked to another person in an interactive task. When participants completed the task on their own, they were equally efficient at judging the magnitude of the numbers 8 and 5, as judging the magnitude of the numbers 9 and 6. When they performed the same task in a pair, however, their responses were faster on trials in which their perspective was consistent with that of their partner than on trials in which their perspective was inconsistent with that of their partner. We suggest that the reason for this was that they were spontaneously sensitive to how the numbers looked to their partner. In Experiment 2, we showed that this was not the result of the mere presence of another person, for participants did not spontaneously take the perspective of a partner who had yet to take part in the task. Here, the *prior observation* of the active role of the partner was required for participants to take the other's perspective. Experiment 3 showed that the partners did not need to do exactly the same task. Perspective-taking occurred even when a partner did an irrelevant task.

Previous studies have shown that someone's performance on a task can be affected by the presence of another person, even though the task does not require considering their point of view (Böckler et al., 2011; Sebanz et al., 2003; Tversky & Hard, 2009). This is strong evidence that we process a scene more globally in the presence of another whose general viewpoint differs from our own (Böckler et al., 2011; Conson, Mazzarella, Donnarumma, & Trojano, 2012; Tversky & Hard, 2009), known as allocentric encoding. What we show in the current study differs in being evidence of altercentric encoding (Samson et al., 2010), i.e. encoding of the discrepant other-perspective. This sensitivity has never been shown before between representations of how something looks (level-2 perspective-taking).

This study presents an example of how testing using *second person perspective situations* (Schilbach et al., 2013) can add to our knowledge of social interaction and perspective-taking. Schilbach et al. characterise second person perspective-taking tasks as those in which participants actively engage with another person, often involving emotions and joint goals or representations. Previous work has shown that a stimulus containing a cartoon avatar is not enough to induce sensitivity to someone else's perspective (Surtees et al., 2012; 2016). Surtees et al. (2016) showed that whilst adults suffered a cost of switching between their own perspective and someone else's, when they completed single blocks of only their own perspective, they could ignore the presence of the avatar. Here, using a real life partner, adults showed measurable costs when perspectives differed. It is important to note that in the current new task participants never had to take their partner's perspective. What this suggests is that although interpreting how another person sees a given object may not be triggered simply by the presence of a social stimulus, it may be triggered by the right motivational circumstances. This sensitivity to the other person's point of view had no relevance to task demands and actively harmed performance when perspectives were in conflict. These findings are an important complement to evidence that level-2 perspective-taking is not automatic by default (Surtees et al., 2012; 2016). They suggest that a team context leads to spontaneous perspective-taking, which will assist with inter-personal co-ordination, but potentially incur a cost to judgements in which such co-ordination is irrelevant. Similarly, the findings raise new questions about the development of perspective-taking (Apperly & Butterfill, 2009; Flavell et al., 1981). Interpreting someone else's level-2 perspective explicitly is relatively demanding, and slow to develop. However, the current findings suggest that once this ability is established it may then become recruited unintentionally, conditional on social cues such as a team context. This suggests that the development of adult-like perspective-taking may be much more protracted than developmental psychologists have typically recognised.

If Experiment 1 shows the discovery of an intriguing new finding, Experiments 2 and 3 go further to elaborate the conditions in which this process occurs. Experiment 2 demonstrates the necessity of our partner already having actively participated in the task. This confirms that it is not the biophysical features of another person that prompts us to take their perspective, but rather the context in which we act. In one sense this seems surprising. In the current case, this perspective-taking holds no purpose and actively hinders performance on inconsistent trials, therefore we should avoid doing so if we can. Under a traditional modular information processing framework (Fodor, 2001), the fact that we do not would suggest that this process is triggered outside of cognitive control. Having such processes occur is thought to provide overall efficiency, through the constraints under which it operates; specific inputs being associated with specific outputs. This is not the case, here, however, where the moment by moment input is the same, but we only observe the effect when a joint history is apparent. Under a static information processing model this is not what we should expect. One explanation for this could be through understanding interactions as dynamic systems. Dale, Fusaroli, Duran, and Richardson (2013, p 78) suggest that "Perspective-taking might be seen as part of this synergic process, shifting from allo- to egocentric or vice versa, as the interlocutors enact or develop coordinative routines". The broader suggestion is that as individuals cooperate, they prove to be efficient interactors by jointly constraining their behaviour. By operating thus, the degrees of freedom within the interaction are reduced, in comparison to open-ended models through which process reflects events, regardless of context. These joint constraints may be triggered by observing another person engaging in a common task. A second alternative could be that observing another person complete the task promotes taking their perspective (Furlanetto, Cavallo, Manera, Tversky, & Becchio, 2013). This perspective-taking may carry over from observing them completing the task to completing our own task. One way to distinguish between the two alternatives would be to facilitate joint engagement without observation, perhaps through partners gaining a reward for joint performance or completing an irrelevant task as a team.

Experiment 3 shows that we represent the other's perspective on a stimulus aspect which is relevant to our own task goal but to which the other person is not currently attending and has never done during the course of the experiment. However, what we cannot disentangle yet is whether we only take into account the stimulus aspect relevant to us or whether we take into account some or all the other aspects. First, it is possible that each partner only takes into account the stimulus aspect that is relevant for his own task goal and represents this aspect from both his and his partner's perspective. The motive for perspective-taking would be here more self-directed. Hence, the team member who does the magnitude judgement will care about the number identity from his and that of the partner's perspective even if the partner's goal has nothing to do with magnitude. This would explain why that team member finds it harder to judge the magnitude of numbers like 6 and 9 which are seen differently from the partner's perspective than numbers like 5 and 8. The team member who judges the surface feature of the number will focus on whether the number is spotted or plain and consider that from his perspective and the perspective of his partner, but because there is no difference in how the surface feature appears to one or the other partner in our design, there would be no effect of number magnitude. The second interpretation is that when we take the other person's perspective spontaneously, we do it for all stimulus aspects (irrespective as to which is relevant to whom). That means that if the joint task setting requires separate task goals (one partner judges the number magnitude, the other judges whether the number is spotted or plain), both partners represent the stimulus according to the two task goals. Hence, the team member who judges the magnitude takes into account how the partner sees the numerosity *and* the surface feature. Likewise, the team member who judges the superficial features takes into account how the partner sees the surface feature *and* the numerosity. This could be due to the fact that it is difficult to dissociate the two stimulus aspects or because the partners really care about the two task goals. This interpretation would explain why the team member performing the magnitude judgement is influenced by how the partner sees the number even when numerosity is not part of the partner's task goal. The interpretation is also compatible with the pattern of performance of the team member who performs the surface feature judgement. It may simply mean that representing incompatible aspects on the number stimuli did not affect the decision time on the surface feature task.

Disentangling these two interpretations is an interesting avenue for future research. In the meantime, it can however be concluded that spontaneous perspective-taking occurs even for stimulus aspects that the partner is not attending to.

5.1. Facilitation vs interference

The literature on social facilitation posits a role for the presence of engaged others acting to improve our task performance on some tasks and diminish it on others (Aiello & Douthitt, 2001; Shteynberg, 2010). On the other hand, the literature on "altercentric" effects in perspective-taking has, more commonly, interpreted these effects rather differently (Kovacs et al., 2010; Samson et al., 2010). That is, that they result from interference when perspectives are different. Another underlying mechanism for this could be that poor performance on inconsistent trials could come from a "social psychological refractory period", Liepelt and Prinz (2011), such that a bottleneck in processing occurs when a task is shared across two individuals (similar to what occurs in dual task paradigms).

Our results cannot draw a clear distinction between the two interpretations. In spite of the interaction between conditions and consistency, there were no significant differences found between groups on independent analysis of consistent and inconsistent conditions on any of the experiments. This is likely because the design of the experiments meant that these comparisons were made between subjects and thus had to take into account individual differences in factors such as number processing and motor coordination. Such comparisons would also need to be interpreted in the light of global facilitation effects between joint and alone conditions, regardless of perspective difference, as well as local facilitation effects when perspectives were consistent. We believe that distinguishing whether the effects herein result from facilitation or distraction would merit an exciting future line of research (the same could, in fact, be said for many altercentric effects, Kovacs et al., 2010; Samson et al., 2010). The most obvious way for this using our paradigm would be to include numbers that do not look like another number if inverted, such as the number 4. A facilitation account would predict 4s to elicit the same performance as 6s, that is, slower than 8s. An interference account would predict 4s to elicit the same performance as 8s, that is better than 6s.

6. Conclusion

In sum, we present the first evidence of people being spontaneously sensitive to a *shared or conflicting* perspective of how an object looks to another person. This suggests that when performing a task together people either make sacrifices to the performance of their own task to allow them to understand others better or incur a cost-free benefit when perspectives happen to converge. This occurs under the limiting condition that the partner has previously shown an active role in the task but extends to situations where the partner is not attending to the relevant stimulus aspect.

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