Inclined to see it your way: Do altercentric intrusion effects in visual perspective taking reflect an intrinsically social process?

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Abstract

It has been suggested that some aspects of mental state understanding recruit a rudimentary, but fast and efficient, processing system, demonstrated by the obligatory slowing down of judgements about what the self can see when this is incongruent with what another can see. We tested the social nature of this system by investigating to what extent these altercentric intrusions are elicited under conditions that differed in their social relevance and, further, how these related to self-reported social perspective taking and empathy (Davis, 1983). In Experiment 1, adult participants were asked to make 'self' or 'other' perspective-taking judgements during congruent ('self' and 'other' can see the same items) or incongruent conditions ('self' and 'other' cannot see the same items) in conditions that were social (i.e., involving a social agent), semi-social (an arrow) or non-social (a dual-coloured block). Reaction time indices of altercentric intrusion effects were present across all conditions, but were significantly stronger for the social compared to the less social conditions. Self-reported perspective taking and empathy correlated with altercentric intrusion effects in the social condition only. In Experiment 2, the significant correlations for the social condition were replicated, but this time with gaze duration indices of altercentric intrusion effects. Findings are discussed with regard to the degree to which this rudimentary system is socially specialized and how it is linked to more conceptual understanding.

Key words: Visual perspective taking; automatic; individual differences; altercentric intrusion effects; Theory of Mind.

Introduction

The ability to impute mental states, such as beliefs and perspectives, to oneself and to others is considered essential for social interaction and communication (e.g., Butterfill & Apperly, 2013; Waytz, Gray, Epley, & Wegner, 2010). Recently, Apperly and colleagues (Apperly & Butterfill, 2009; Samson & Apperly, 2010) have suggested that this ability is handled by two distinct processing systems. One system, characterised as cognitively flexible but effortful, is argued to underpin children's conceptual development of beliefs and perspectives, as shown by their ability to pass verbal and explicit false belief and perspective-taking tasks at around four years of age (Callaghan et al., 2005; Wellman, Cross, & Watson, 2001). This system is linked to general reasoning abilities, such as executive functions and language ability (e.g., Carlson & Moses, 2001; Milligan, Astington, & Dack, 2007), and is influenced by social experience (e.g., Hughes et al., 2005; Ruffman, Slade, & Crowe, 2002).

The other, more rudimentary, system is characterised as being fast and efficient but not flexible. This automatic-like system tracks and calculates information relevant to mental state computation but does not achieve full conceptual understanding (Apperly & Butterfill, 2009, p. 956; Samson & Apperly, 2010, p. 450). It is this system, they argue, that underpins young infants' apparent understanding of beliefs and perspectives as shown in non-verbal looking time tasks (e.g., He, Bolz, & Baillargeon, 2011; Onishi & Baillargeon, 2005; Surian, Caldi, & Sperber, 2007; see also Baillargeon, Scott, & He, 2010 for a review). Thus, for Apperly and colleagues, the problem of understanding how it is that children apparently show understanding of beliefs as young as seven months (Kovács, Téglás, & Endress, 2010; but see Phillips et al., in press) using looking time tasks but do not pass explicit verbal tasks until much later, can be explained by the fact that these types of tasks do not tap the same systems of understanding (but see Luo & Baillargeon, 2010 and Scott, He, Baillargeon, & Cummins, 2012, for an alternative view). Some of the characteristics (or "signature limitations") of this rudimentary system have been identified: for example, it operates under conditions of limited task complexity i.e., simple cues and limited numbers of objects (Apperly & Butterfill, 2009; Surtees, Butterfill, & Apperly, 2011; c.f. Trick & Pylyshyn, 1994), and is not dependent on executive function (Qureshi, Apperly, & Samson, 2010; see also Low, 2010). However, it is unclear whether this rudimentary system is specifically dedicated to processing social situations and stimuli. In other words, it has yet to be clarified whether the rudimentary system is intrinsically social in nature or is more domain general. It is this issue that we address here.

Evidence for the utilisation of the rudimentary system has been demonstrated in adults using a simple (Level 1) perspective-taking task (Qureshi et al., 2010; Samson, Apperly, Braithwaite, Andrews, & Bodley-Scott, 2010; see also Low & Watts, 2013). Typically, participants are presented with a picture of a room containing a limited number of red discs on the wall (i.e., no more than three) and a single avatar in the centre (see Figures 1a and 1b). On some trials the avatar can see the same number of red discs as the participant (congruent condition) and on other trials the avatar can see only some or none of the red discs (incongruent condition). Participants are then asked to make judgements about how many discs they themselves can see (self condition) or how many the avatar is able to see (other condition). As expected, participants were slower to judge the number of discs the avatar could see when this conflicted with how many they themselves could see. Interestingly, when asked to take their own perspective, participants were also slower to judge how many discs were in the room when the number visually available to them differed from the number visible to the avatar. This was the case even when participants were not required to make any judgements about what the avatar could see (Samson et al., 2010, Exps 2 and 3), or when participants were required to engage in other cognitively demanding tasks (Qureshi et al., 2010). These results, they argue, indicate an obligatory, automatic-like processing (or calculation) of the other’s perspective which interfered with the processing of self-perspective, referred to as an altercentric intrusion. Taken together, these findings suggest the notion of a fast, efficient system operating free from executive control (unlike the cognitively flexible system) but within the constraints of limited complexity (such as small numbers of objects, simple instructions and task demands) — precisely, they argue, the conditions under which infants' apparent understanding of beliefs and perspectives (e.g., Onishi & Baillargeon, 2005) have been demonstrated.

However, it is still unclear as to whether such a rudimentary system is inherently dedicated to process specifically *social* information or whether it is more domain general in nature. In other words, it has yet to be clarified whether this is a generic system for processing potentially conflicting information without specific reference to the domain (Egner, Etkin, Gale, & Hirsch, 2008; Zaki, Hennigan, Weber, & Ochsner, 2010) or whether it is selective for social information such as that likely to involve a social agent (Kovács et al., 2010; Shelton, Clements-Stephens, Lam, Pak, & Murray, 2011).

Domain-general accounts for belief and perspective understanding are plausible (Perner, 2000). For example, Perner, Brandl, and Garnham (2003) argue that perspective-understanding problems require the higher-order integration of representations in a way that is independent of the social nature of this information (see also Iao, Leekam, Perner, & McConachie, 2011). In support of this, for example, Perner and colleagues show that social understanding of belief (i.e., that the mind can represent one thing in more than one way) co-occurs with the non-social understanding of identity (that one thing can be labelled in more than one way; Perner, Mauer, & Hildenbrand, 2011). It is possible, therefore, that the rudimentary system could similarly process information about potentially conflicting perspectives by drawing on a general system that is not inherently social in nature. In contrast to the domain-general account, other authors (e.g., Baillargeon et al., 2010; Leslie, German, & Polizzi, 2005) argue that understanding of beliefs and perspectives is innately specialized. In support of this, Kovács et al. (2010, Exp 3) have shown that it was the presence of a social agent (a cartoon figure) rather than a comparable non-social object that modulated reaction times to false-belief scenarios and, as such, are part of the evidence for a "social sense" (Kovács et al., 2010 p. 1831, see also Surtees, Noordzij, & Apperly, 2012). The rudimentary system may be similarly specialized towards information relevant to social agents.

We took two approaches to address this issue. Our first approach was to manipulate, across three conditions, the degree of social relevance of stimuli in a similar perspective-taking task to the one used by Apperly and colleagues (Qureshi et al., 2010; Samson et al., 2010). Two previous studies (Samson et al., 2010 Exp 3; Surtees & Apperly, 2012) have employed non-social stimuli to control for possible non-social (e.g., task switching) task demands. This is the first systematic investigation of the influence of differing degrees of social relevance. To do this we manipulated the presence or otherwise of a social agent (Böckler, Knoblich, & Sebanz, 2012; Kovács et al., 2010; Shelton et al., 2011). Participants were presented with either a social cue (avatar; Samson et al., 2010), a semi-social cue (arrow, which possesses both symbolic and social characteristics; Kingstone, Tipper, Ristic, & Ngan, 2004; Ristic, Friesen, & Kingstone, 2002; see also Zwickel, 2009), or a non-social cue (a dual-coloured block). Additionally, given the known effect of pronoun use (particularly the use of “you”) on inducing or modulating social perspective taking (Brunyé, Ditman, Mahoney, Augustyn, & Taylor, 2009), we modified the instructions for selecting perspective across conditions by employing personal pronouns in the social cue condition but replacing them in the other two conditions. Thus, whilst we kept the basic selection requirements constant across conditions, the social content of the cue stimuli and instructions was varied. If this automatic-like processing system is indeed social in nature we would expect to see altercentric[i] intrusion effects for the social, and to a lesser degree the semi-social, task, but no intrusion effects for the non-social task. Alternatively, if this system is not socially specialized but rather is utilising a domain-general system, then we would expect to see equivalent altercentric intrusions across all tasks independently of the degree of social relevance. It should be noted, however, that a ‘domain-general system’ explanation is not the only plausible account of such equivalent altercentric intrusion effects. It is possible that there may be more than one underlying mechanism for cueing effects elicited by biologically relevant (e.g. avatar) and biologically irrelevant (e.g., arrow, dual-coloured block) cues (see Frischen, Bayliss, & Tipper, 2007).

Our second approach involved going beyond manipulating the social nature of the stimuli to consider individual differences. Although individual differences have been shown in the cognitively flexible system in adults (e.g., Brunyé et al., 2012; Shelton et al., 2011) and children (Deák, Ray, & Brenneman, 2003; Farrant, Devine, Maybery, & Fletcher, 2012), they have not, to the best of our knowledge, been investigated with respect to the rudimentary, automatic-like system. We were specifically interested in how self-reported perspective taking and empathy, as measured by the Interpersonal Reactivity Index (IRI; Davis, 1980, 1983), would positively relate to altercentric intrusions. Since little is known about whether or how the rudimentary system relates to the more explicit, cognitively flexible system, either during the on-line processing of a task or through development (but see Low, 2010 and Thoermer, Sodian, Vuori, Perst, & Kristen, 2012), any finding of a positive association between individual differences in this system and self-reported perspective taking would be of interest. However, with respect to our specific question as to the domain-general or domain-specific nature of the rudimentary system, should we find a positive association, we would expect this pattern across all conditions if this system is domain general but only for the social agent (avatar) condition if the system is socially specialized. As described thus far, altercentric intrusion effects were assessed primarily using reaction times, but here a looking time measure of altercentric intrusions was also employed in order to explore further the correlational results, obtained using the RT indices.

In sum, we aimed to investigate whether the rudimentary, automatic-like system proposed by Apperly and colleagues (Apperly & Butterfill, 2009; Samson & Apperly, 2010; Surtees et al., 2011) is domain general (geared to process conflicting or incongruent cues irrespective of their social nature) or domain specific (socially specialized) in nature. We approached this question in two ways. First, we examined whether altercentric intrusions are produced only by socially relevant stimuli (i.e., by the presence of a social agent) or occur also with physically comparable, non-social stimuli. Second, we explored whether self-reported empathy and understanding of others' perspectives were associated with altercentric intrusions when elicited by social stimuli only, or whether they were also related to intrusions elicited by non-social stimuli.

Experiment 1

Method

Participants:

Data for the social task (avatar) were obtained from 33 participants (16 females) with a mean age of 21.8 (*SD* = 6.5) ranging from 18 to 48 years of age. Data for the semi-social task (arrow) were obtained from 32 participants (16 females) with a mean age of 29.9 (*SD* = 5.4) ranging from 23 to 44 years of age. Data for the non-social task (dual-coloured block) were obtained from 44 participants (35 females) with a mean age of 20.9 (*SD* = 1.7) ranging from 18 to 25 years of age. Of the original data set (N = 135), 13% of participants were excluded due to accuracy below 50% of trials for at least one condition as were 6% who had overall mean RTs above 2.5 SD of the overall mean RT. A one-way ANOVA was carried out on the age differences and a significant difference was found ($F(2,106) = 38.03$, $p < .001$) between groups. Paired contrasts (Bonferroni-corrected) found participants from the semi- social task to be significantly older than participants from both the social ($p < .001$) and the non-social ($p < .001$) tasks. Participants were rewarded with either course credits or monetary compensation.

Materials

Apparatus and experimental set-up. Stimuli were presented on a Dell computer running a Windows operating system and stimulus presentation was controlled with E-prime software (Psychology Software Tools, Inc.). The stimuli were adapted from Vogeley et al. (2004) and Samson et al. (2010).

Reaction times (RTs) were recorded from key presses: ‘m’ for a ‘True’ and ‘x’ for a ‘False’ response to the preceding statement. These response options were clearly marked on the keyboard.

Perspective-taking and digit prompts. The perspective-taking prompt indicating the perspective (i.e., YOU/HE for the social task; ROOM/ARROW for the semi-social task; ROOM/GREEN [or BLACK] for the non-social task) was followed by a digit (0-3) stating the number of red discs the perspective-taking unit might be able to see and/or was oriented towards. The red disc configurations were matched between first- and third- person perspective trials and were identical across the three tasks (social, semi-social, non-social). All prompts were presented in solid black on a dark grey background and positioned in the centre of the screen.

Target stimuli. Target stimuli were presented in a depiction of a three-dimensional room including a back wall, and two side walls with a varying number of red discs (0-3). For the social task the target perspective-taking unit was an avatar (created using Poser 7; e frontier, Tokyo, Japan). For the semi-social task the perspective-taking unit was an arrow and for the non-social task the perspective-taking unit consisted of a dual-coloured (green and black) block. All perspective-taking units were depicted at centre or slightly off centre (50% of trials oriented to the left and 50% oriented to the right).

Inter-stimulus fixations. Interspersed between prompts and targets were black fixation crosses, displayed centrally on a dark grey background.

Interpersonal Reactivity Index (IRI; Davis, 1983). We were particularly interested in two subscales, Perspective Taking and Empathic Concern, from this non-clinical, self-report measure. We used these two measures to investigate individual differences and their potential relation to RT measures of altercentric intrusions. These subscales were each calculated from seven items using a 5-point Likert scale varying from ‘does not describe me well’ to ‘describes me very well’. Perspective Taking (α = .69) items included statements such as ‘I try to look at everybody’s side of a disagreement before I make a decision', and Empathic Concern (α = .75) included statements such as 'I often have tender, concerned feelings for people less fortunate than me'.

Procedure

Participants were introduced to the stimuli and given both oral and written instructions. Judgements were to be made according to first- ("self") and third- ("other") person perspectives as follows. Participants in the social task were asked to make perspective judgements about the number of red discs they themselves could see or how many red discs the avatar was oriented towards (prompts: YOU/HE). For the semi-social task the participants made judgements about the number of red discs in the room from their own perspective or how many the arrow was oriented towards (prompts: ROOM/ARROW). Finally, for the non-social task participants were asked to make judgements about how many red discs were in the room from their own perspective or how many red discs a pre-specified side of the dual-coloured block was orientated towards (half of participants were asked to make judgements about the green side only and half were asked to make judgements about the black side only) (prompts: ROOM/GREEN or ROOM/BLACK). Following 10 practice trials, the experiment proper commenced. Half of experimental trials consisted of the first person perspective ("self": YOU/ROOM) and the other half of trials consisted of third person perspectives ("other": HE/ARROW/GREEN). Half of trials were congruent (first person and third person share visual scene; see Figure 1a) and half of trials were incongruent (first person and third person do not share visual scene; see Figure 1b). The experiment consisted of two experimental blocks, each containing 48 experimental trials (12 "self" congruent; 12 "self" incongruent; 12 "other" congruent; 12 "other" incongruent) and 12 filler trials (the digit prompt did not correspond to either perspective) pseudo-randomly sequenced within each experimental block. The total number of experimental trials was therefore 96 (24 trials for each condition), plus 24 filler trials.

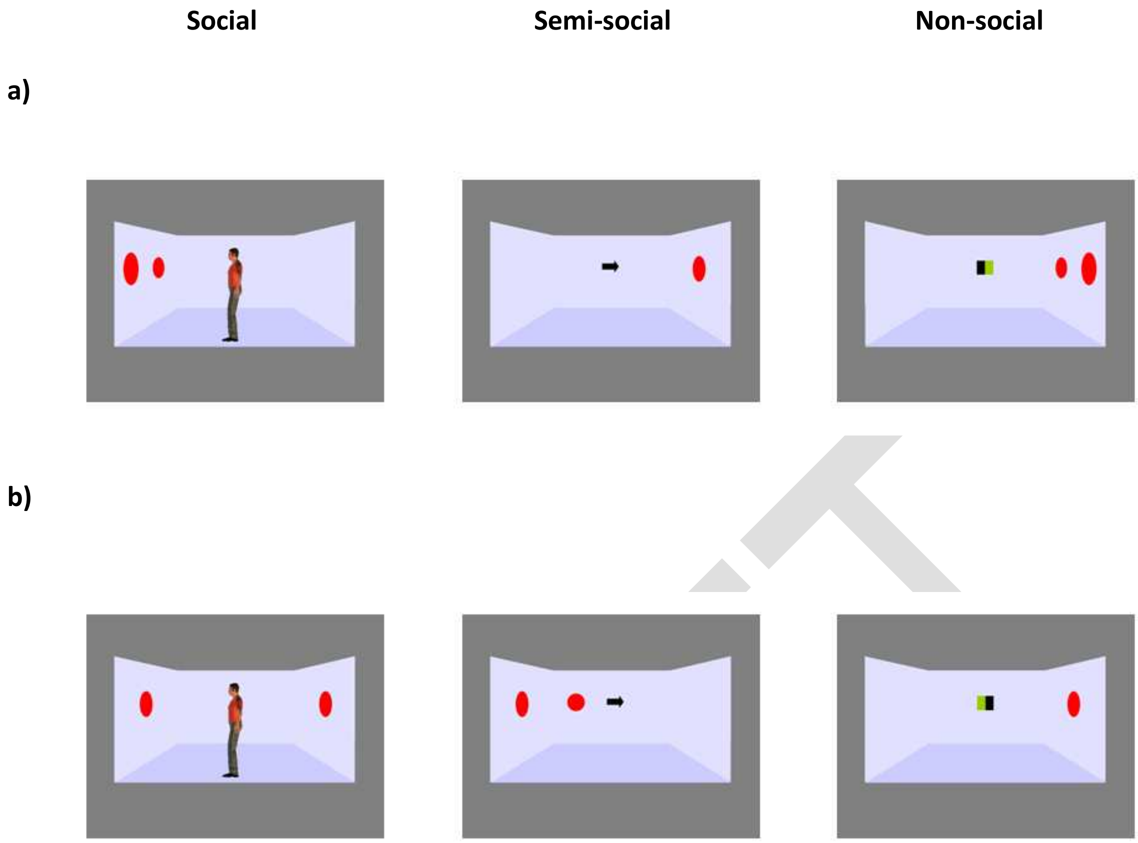

Figure 1. a) Examples of congruent trials: "self" and "other" share visual information b) Examples of incongruent trials: "self" and "other" do not share visual information

Each trial started with a fixation cross displayed for 1000ms. This was followed by the perspective-taking prompt, which was shown for 750ms. The prompt indicated which perspective the participant was required to take for that particular trial, i.e., first or third perspective ("self" or "other"). A fixation cross was then displayed for 1000ms and followed by the digit prompt for 750ms. The digit prompt indicated the number of red discs that the participant would be able to see, or the perspective-taking unit would be oriented towards, (i.e., 0-3), during the following target stimulus presentation. This prompt was followed by a fixation cross for 1000ms. The target stimulus was then displayed until a response was detected. Participants were required to respond either True or False depending on the preceding 'statement' (e.g., 'HE' '2' [he can see 2 red discs]) as fast and as accurately as possible. See Figure 2 for a schematic representation of the presentation sequence for a single trial. Once a response was detected a new trial was initiated. Following the two experimental blocks participants were asked to complete the IRI (Davis, 1983).

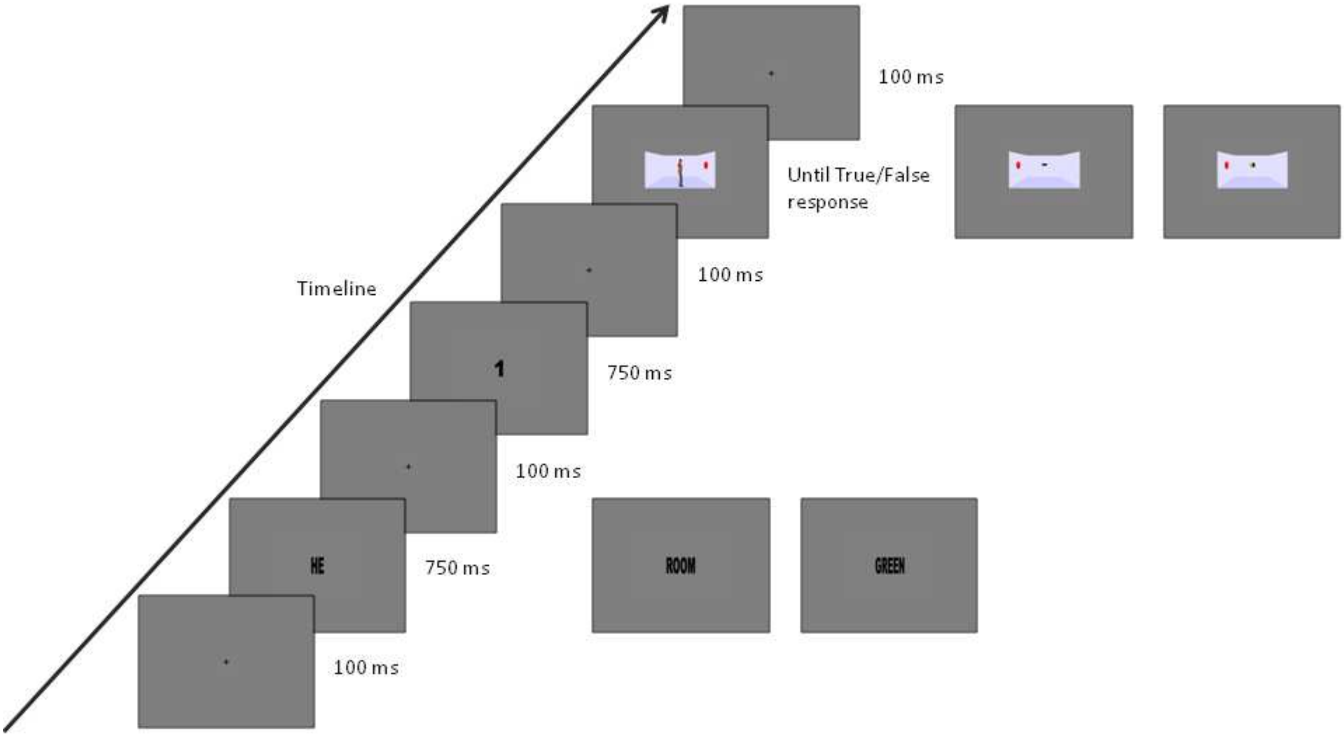

Figure 2. Level 1 perspective taking task presentation timeline for a single trial

Results

Analyses of RTs were performed on experimental trials only (not filler trials)[ii]. Experimental trials with incorrect responses (8.5% of data) were discarded. In order to reduce the influence of outliers, RTs that were less than 250ms or ±2.5 standard deviations (SDs) from the overall mean for each participant were excluded (2.5% of data). RT indices of altercentric and egocentric intrusions were calculated by subtracting congruent trial mean RTs from incongruent trial mean RTs for first-person (self) and third-person ("other") perspectives respectively (see Tables 1 and 3 for mean RTs). Thus, the larger the difference score, the more interference was caused by the irrelevant perspective, i.e., the more pronounced the intrusion. An ANOVA was carried out on these RT indices of intrusion effects with a between-subjects factor of task (social vs. semi-social vs. non-social) and a within-subjects factor of intrusion type (altercentric vs. egocentric). The ANOVA revealed a significant main effect of intrusion type, $F(1,106) = 16.20$, $p < .001$, $\eta_p^2 = .13$ and a significant main effect of task, $F(2,106) = 6.99$, $p = .001$, $\eta_p^2 = .92$. Although there was no higher order interaction between Task and Intrusion type, $F(2,106) = 2.25$, $p = .110$, $\eta_p^2 = .04$, planned partial one-way ANOVAs were conducted separately on altercentric and egocentric intrusion effects in order to allow for a direct examination of our specific hypotheses relating to the altercentric intrusions. Error indices of altercentric intrusion effects were also calculated by subtracting 'congruent' trial mean error responses from 'incongruent' trial mean error responses for first person (self) and third-person (other) perspectives, respectively (see Tables 1 and 3 for mean errors). A task (social vs. semi-social vs. non-social) by intrusion type (altercentric vs. egocentric) ANOVA on these error indices revealed a significant main effect of intrusion type, $F(1,106) = 10.88$, $p = .001$, $\eta_p^2 = .91$, a main effect of task, $F(2,106) = 4.28$, $p = .016$, $\eta_p^2 = .74$, and a significant interaction between Intrusion type and Task, $F(2,106) = 11.43$, $p < .001$, $\eta_p^2 = .99$.

Altercentric intrusion effects

One-sample t-tests confirmed the presence of altercentric RT intrusions across the three task conditions as all indices differed significantly from zero (all *p*s < .001). (See Table 1 for reaction time data).

Table 1: Mean reaction times (RT) in ms and mean errors for "self" trials for social, semi-social, and non-social conditions (standard deviation in parentheses).

"Self" trials		**Social**	**Semi-social**	**Non-social**	**Total**
		N = 33	***N = 32***	***N = 44***	***N = 109***
Congruent	RT	844.7 (218.2)	974.5 (321.3)	784.7 (252.7)	858.6 (274.6)
	Errors	1.0 (.9)	.5 (.7)	1.3 (1.5)	1.0 (1.2)
Incongruent	RT	1006.7 (275.8)	1090.5 (361.3)	843.3 (249.7)	965.3 (309.9)
	Errors	3.9 (1.7)	1.7 (1.7)	2.0 (1.7)	2.5 (1.9)
Intrusion effects	RT	162.0 (109.5)	116.1 (119.5)	58.6 (96.1)	106.8 (115.0)
	Errors	2.9 (1.9)	1.2 (1.8)	.7 (1.6)	1.5 (2.0)
Total	RT	925.7 (242.5)	1032.5 (336.6)	814 (246.6)	912.0 (287.1)
	Errors	2.5 (1.0)	1.1 (1.0)	1.6 (1.4)	1.7 (1.3)

We performed a one-way analysis of variance (ANOVA) with a between-subjects factor of task (social vs. semi-social vs. non-social) on altercentric RT intrusion indices (see also Thomas & Zumbo, 2011). The ANOVA revealed a significant main effect, $F(2,106) = 8.91$, $p < .001$, $\eta_p^2 = .14$[iii]. Planned contrasts (Helmert) revealed significantly greater altercentric intrusion for the social task (*M* = 162.0 ms, *SD* = 109.5) when compared against the semi-social (*M* = 116.1 ms, *SD* = 119.5) and non-social (*M* = 58.6ms, *SD* = 96.1) tasks, $t(106) = 3.32$, $p = .001$, as well as significantly greater altercentric intrusion during the semi-social compared to the non-social task, $t(106) = 2.30$, $p = .023$ (see Figure 3). The altercentric intrusion RT indices portray a linear-like relationship between the degree of social relevance and the magnitude of altercentric intrusions; the more social the task the greater the altercentric intrusion. A polynomial analysis found this linear relationship between the three tasks to be significant, $F(1,106) = 17.49$, $p < .001$.

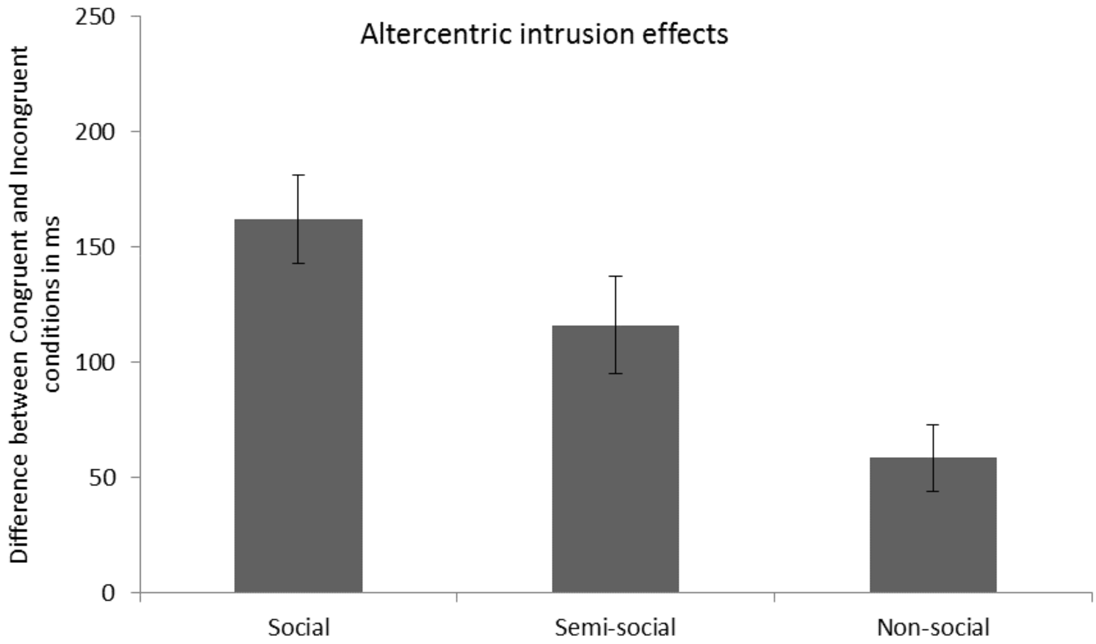

Figure 3. Altercentric intrusion RT indices in ms (standard error of the mean)

To investigate their potential positive associations with altercentric intrusions, the Perspective Taking and Empathic Concern subscales of the Davis IRI (Davis, 1983; see Table 2) were correlated with altercentric intrusion indices using Pearson's Correlation, one-tailed. Some participants did not complete the IRI (one in the social, one in the semi-social and five in the non-social task condition), resulting in a slightly reduced sample size for these analyses. Significant positive correlations were found for the social task between altercentric intrusion and Perspective Taking, $r = .32$, $p = .035$, and altercentric intrusion and Empathic Concern, $r = .34$, $p = .029$ (see also Figure 4a and 4b)[iv]. There were no significant correlations between altercentric intrusion effects and self-reported Perspective Taking or Empathic Concern for either the Semi-social or Non-social conditions (all *r*s < -.17, *p*s > .05; see Table 2).

Table 2: Descriptive statistics of the Perspective Taking and Empathic Concern subscales of the IRI and correlations with altercentric intrusion effects for the social, semi-social, and non-social conditions.

	Mean (S.D.)			Correlations		
	Social *N = 32*	**Semi-social** *N = 31*[v]	**Non-social** *N= 39*	**Social**	**Semi-social**	**Non-social**
Perspective Taking	2.1 (.7)	2.4 (.5)	2.5 (.6)	.32*	-.01	-.07
Empathic Concern	2.3 (.8)	2.2 (.5)	2.9 (.6)	.34*	-.04	-.17

* p < .05, all p values one-tailed

a) **b)**

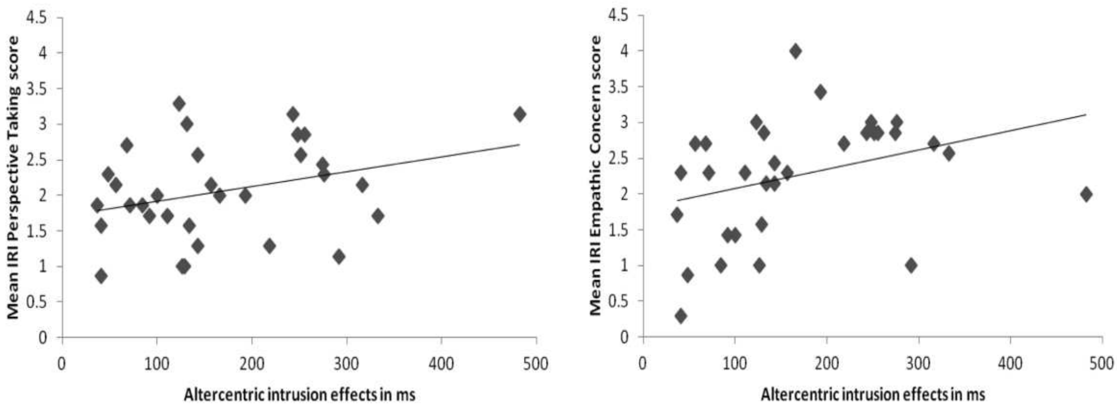

Figure 4. a) Scatteplot for the correlation between Perspective Taking (IRI) and altercentric intrusion effects (reaction time in milliseconds) for the Social task in Experiment 1. R^2 Linear = .105. b) Scatterplot for the correlation between Empathic Concern (IRI) and altercentric intrusion effects (reaction time in milliseconds) for the Social task in Experiment 1. R^2 Linear = .114.

One-sample t-tests also confirmed the presence of altercentric error intrusion effects across the three task conditions as all error indices differed significantly from zero (all *p*s < .01) (see Table 1 for error data).

A one-way ANOVA with a between-subjects factor of task (social vs. semi-social vs. non-social) on altercentric error intrusion indices revealed a significant main effect, $F(2,106) = 15.65$, $p < .001$, $\eta_p^2 = .23$. Bonferroni-corrected comparisons showed a significant difference between the social task ($M = 2.9$, $SD = 1.9$) and both the semi-social ($M = 1.2$, $SD = 1.8$) and the non-social ($M = .7$, $SD = 1.6$) tasks ($p < .001$). There was no significant difference between the semi-social and the non-social tasks ($p = .72$) (see also Figure 5). These results suggest that there was no speed-accuracy trade-off.

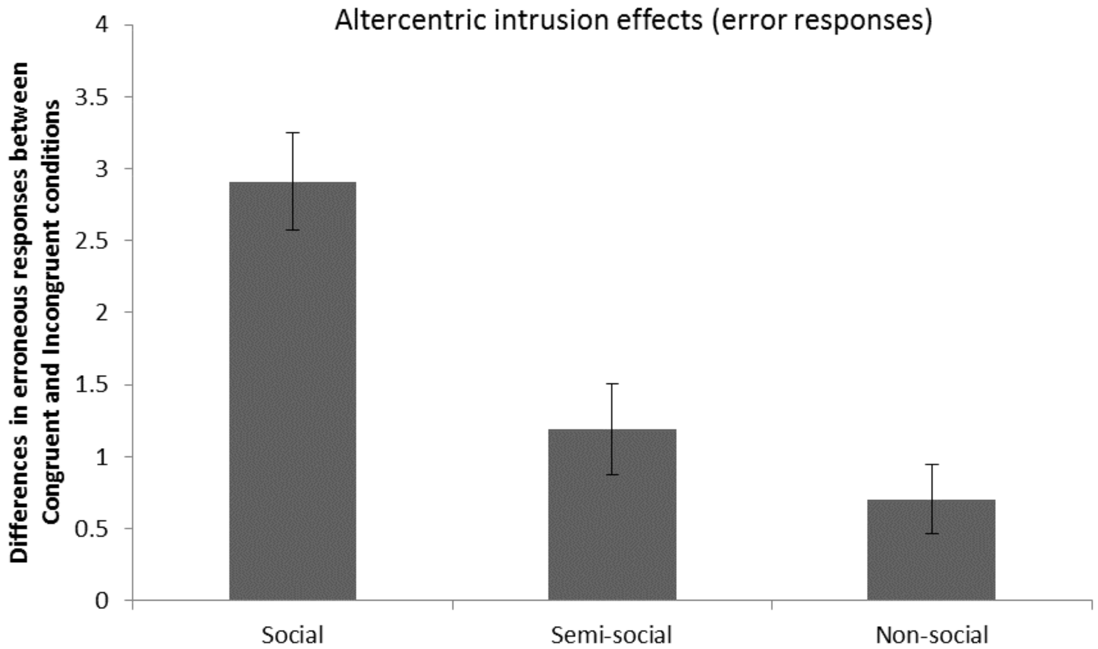

Figure 5. Altercentric intrusion error response indices in the form of mean difference scores (standard error of the mean)

Egocentric intrusion effects

Indices of egocentric RT intrusions for the three tasks (social, semi-social, non-social) are displayed in Figure 6. One-sample t-tests confirmed the presence of egocentric intrusions across the three task conditions as all indices differed significantly from zero (all *p*s < .001). (See Table 3 for reaction time data).

Table 3 : Mean reaction times (RT) in ms and mean errors for "other" trials for social, semi-social, and non-social conditions (standard deviation in parentheses).

"Self" trials		**Social**	**Semi-social**	**Non-social**	**Total**
		N = 33	***N = 32***	***N = 44***	***N = 109***
Congruent	RT	897.6 (271.9)	1023.7 (320.2)	828.5 (220.6)	906.7 (278.0)
	Errors	1.1 (1.4)	1.3 (2.6)	1.0 (1.2)	1.1 (1.8)
Incongruent	RT	1076.7 (271.1)	1213.2 (411.6)	979.1 (274.7)	1077.4 (331.4)
	Errors	3.5 (2.0)	3.1 (2.6)	4.1 (2.4)	3.6 (2.3)
Intrusion effects	RT	179.1 (124.2)	189.5 (132.6)	150.6 (98.0)	170.7 (117.2)
	Errors	2.4 (2.3)	1.9 (2.8)	3.1 (2.1)	2.5 (2.4)
Total	RT	987.2 (264.3)	1118.4 (362.8)	903.8 (244.3)	992.0 (300.2)
	Errors	2.3 (1.3)	2.2 (2.1)	2.5 (1.6)	2.4 (1.7)

We performed an ANOVA with a between-subjects factor of task (social vs. semi-social vs. non-social) on the egocentric RT intrusion indices. The ANOVA revealed no significant difference between the three levels of social relevance, $F(2,106) = 1.15$, $p = .322$, $\eta_p^2 = .02$ (social task: *M* = 179.1, *SD* = 124.2; semi-social task: *M* = 189.5, *SD* = 132.6; non-social task: *M* = 150.7, *SD* = 98.0). There were no significant correlations between egocentric intrusion effects and self-reported Perspective Taking or Empathic Concern (all *r*s < .25, *p*s > .05).

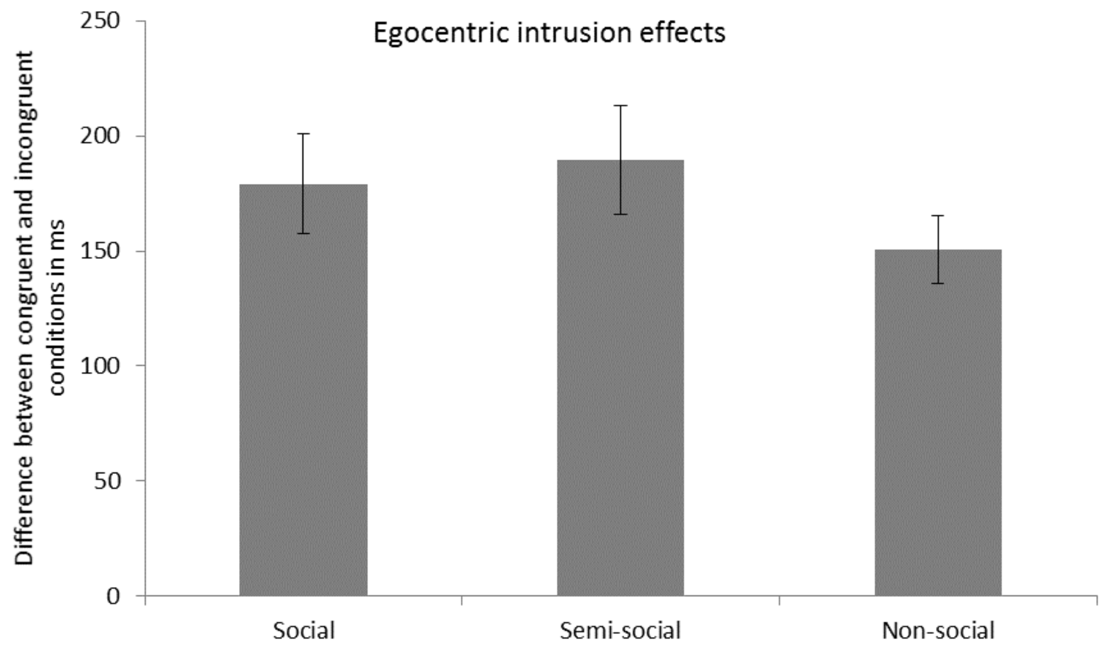

Figure 6: Egocentric intrusion RT indices in the form of mean difference scores in ms (standard error of the mean)

One-sample t-tests also confirmed the presence of egocentric error intrusions across the three task conditions as all error indices differed significantly from zero (all *p*s ≤ .001) (see Table 3 for error data).

A one-way ANOVA with a between-subjects factor of task (social vs. semi-social vs. non-social) on egocentric intrusion indices revealed no significant main effect, $F(2,106) = 2.74$, $p = .07$, $\eta_p^2 = .05$. (social task: *M* = 2.4, *SD* = 2.3; semi-social task: *M* = 1.9, *SD* = 2.8; non-social task: *M* = 3.1, *SD* = 2.1). See also Figure 7.

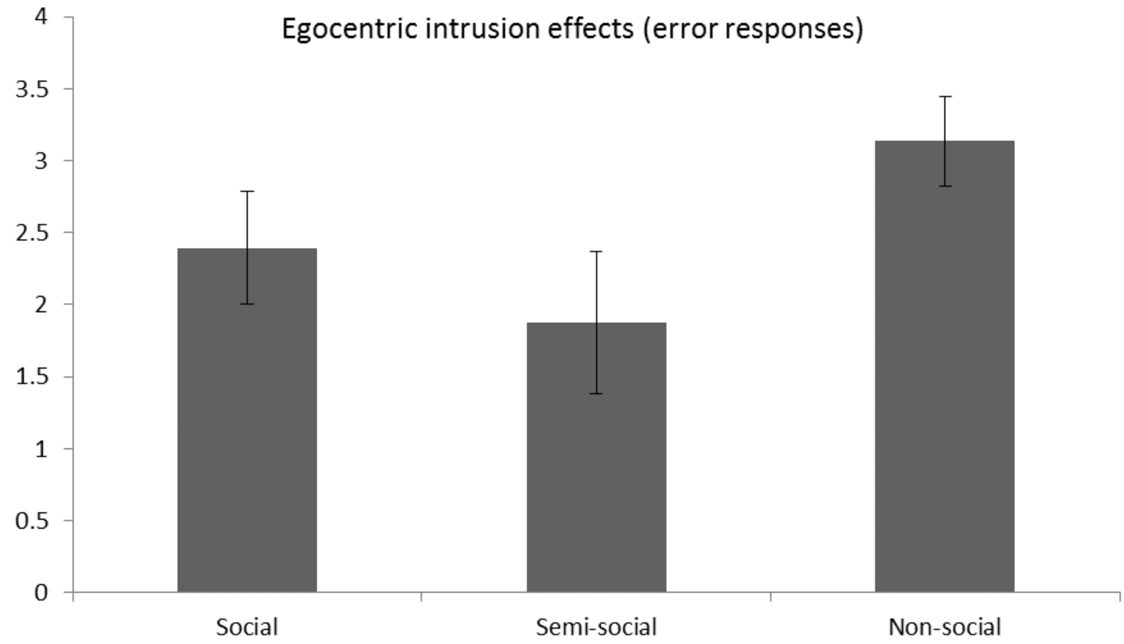

Figure 7: Egocentric intrusion error response indices in the form of mean difference scores (standard error of the mean)

Experiment 2

Given the novel finding of an association between the rudimentary and cognitively flexible systems for perspective taking, as indicated by the significant positive correlations between altercentric intrusions and self-report measures of Perspective Taking and Empathic Concern for the social task, we sought to replicate this finding using measures of gaze duration. These latter measures are increasingly used to investigate social cognitive processing, particularly in view of their close association with attentional processes (Guillon, Hadjikhani, Baduel, & Rogé, 2014; Rubio-Fernáandez, 2013; Schneider, Bayliss, Becker, & Dux, 2012). It is predicted that the slowing of processing of self-perspective due to interference caused by the automatic processing of another's perspective should be reflected in longer gaze duration on the social agent (avatar) and surrounding discs for inconsistent relative to consistent trials. In line with the previous experiment, this altercentric intrusion effect is anticipated to relate positively to self-reported perspective taking and empathy.

Method

Participants

Data were obtained from 28 participants (14 female) with a mean age of 23.6 (*SD* = 6.6) ranging from 18 to 46 years of age. Of the original data set (*N* = 39) six participants were excluded due to poor calibration. A further five were excluded due to low accuracy scores (below 50% for one or more conditions).

Materials

Apparatus and experimental set-up. As with the RT studies stimuli were presented on a Dell computer running a Windows operating system. Stimulus presentation was controlled with Tobii Studio 2.3 (Tobii Technology) and verbal answers were recorded to measure accuracy. All other aspects of the stimuli were the same as those used for the Social task. Total duration of looking within the area of interest was recorded using a Tobii X120 eye-tracker. The area of interest incorporated three equivalent elliptical regions focusing on: a) the avatar; b) the area between the avatar and the discs in front (avatar's viewing perspective); c) the area between the avatar and the discs behind (see Figure 8). The IRI was also employed using the two subscales of Perspective Taking (α = .71) and Empathic Concern (α = .83).

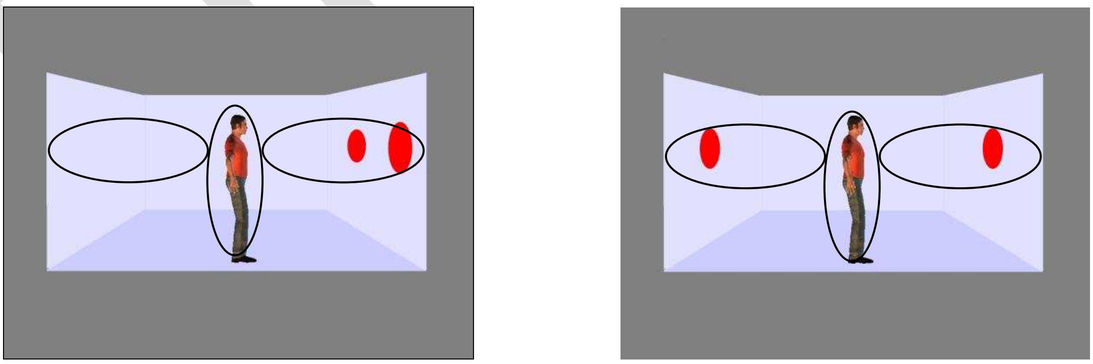

Figure 8: Gaze duration was collapsed across three areas of interest. See here an example for a) congruent trial ("self" and "other" share visual information) and incongruent trial ("self" and "other" do not share visual information).

Procedure

Each trial started with a fixation cross displayed for 1000ms, which was followed by the perspective-taking prompt, shown for 1000ms. A fixation cross was then displayed for 2000ms and followed by the digit prompt for 1000ms. This prompt was followed by a fixation cross for 2000ms and the target stimulus was then displayed until a response was detected. Instructions were given in accordance with the Social RT study (Experiment 1) with the exception that responses were verbal. The experiment consisted of 64 experimental trials (16 “self” congruent, 16 “self” incongruent, 16 “other” congruent, 16 “other” incongruent) and 16 filler trials. All other aspects of the procedure were identical to those for Experiment 1.

Results

Analyses of gaze duration, collapsed across the three areas of interest, were based on correct experimental trials (2.8% incorrect trials discarded). Error rates across the four conditions were as follows: self-congruent *M* = .07, *SD* = .26; self-incongruent *M* = .93, *SD* = 1.3; other-congruent *M* = .26, *SD* = .71; other-incongruent *M* = .5; *SD* = .75. Gaze duration indices of altercentric intrusions were calculated by subtracting congruent trial mean gaze durations (*M* = 793.3ms, *SD* = 374.4) from incongruent trial mean gaze durations (*M* = 1351.4ms, *SD* = 557.5) for first-person (self) perspectives. Gaze duration indices of egocentric intrusions were calculated by subtracting congruent trial mean gaze durations (*M* = 1002.4ms, *SD* = 348.0) from incongruent trial mean gaze durations (*M* = 1312.9, *SD* = 514.9) for third-person (other) perspectives. Thus, the larger the difference score, the more interference was caused by the irrelevant perspective, i.e., the more pronounced the intrusion. One participant’s difference score was an outlier for the altercentric measure which affected both skewness and kurtosis (z scores > 3). To normalize the data we therefore Winsorized the score for this participant. Notably, altercentric intrusion effects (*M* = 522.2ms, *SD* = 326.1) were significantly greater than egocentric intrusion effects (*M* = 310.5ms, *SD* =

404.0), *t*(27) = 2.39, *p* = .024. Gaze duration indices of altercentric (*M* = 522.2ms, *SD* = 326.1) and egocentric intrusions (*M* = 310.5ms, *SD* = 404.0) were correlated with the two IRI subscales PT (*M* = 2.5, *SD* = .6) and EC (*M* = 2.6, *SD* = .7). Positive correlations were observed between altercentric intrusions and PT (*r* = .37, *p* = .027) and EC (*r* = .32, *p* = .051), but not between egocentric intrusions and the IRI subscales (*r*s < .20, *p*s > .05), all one-tailed (see also Figure 9a and 9b).

a) **b)**

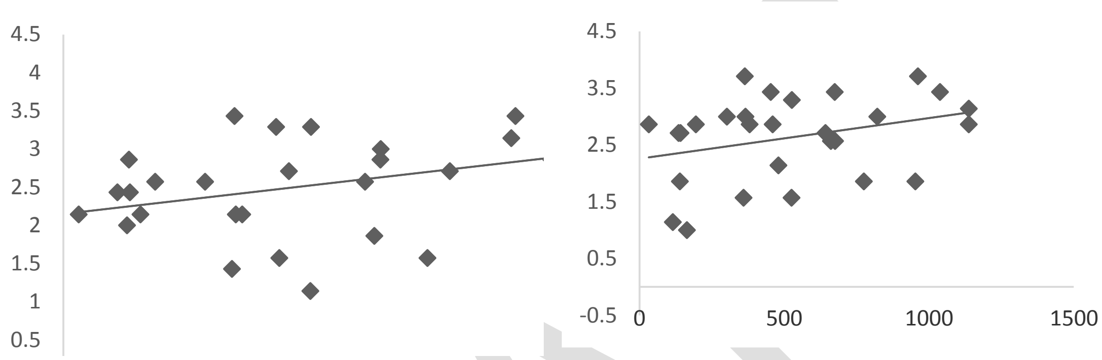

Figure 9. a) Scatteplot for the correlation between Perspective Taking (IRI) and altercentric intrusion effects (gaze duration in milliseconds) for the Social task in Experiment 2. R^2 Linear = .135. b) Scatterplot for the correlation between Empathic Concern (IRI) and altercentric intrusion effects (gaze duration in milliseconds) for the Social task in Experiment 2. R^2 Linear = .992.

Discussion

Recent studies have suggested that some aspects of mental state understanding are processed by a rudimentary, but fast and efficient, system (Apperly & Butterfill, 2009; Samson & Apperly, 2010). Evidence for this system comes from demonstrations of the obligatory slowing down of judgements about what the self can see when this is inconsistent, or incongruent, with what another can see (i.e., altercentric intrusion effects: Qureshi et al., 2010; Samson et al., 2010; Surtees & Apperly, 2012). The current study tested whether this system is intrinsically social in nature by investigating whether altercentric intrusions are elicited under conditions which differ in terms of their social relevance. It further investigated how these intrusion effects would relate to self-reported social perspective taking.

Adult participants were asked to make ‘self’ or ‘other’ perspective-taking judgements during congruent (‘self’ and ‘other’ can see the same number of red discs in a room) or incongruent (‘self’ and ‘other’ cannot see the same number of discs) conditions that were either social (involving a social agent [avatar]), semi-social (involving an arrow) or non-social (involving a dual-coloured block). As expected, there was a slowing of decisions about what the social other (avatar) could see when this conflicted with what the self could see (egocentric intrusion effect). Like Apperly and colleagues (Qureshi et al., 2010; Samson et al., 2010; Surtees & Apperly, 2012), we also found clear evidence of the slowing of judgements about what the self could see when this was inconsistent with what the social other (avatar) could see (altercentric intrusion effect). Our study together with a recent investigation by Santiesteban, Catmur, Hopkins, Bird and Heyes (2014) provide the first replications of altercentric intrusions outside of the research group that originally demonstrated the effect (Apperly and colleagues; see Francis, 2012; Koole & Lakens, 2012, for a discussion of the importance of replication). Crucially, these intrusion effects were not limited to the ‘social’ condition. Both egocentric and altercentric intrusion effects (reflected by both reaction time and accuracy measures) were also shown for the semi-social and non-social levels of social relevance.

A plausible interpretation for the presence of intrusion effects across all social conditions is that the ‘automatic-like’ processing of what another can see draws on a domain-general system for computing conflicting information that operates independently of the social nature of the information. Such a system is thought to be responsible for the congruency effects that have been reported for cognitive tasks, such as the Simon, Stroop and flanker tasks (e.g., Hommel, 2011; Kornblum, Hasbroucq, & Osman, 1990; see Lu & Proctor, 1995, for a review). It has also been discussed in association with the resolution of conflict between competing socio-emotional cues (e.g., Egner et al., 2008; Zaki et al., 2010), and its suggested involvement in the automatic computation of another's perspective would be consistent with domain-general accounts of belief and perspective understanding (e.g., Aichhorn et al., 2009; Perner, Aichhorn, Kronbichler, Staffen, & Ladurner, 2006; Perner & Leekam, 2008). For example, Perner, Aichhorn, Kronbichler, Staffen, and Ladurner (2006) argued for the domain-general processing of visual perspective following evidence that the 'false belief' task, involving how another mind might take a different perspective, and the 'false sign' task, involving how a non-mental entity might indicate a differing perspective, activated equivalent brain areas (e.g., the left temporo-parietal junction).

Despite the presence of significant altercentric intrusions across social conditions, these effects were none the less modulated by degree of social relevance. There was a clear linear relation between degree of social relevance and the degree of altercentric intrusion: the social (avatar) condition elicited the greatest levels overall, followed by the semi-social condition (arrow), which in turn elicited greater levels than the non-social (dual-coloured block) condition. Arguably, the level of altercentric intrusion was determined by the extent to which the task was social in nature; the more social the task, the stronger the altercentric intrusion effect. These findings are compatible with studies showing attenuated altercentric intrusions for conditions in which non-social control stimuli were employed (Samson et al., 2010, Exp. 3; Surtees & Apperly, 2012). They support the notion of a degree of specialisation, or domain-specific processing, operating possibly in conjunction with the domain-general processing of perspectives. Similar conclusions were offered by the fMRI studies noted above (Egner et al., 2008; Perner et al., 2006; Zaki et al., 2010), which argued not only for the role of domain-general processing, but also for specialisation of processing following evidence of the activation of separable, in addition to overlapping, brain regions, during task performance. It should also be noted, however, that the effects that are being attributed in our study to possible domain-general processes could also be explicable in terms of task-switching or other strategies. For example, the need to alternate between 'self' and 'other' perspectives may lead to the treatment of the apparently 'non-social' stimulus as a social agent (c.f. Surtees & Apperly, 2012). This explanation cannot, however, account for the modulation of altercentric intrusion effects following the systematic manipulation of social relevance; the involvement of a socially dedicated system would appear to be the most parsimonious explanation for this.

In contrast to the variation in magnitude of altercentric intrusion effects across social conditions in the current study, the level of egocentric intrusion was statistically equivalent across the conditions of social relevance. This indicates that the potential interfering effects of self-relevant (first-person perspective) information during the deliberate computation of 'other' perspectives may be immune to the influence of social context, which is perhaps in line with the clear dominance of the self-perspective (Epley, Keysar, Van Boven, & Gilovich, 2004; Epley, Morewedge, & Keysar, 2004; see also Light & Nix, 1983) and its potentially over-riding impact on the processing of competing cues. On the other hand, a different pattern of results was recently obtained in a study with 8-year-old children (Surtees & Apperly, 2012). In this latter study, although egocentric intrusion effects were present for the social (avatar) condition, they were largely absent for the control (dual-coloured stick) condition (at least on the basis of RT data). The explanation offered by Surtees and Apperly (2012) was that perspective taking may be easier when participants can easily imagine themselves as occupying the body of the alternative position. We speculate further on why social influences may be present for egocentric intrusions in children but not adults a little later in the discussion. In general, however, it is clear that further research is needed to clarify the difference between adults and children in the extent to which either interference from the self-perspective, or the ease of adopting another's perspective, is modulated by social context.

The second approach taken to investigate the social nature of the rudimentary system was to test the relation between altercentric intrusion effects and self-reported perspective taking. Self-reported perspective taking was measured using two subscales of the IRI (Davis, 1983): Perspective Taking and Empathic Concern. For the social condition, there were significant associations between altercentric intrusions (as reflected by reaction times) and self-reported levels of both empathic concern and perspective taking, but there were no associations between these measures for the semi-social and non-social conditions (Experiment 1). The finding that the self-reported social ability to understand and empathise with other people was specifically associated with the degree of altercentric intrusions during the processing of socially relevant stimuli lends support to the idea that altercentric intrusion effects are specialised to some extent within the social domain. These results were further supported by the finding of significant associations between these self-report measures and altercentric intrusions as reflected by gaze durations (Experiment 2).

As noted earlier, individual differences in the IRI subscales reflect the operation of an explicit, conceptual system (Davis, 1983, 1994; Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004) for perspective taking, whereas altercentric intrusion effects are considered to reflect the operation of a fast and efficient rudimentary (implicit) system. The novel demonstration of a link between these systems within the social domain using two separate measures of intrusion effects (RT and gaze duration) across distinct experiments increases our confidence in the reliability of the correlational results and therefore the relation between the conceptual and rudimentary systems.

The present association between self-reported empathic concern and perspective taking with altercentric intrusions within the social domain lead us to speculate about factors that may underlie the relation between the conceptual system and the rudimentary system. Possibly those possessing a rudimentary system that is more sensitive to the computation of others' perspectives (i.e., as reflected by enhanced altercentric intrusion effects) may, over time, develop greater levels of empathy and enhanced social perspective taking abilities. Similar developmental accounts have been put forward to explain the link between early implicit belief understanding and later explicit understanding (Low, 2010; Thoermer et al., 2012). An alternative explanation is that a top-down modulation of the rudimentary system by system(s) (conceptual or otherwise) that are involved in social understanding and empathy may engender a link between enhanced social perspective taking ability and the greater tendency to automatically take another's visual perspective. It should be noted at this point that the extent to which self-reported perspective taking and empathy can be mapped onto the more explicit, cognitive system is not entirely clear. To examine this issue, further research investigating the links between the rudimentary and the conceptual system should be pursued using visual perspective taking tasks in conjunction with behavioural indices of the explicit system, such as false belief or complex perspective taking tasks (e.g., the Keysar task; Keysar, Lin, & Barr, 2003).

Of note, although stimuli were equated for position of main focal point of the stimuli (i.e. head of avatar, arrow, and dual-coloured block) there were none the less physical differences between the stimuli which might have led to differences in altercentric cueing effects between conditions. However, the fact that there were no significant differences in egocentric intrusion effects between social relevance conditions suggests that the altercentric findings cannot be explained simply in terms of cue saliency or size. Furthermore, the positive correlations found between altercentric intrusion effects and perspective taking and empathic concern cannot be explained easily in terms of individual differences in the strength of general attentional cueing effects elicited by the differing cue stimuli.

As discussed thus far, the results from this study have shown that intrusion effects were significantly more pronounced when the 'other' perspective taking unit was social as compared with less social or non-social, and were correlated with self-reported measures of empathy and perspective taking for the social condition only. We suggest that these data reveal, first, the modulation of a fast and efficient rudimentary system for perspective taking by social relevance, and, second, an association, which is socially moderated, between the rudimentary system and a cognitively flexible conceptual system. Our findings are comparable with those of Kovács et al. (2010), who, unlike the simple perspective task used here and by Apperly and colleagues, used a conceptually more demanding (false) belief task. They found that for this higher-order representational task, infants as well as adults were influenced by social (cartoon figure), but not non-social (stack of boxes), stimuli, when observing belief scenarios. Their findings indicated that, at least for belief situations, adults were not processing the non-social stimuli to the extent of them interfering with their responses. If their findings are correct (see Philips et al, in press, for a recent challenge) then, taken together, the current results and those of Kovács et al. (2010) could be argued to be indicative of a “social sense,” that is, a predisposition for visuo-perceptual and belief computations pertaining to social (or mentalistic) stimuli.

The fact that altercentric intrusion effects were still present in the current study, albeit in attenuated form, when less socially relevant stimuli were employed, has been discussed thus far in terms of the concurrent operation of a domain-general system alongside a socially specific system. However, a position that is equally plausible, and may be considered to be more in line with an account that views social processing as central to perspective taking, is that a socially specialised system is recruited for the processing of more general types of stimuli. This would include processing of perspectives signalled by socially arbitrary / non-social stimuli, although to a lesser degree than those signalled by social stimuli. Such an account may be considered without the need for recourse to the parallel operation of a domain-general system.

Our results are unable to address the question of whether the rudimentary system is separate from the cognitively flexible conceptual system (see Apperly & Butterfill, 2009) or whether they should both be viewed as aspects of one system (see Luo & Baillargeon, 2010). The extent to which the rudimentary system can be conceived of as ‘automatic’ is also open to debate. The results of the current study suggest that there is a degree of ‘unintentional’ processing of another’s perspective. However, they also indicate that a strong form of automaticity cannot be assumed as the propensity to adopt another’s perspective when there was no need or intention to do so depended in part on the social status of the perceived entity (i.e., whether social, semi-social, or non-social). The susceptibility of the rudimentary system to manipulations of social relevance and its associations with individual differences may also indicate that there are limits to its automaticity (see Moors &

De Houwer, 2006). Further research is required to determine the nature and extent of the limits to automaticity in respect of the rudimentary system.

Further research is also needed to clarify the role of social specialisation in the separate processes underlying altercentric intrusions. Such research may help resolve debates concerning the extent to which these intrusion effects are indicative of a separate automatic-like system, as the idea of a separate system has been contested by researchers such as Luo and Baillargeon (2010) and Scott, He, Baillargeon, and Cummins (2012). As highlighted by Qureshi et al. (2010), altercentric intrusions may reflect two types of processes: (i) the calculation of what the avatar sees and (ii) domain-general processes (e.g., inhibition) involved in the selection of such information in order to make a judgement. Our findings from the correlational analyses, which show significant positive associations between self-reported empathic concern, perspective taking and altercentric intrusions for the social task alone, suggest that the computation of what the avatar sees may rely on processes that differ from those involved in the orientation of attention by other cues. One possible explanation is that individual differences are correlating with processes of perspective selection, but that these processes differ according to the social relevance of the cue. A more intuitively plausible account is that there is a specialised role for perspective calculation within the social domain (e.g., when observing an avatar), which may not prevail when observing less ‘social’ stimuli (e.g., non-biological arrows or dual-coloured blocks). Differential underlying mechanisms for the processing of cues to perspective in social versus non-social domains may also account for why equivalent egocentric intrusion effects were obtained across cue conditions in our experiment, in contrast to the findings of larger egocentric intrusion effects for social (avatar) compared with non-social (dual-coloured stick) conditions in 8-year-old children in a recent study by Surtees and Apperly (2012). Following the suggestion that perspective selection requires general processing resources (e.g., Leslie et al., 2005), it is conceivable that age related increases in these resources may counteract any social influences on egocentric intrusion effects. The same argument should not hold for altercentric intrusions, as these would appear to be subserved by automatic perspective calculation, as well as selection, processes (Qureshi et al., 2010). Such calculation effects are unlikely to be influenced by age-related improvements in executive function or increases in general processing resources (see Qureshi et al., 2010).

In conclusion, the results from this study provide evidence for the ‘unintentional’ computation of visual perspective in relation to a range of perspective-taking units that vary in degree of social relevance. They also provide systematic evidence that these computations can be modulated by social context. Moreover, the results indicate an association between computation of another’s perspective and self-reported empathy and perspective taking, but only when the other entity is perceived as clearly ‘social’.

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[i] For ease of explication, throughout this manuscript we use the term “altercentric” to refer to both biologically relevant (avatar) and biologically irrelevant (arrows, dual-coloured blocks) cues.

[ii] The same patterns of results were obtained irrespective of whether consistent mismatching trials or both consistent and inconsistent mismatching trials were removed from the analyses. See Samson et al. (2010, p.1257) for a discussion on the unbalanced way mismatching trials have to be constructed and concomitant dangers around the artificial inflation of consistency effects.

[iii] This was still the case when using age and sex as covariates, $F(2,105)=8.90$, $p < .001$

[iv] Spearman’s correlations were also carried out as the range of mean RTs across tasks (“Self” trials: Social 925.7ms; Semi-social 1032.5 ms; Non-social 814 ms) might have affected our results. These revealed a significant positive association between altercentric intrusion and Empathic Concern, $r = .44$, $p = .005$, and an association approaching significance between altercentric intrusion and Perspective Taking, $r = .28$, $p = .06$.

[v] One participant in the semi-social condition was an outlier for the IRI subscale Perspective Taking. Removing this participant did not change the results, so this participant was left in for the analyses