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"Making it explicit" makes a difference: Evidence for a dissociation of spontaneous and intentional level 1 perspective taking in high-functioning autism

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Highlights:

- We show that participants with autism spontaneously take the level 1 perspectives of others
- We show that participants with autism have difficulties if they intentionally try to take another perspective
- We argue that different cognitive processes underlie intentional perspective taking vs. spontaneous perspective taking
- We argue that intentional perspective shifts require an attention shift that individuals with autism have difficulties with.

Abstract

The ability of perspective taking is a fundamental aspect of social cognition. The ability to decide, what another person can or cannot see is referred to as "level 1 perspective taking." This is thought to be a process that we can make use of intentionally, but which also takes place spontaneously. Autism is characterized by impairments of social interaction, which are thought to be related to deficits in implicit rather than explicit perspective taking. In order to assess both levels of processing with regard to perspective taking, we employed an established task in patients and controls. Our results demonstrate that both groups engage in spontaneous level 1 perspective taking. In contrast to controls, however, patients reacted more slowly if they had to verify the other's as compared to their own perspective, which shows that participants with high-functioning autism have selective difficulties in explicit, but not implicit, level 1 perspective taking. These findings demonstrate that while spontaneous level 1 perspective taking appears to be intact in autism, this ability is impaired in patients when used explicitly.

Keywords: visuospatial level 1 perspective taking, high-functioning autism, Asperger syndrome, attention shift, implicit processing

1 Introduction

To be able to put oneself in the spatial position of another person is assumed to play a crucial role in many other higher-level processes involved in social cognition. We take perspectives all the time, and we do so both consciously and unconsciously, both intentionally and spontaneously. Children acquire their first perspective taking skills at the age of seven months (Kovács, Téglás, & Endres, 2010); even non-human primates, to some degree, have an understanding of other perspectives (Hare, Call, & Tomasello, 2001). If a person has problems with perspective taking tasks, the inability to take the perspective of someone else is often due to "natural egocentrism" (Piaget, & Inhelder, 1956) and an inability to "decenter" or, in other words, to perform a perspective shift from the first person perspective to a third person perspective. Usually, however, humans cannot ignore others' visuospatial perspectives and even take them spontaneously (Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010). Persons suffering from autism spectrum disorders (ASD), however, experience disturbances in social interactions (Schilbach, Timmermans, Reddy, Costall, Bente, Schlicht, & Vogeley, 2013) that are associated with deficits in the ability to access others' mental states and in spatial perspective taking (Frith, 1996). In this paper we study whether persons diagnosed with high-functioning autism (HFA) *spontaneously* adopt others' perspectives.

The available literature distinguishes between different types of perspective taking. On the one hand there are pure perceptual forms of perspective taking (Newcombe, 1989), referring to the capacity to imagine how others perceive the world, here research focuses on visuospatial perspective taking processes. The most famous visuospatial perspective taking task is the three mountains experiment (Piaget, & Inhelder, 1956) in which children have to decide what a landscape looks like from another person's point of view. On the other hand, the term "perspective taking" is also used to indicate the capacity to ascribe mental states (e.g. judgments, thoughts, beliefs, feelings, emotions, desires etc.) to other persons, also referred to as “mentalizing” or “theory of mind” processes (Frith, & Frith, 2006). In a well-known mentalizing task, namely the Sally-Anne task (Baron-Cohen, Leslie, & Frith, 1985), children have to decide where an agent Sally will search for a marble that was moved elsewhere (by Anne) while the agent Sally was absent. To which degree visuospatial perspective taking and mentalizing are based on functionally similar or independent processes is still an open question (David, Aumann, Santos, Bewernick, Eickhoff, Newen, Shah, Fink, & Vogeley, 2008; Kockler, Scheef, Tepest, David, Bewernick, Newen, Schild, May, & Vogeley, 2010), but we can assume that the ability of visuospatial perspective taking plays an important role for the ability of mentalizing (Frith, & Frith, 2006).

In our study we focus on visuospatial perspective taking processes. Research distinguishes between “level 1” and “level 2” perspective taking (Flavell, Abrahams Everett, Croft, & Flavell, 1981; Michelon, & Zacks, 2006): Taking the visuospatial level 1 perspective of another person requires responding adequately to the question of *what* the target person can and cannot see or, for example, *whether* a certain object is visible from the other’s perspective. In contrast, level 2 perspective taking addresses the question of *how* the target person perceives the world, or *how* an object appears from the other’s perspective, as is illustrated in the three mountains problem.

In level 1 perspective taking tasks, participants usually have to judge what another person is able to perceive in comparison to their own perceptions (Michelon, & Zacks, 2006; Vogeley, May, Ritzl, Falkai, Zilles, & Fink, 2004). As an example, Vogeley et al. (2004) presented static visual stimuli with a virtual character standing in the center of a room with several red balls placed around him. The scene was presented from different viewpoints and participants had to judge the number of balls as seen by the virtual character or by themselves. When participants had to judge from the other´s perspective, reaction times increased and neural activation was increased in brain areas recruited during spatial cognition including the precuneus, the right superior parietal and the right premotor cortices. Samson et al. (2010) used similar stimuli to investigate the spontaneous nature of perspective taking in healthy controls under systematic manipulation of the consistency between the participant’s and the other´s perspectives. The underlying idea is that any perspective that is taken spontaneously or even automatically will interfere with the perspective that people are asked to take intentionally, provided that the perspectives differ from one another. In their scenes, participants always had the same view on the virtual character. Instead of balls, discs were located on only two of the room’s walls so that they were either in front of or behind the virtual character. Participants were presented with a number and had to verify whether the number corresponded to the number of discs as seen from either their own or the other´s perspective. Samson et al. (2010) found an effect of “egocentric intrusions”: The verification of the other´s perspective was more difficult if participants saw a different number of discs than the virtual character, suggesting that one´s own perspective has to be disengaged to verify the perspective of the other person. Crucially, however, they also found an effect of so-called “altercentric intrusions”: It was more difficult for participants to verify the number of discs seen from their own perspective if the virtual character saw a different number of discs. This effect shows that the level 1 perspective of the virtual character is taken spontaneously, even if it goes against ostensible task demands. These results suggest that level 1 perspective taking is a spontaneous, pre-reflective process.

Autistic persons have difficulties with social interaction and with taking others' perspectives (Frith, 1996; Baron-Cohen, 1988). Interestingly, while they have difficulties with mentalizing tasks and also with level 2 perspective taking tasks (Hamilton, Brindley, & Frith, 2009), they do not appear to have any problems with level 1 perspective taking. For example, adult HFA participants are able to decide which of two objects appears at an elevated position with respect to a virtual character as quickly and as accurately as control participants do (David, Aumann, Bewernick, Santos, Lehnhardt, & Vogeley, 2010). Even autistic children show no difference to controls when they have to position a doll to make it "see" a specific object or when they have to indicate what a doll or an experimenter can "see" from its viewpoint (Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997; Baron-Cohen, 1989; Leslie, & Frith, 1988; Reed, & Peterson, 1990; Hobson, 1984). As described above, non-autistic participants cannot ignore the visuospatial perspectives of other persons and take them spontaneously (Belopolsky, Olivers, & Theeuwes, 2008; Frischen, Loach, & Tipper, 2009; Tversky, & Hard, 2009; Zwickel, 2009; Samson et al., 2010; Zwickel, White, Coniston, Senju, & Frith, 2011). In this study, we wanted to investigate whether individuals with HFA, who are generally able to take others' visuospatial level 1 perspectives, also process them spontaneously, or whether they can only refer to others´ perspectives in a controlled, intentional way. This objective was motivated by demonstrations of a dissociation between impaired implicit and relatively intact explicit levels of social cognition in high-functioning autism (Senju, Southgate, White, & Frith, 2009; Schilbach, Eickhoff, Cieslik, Kuzmanovic, & Vogeley, 2012).

To test these different levels of processing in autistic and control persons, we used a level 1 perspective taking task that differentiates between intentional and spontaneous perspective taking (Samson et al., 2010). To measure intentional perspective taking, participants were explicitly asked to take their own or someone else's perspective. To address spontaneous perspective taking, we measured the degree of interference between the explicitly requested perspective and the competing contrary perspective. Our study, thereby, constitutes the first attempt at examining *intentional* and *spontaneous* visuospatial perspective taking in individuals with HFA within the same task. According to the literature, we expect participants with HFA to have no difficulties with intentional visuospatial level 1 perspective taking (David et al., 2010; Leekam et al., 1997; Baron-Cohen, 1989; Leslie, & Frith, 1988; Reed, & Peterson, 1990; Hobson, 1984). On the contrary, we expect to find evidence for impairments of spontaneous perspective taking consistent with findings that indicate difficulties with implicit belief reasoning (Senju, Southgate, Miura, Matsui, Hasegawa, Tojo, Osanai, & Csibra, 2010; Senju et al., 2009) and an absence of the spontaneous integration of directional gaze cues provided in a stimulus-response compatibility paradigm (Schilbach et al., 2012). For control participants, we expect to replicate the results found by Samson et al. (2010).

2 Method

2.1 Participants

Thirty-one participants were studied and received a small honorarium for their participation. The diagnostic group comprised 16 HFA participants (7 female, 9 male) aged 29-54 years old. All had been diagnosed with Asperger syndrome (AS). Fifteen of them were recruited at the autism outpatient clinic at the Department of Psychiatry of the University of Cologne and one at the Autism Therapy Center Cologne. They were compared to 15 control participants (11 female, 4 male) 29-53 years of age who were matched with respect to age, gender, handedness and years of education (see Table 1). Control participants did not report a history of neurological or psychiatric disease. They were recruited locally, mostly through on-campus advertisement. The study was approved by the local ethics committee of the Medical Faculty of the University of Cologne, and participants gave written consent before taking part.

Table 1. Demographic and neuropsychological variables

	HFA	CON	
Age	M = 44.0, SD = 7.1	M = 42.9, SD = 8.8	n.s.
Gender	7 female, 9 male	11 female, 4 male	n.s.
Handedness	15 right-handers, 1 left-hander	14 right-handers, 1 left-hander	n.s.
Years of education	M = 16.9, SD = 4.1	M = 18.1, SD = 3.7	n.s.
AQ	M = 41.6, SD = 3.6	M = 13.9, SD = 3.9	$p < .001$
BDI	M = 14.1, SD = 9.2	M = 3.9, SD = 3.2	$p < .001$

HFA HFA group, *CON* control group, *M* mean, *SD* standard deviation, *AQ* Autism Spectrum Quotient, *BDI* Beck Depression Inventory

The AS diagnoses were based on two independent physicians who explored the autistic traits in clinical interviews according to ICD-10 criteria supplemented by an extensive neuropsychological assessment and diagnosed Asperger syndrome. We use the more general term HFA to describe the clinical group with AS, because research does not provide differences between the two (Frith, & de Vignemont, 2005). The term HFA refers to patients with ASD who have a high intellectual level of functioning and does not take into account diagnostic criteria relating to early childhood.

Participants were screened with the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). As expected, the HFA group showed a significantly higher score than the control group. As depression is a common co-morbidity in HFA (Stewart, Barnard, Pearson, Hasan, & O'Brien, 2006), we tested the presence of a depressive syndrome with the Beck Depression Inventory (BDI; Beck, & Steer, 1987; Hautzinger, Bailer, Worall, & Keller, 1995) and found significantly higher scores in the HFA group as compared to the control group. Demographic and neuropsychological variables for both groups are listed in Table 1.

2.2 Materials

The stimuli showed virtual scenes of a room with three visible walls (see Fig. 1) as used in Samson et al. (2010). A virtual character was located in the centre of this virtual room, always at the same position, facing either the right or the left wall. A number of red discs (0, 1, 2, or 3 discs) were located on these two walls – either on one or on both of them. The virtual character's gender was the same as the participant's gender.

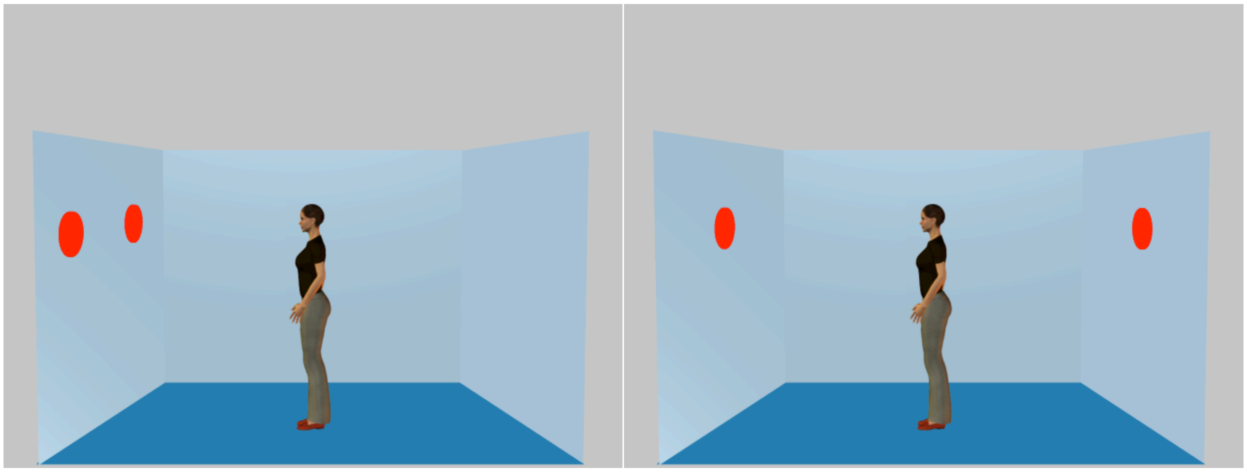

Figure 1. Example stimuli (taken from: Samson et al., 2010).

2.3 Design and Procedure

We used the same procedure as Samson et al. (2010) and added the factor *(diagnostic) Group (HFA* vs. *Control)* to the design. The experiment had a 2x2x2 design with *Perspective (Self* vs. *Other)* and *Consistency (Consistent* vs. *Inconsistent)* as within-participants factors and *Group* as between-participants factor. The *Perspective* factor had two levels: In the *Self* condition participants had to verify their own perspective, whereas in the *Other* condition they had to verify the virtual character's perspective. The *Consistency* factor differentiated the *Consistent* condition, with scenes in which participant and virtual character saw the same number of discs, and the *Inconsistent* condition, where they saw a different number of discs. The *Group* factor compared participants with *HFA* with *Control* participants.

In each trial participants first saw a fixation cross followed by the German words for "YOU" ("DU") or "HE"/"SHE" ("ER"/"SIE") indicating whose perspective participants had to verify. Then they saw a digit between 0 and 3 that indicated the number of discs that had to be verified. These three screens were presented for 750 ms each with a 500 ms time window in between. Finally, the scene appeared and participants had to verify as quickly as possible if the given number of discs was seen from the requested perspective via mouse button press. The position of the mouse depended on the handedness of the participants, so that all used the index finger of their preferred hand for a "yes"-response. Reaction times and error rates were measured. As soon as a response was given, or after a maximum of 2000 ms, the scene disappeared and the next trial started.

The experiment consisted of 26 practice trials and 208 test trials. In 96 of the test trials participants had to give a "yes"-response (matching trials); the other 96 were fillers and required a "no"-response (non-matching trials). Sixteen additional fillers without any discs in the scene were used, so the number zero also required a "yes"-response in some trials. The conditions were equally dispersed not only among the matching trials, but also among the additional fillers (including matching and non-matching trials) and non-matching trials.

Out of the 96 matching trials, in 48 trials participants saw the same number of discs as the virtual character (*Consistent* condition). Therefore, all discs had to be located on the wall the virtual character was looking at. In the other 48 trials the virtual character saw fewer discs than the participant (*Inconsistent* condition), because one or more of them was located on the wall behind the virtual character. In 24 trials of each condition (*Consistent* vs. *Inconsistent*), participants had to verify their own perspective (*Self* condition); in 24 trials they had to verify the virtual character's perspective (*Other* condition).

The trials were presented in four blocks with 52 trials each and preceded by the practice block. The block order was counterbalanced across participants. The trials within the blocks were pseudo-randomized and fixed across participants to keep the procedure as close as possible to the original study by Samson et al. (2010).

Participants sat down in front of a computer screen and read the printed standardized instructions. After the participants had finished reading, the experimenter asked if they understood the task and had further questions. Then the experiment was started. The stimuli were presented with DMDX (Forster, & Forster, 2003). The experiment started with a practice block which took about three minutes. As all participants performed well, the four experimental blocks were started afterwards. Each block lasted about six minutes and the whole experiment took about 30 minutes.

3 Results

We conducted a 2x2x2 repeated measure analysis of variance (ANOVA) on the matching trials only with the within participant factors *Perspective (Self* vs. *Other)* and *Consistency (Consistent* vs. *Inconsistent)* and the between participants factor *Group (HFA* vs. *Control)*. We ran separate analyses for the two dependent variables reaction time (RT) and error rate (ER). Note that *Perspective* relates to intentional perspective taking: An effect of *Perspective* means that one perspective is intentionally more difficult to take than the other. *Consistency* relates to spontaneous perspective taking: An effect of *Consistency* means that inconsistent perspectives yield a different (higher) RT/error rate than consistent ones, which in turn indicates that an inconsistent perspective that is not explicitly probed interferes with the one that is explicitly probed.

3.1 Reaction Times

Reaction times are depicted in Figure 2. All trials that were either interrupted by timeout (0.5% of the data) or that were not answered correctly (6.5% of the data) were eliminated from the data set when we analysed reaction times as a dependent variable. The ANOVA did not reveal a main effect of *Group*, $F(1, 29) < 1$, $p = .36$, $\eta_p^2 = .03$, so there was no overall reaction time difference between *HFA* participants (M = 807 ms) and *Control* participants (M = 747 ms). We found a main effect of *Perspective*, $F(1, 29) = 7.45$, $p < .05$, $\eta_p^2 = .20$, where participants were significantly faster when verifying their own (M = 758 ms) as compared to the virtual character´s perspective (M = 796 ms). Furthermore, we found an interaction between *Perspective* and *Group*, $F(1, 29) = 6.48$, $p < .05$, $\eta_p^2 = .18$. Pairwise comparisons (Bonferroni corrected) revealed that only *HFA* participants showed a significant *Perspective* effect, $F(1, 29) = 14.38$, $p < .005$, with reaction times being significantly slower when they were asked to verify the virtual character´s perspective (M = 844 ms), as compared to when asked to verify their own perspective (M = 770 ms). The effect of *Perspective* was not significant for *Control* participants (the effect of *Group* was also not significant, neither in the *Self* condition nor in the *Other* condition).

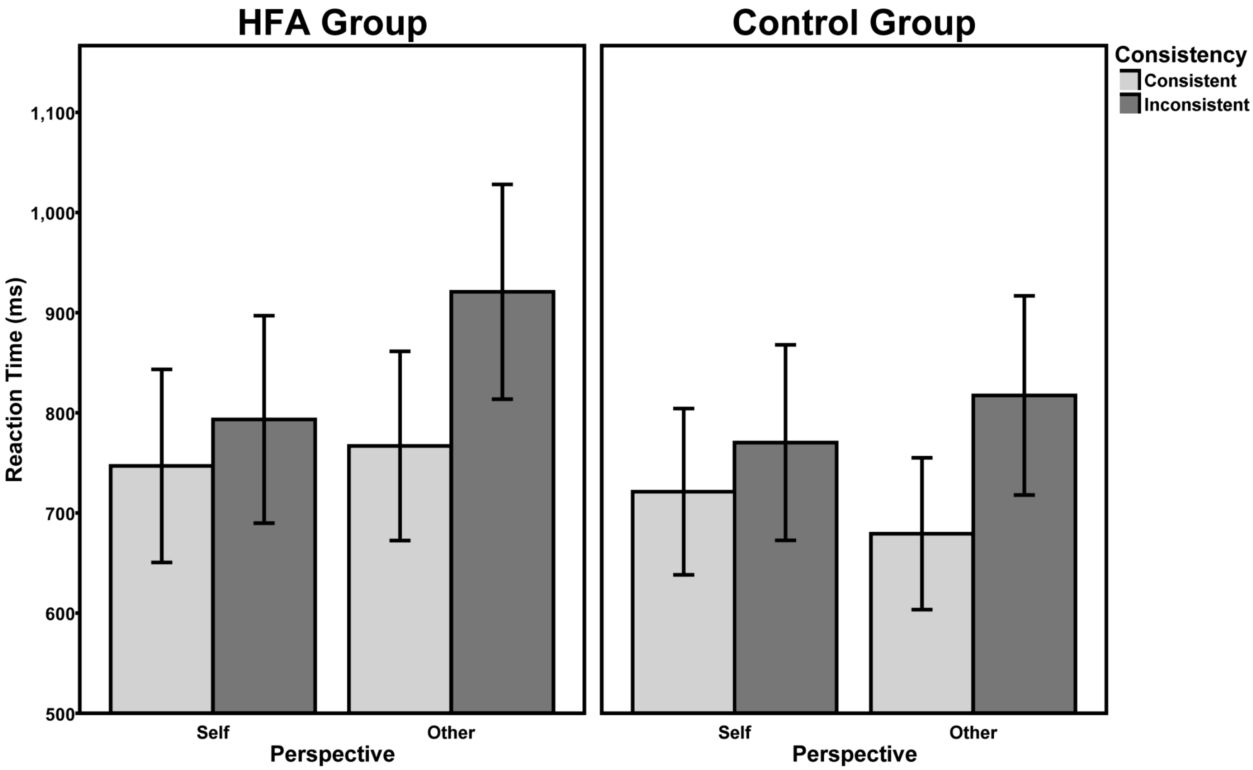

Figure 2. Reaction times for both diagnostic groups, judging either the number of discs seen by oneself or by the other (virtual character), whereby these perspectives could either be consistent or not. Error bars represent two standard error deviations.

Intrusions of one's own perspective onto the other's were shown in the highly significant main effect of *Consistency*, $F(1, 29) = 56.71$, $p < .001$, $\eta_p^2 = .66$, in that reaction times were slower if the virtual character and the participant saw a different (M = 825 ms) rather than the same number of discs (M = 729 ms). There was no interaction of *Consistency* and *Group*, $F(1, 29) < 1$, $p = .80$, $\eta_p^2 = .002$, and the effect of *Consistency* held for *HFA*, $F(1, 29) = 31.33$, $p < .001$, $\eta_p^2 = .52$, as well as for *Control* participants, $F(1, 29) = 25.63$, $p < .001$, $\eta_p^2 = .47$.

Differences between egocentric and altercentric intrusions were evidenced by a highly significant interaction between *Consistency* and *Perspective*, $F(1, 29) = 29.64$, $p < .001$, $\eta_p^2 =$

.51. Pairwise comparisons (Bonferroni corrected) showed that the *Perspective* effect was limited to the *Inconsistent* condition only, $F(1, 29) = 18.23$, $p < .001$, in that only when perspectives did not match were participants slower to verify the virtual character´s perspective (M = 869 ms) compared to their own (M = 781 ms). When the perspectives were congruent, there was no difference in judging perspectives. The *Consistency* effect held for both the *Self* and *Other* conditions, with participants slower to verify if perspectives were inconsistent, although an inconsistent own perspective interfered more on *Other* trials (egocentric intrusion; 146 ms slower; $F(1, 29) = 56.84$, $p < .001$) than an inconsistent virtual character perspective did on *Self* trials (altercentric intrusion; 48 ms slower; $F(1, 29) = 19.18$, $p < .001$). We found no three-way-interaction between *Perspective*, *Consistency* and *Group*, $F(1, 29) < 1$, $p = .84$, $\eta_p^2 = .001$. The interaction between *Perspective* and *Consistency* held independently for *HFA*, $F(1, 15) = 13.72$, $p < .005$, $\eta_p^2 = .48$, as well as for *Control* participants, $F(1, 14) = 18.41$, $p < .005$, $\eta_p^2 = .57$. Also, both altercentric and egocentric intrusions were present in both groups. *HFA* participants showed the effect of *Consistency* in the *Self*, as well as in the *Other* condition, though somewhat stronger in the latter ($F(1, 15) = 10.12$, $p < .01$, and $F(1, 15) = 22.08$, $p < .001$, respectively); *Control* participants likewise showed the effect for *Self* and *Other,* also somewhat stronger in the latter ($F(1, 14) = 9.09$, $p < .01$, and $F(1, 14) = 50.50$, $p < .001$, respectively).

3.2 Error Rates

In a second ANOVA we looked at error rate as the dependent variable; the results are depicted in Figure 3. We didn’t find a main effect of *Group*, $F(1, 29) < 1$, $p = .81$, $\eta_p^2 = .002$. *HFA* participants (M = 6.7% errors) and *Control* participants (M = 6.2% errors) did not differ in the accuracy of their responses.

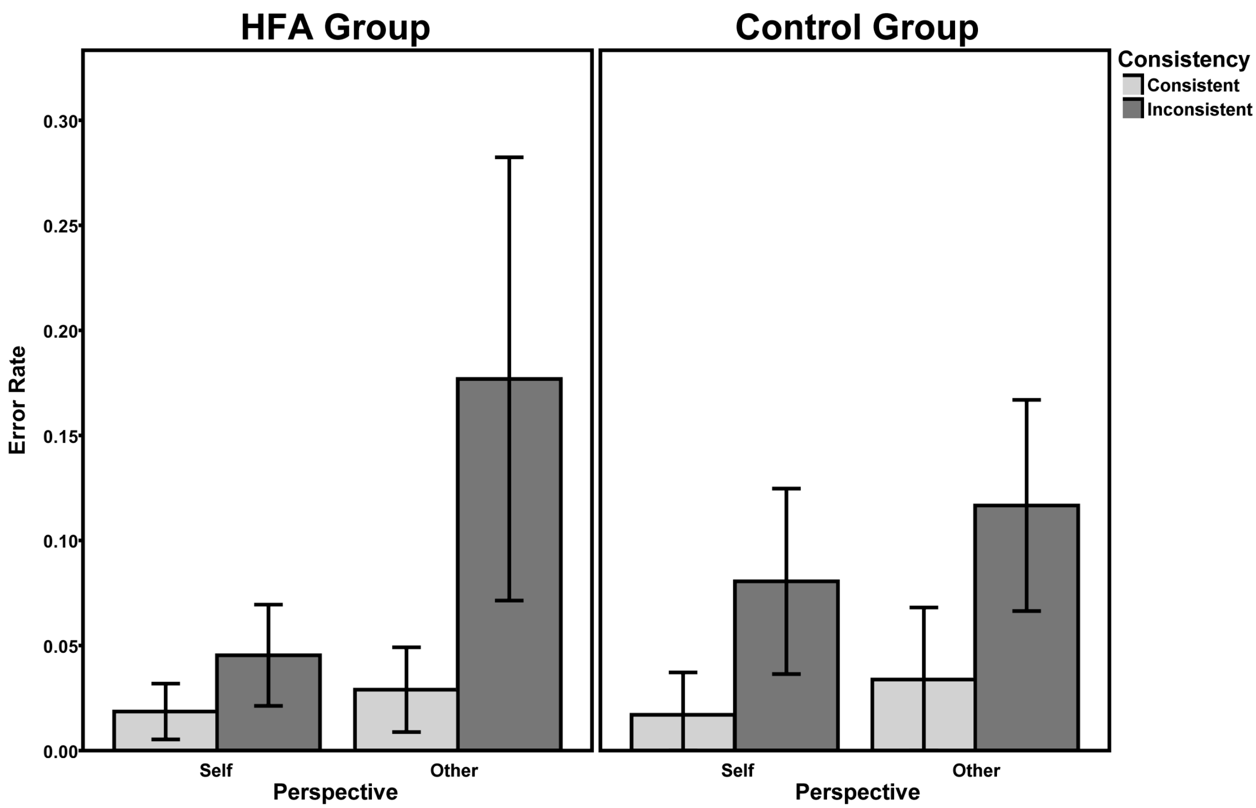

Figure 3. Error rates for both participant groups, judging either the number of discs seen by oneself or by the other (virtual character), whereby these perspectives could either be consistent or not. Error bars represent two standard error deviations[1].

We found a significant main effect of *Perspective*, $F(1, 29) = 11.53$, $p < .005$, $\eta_p^2 = .29$. In line with the RT analysis, participants made more errors if they had to verify the virtual character's perspective (M = 8.9% errors), as compared to their own perspective (M = 4.0% errors). Unlike for RTs, we did not find an interaction between *Perspective* and *Group*, $F(1, 29) = 2.49$, $p = .13$, $\eta_p^2 = .08$, although, like for the RTs, the effect of *Perspective* held only for *HFA*

1 Although the error bar is large for "HFA other-inconsistent," there were no systematic outliers in that all participants understood the task, and none seemed to perform generally worse across multiple sub-conditions. Hence, the error bar represents a genuine heterogeneity within the HFA population with respect to degree of interference of the own perspective on the judgment of the perspective of the virtual character.

participants, $F(1, 29) = 12.65$, $p < .001$, $\eta_p^2 = .30$, and not for the *Control* group, $F(1, 29) = 1.65$, $p=.21$, $\eta_p^2 = .05$ (again, the effect of *Group* was neither significant in the *Self* condition nor in the *Other* condition).

There was a highly significant main effect of *Consistency*, $F(1, 29) = 26.13$, $p < .001$, $\eta_p^2 = .47$, in that, in line with the RT analysis, participants made more errors if they saw a different number of discs than the virtual character (M = 10.9% errors) than if they saw the same number (M = 3.0% errors). As with the RTs, we found no interaction of *Consistency* and *Group*, $F(1, 29) < 1$, $p = .67$, $\eta_p^2 = .01$, and the effect of *Consistency* held for *HFA*, $F(1, 29) = 15.04$, $p < .005$, $\eta_p^2 = .34$, as well as for *Control* participants, $F(1, 29) = 9.90$, $p < .005$, $\eta_p^2 = .25$.

The analysis also showed an interaction between *Consistency* and *Perspective*, $F(1, 29) = 6.28$, $p < .05$, $\eta_p^2 = .18$. Pairwise comparisons (Bonferroni corrected) again showed the *Perspective* effect to be limited to the *Inconsistent* condition, $F(1, 29) = 9.74$, $p < .005$; participants were less accurate in verifying the virtual character's perspective (M = 14.7% errors) than their own (M = 6.3% errors) for trials in which perspectives differed. We didn't find a *Perspective* effect in the *Consistent* condition. Again, the effect of *Consistency* held both for *Self* and *Other* conditions. Participants were less accurate in the verification if perspectives were inconsistent, although an inconsistent own perspective interfered more on *Other* trials (egocentric intrusion; 11.5% error increase; $F(1, 29) = 16.39$, $p < .001$), than an inconsistent virtual character perspective did on *Self* trials, (altercentric intrusion; 4.5% error increase; $F(1, 29) = 19.51$, $p < .001$). Again, there was no three-way-interaction between *Consistency*, *Perspective* and *Group*, $F(1, 29) = 3.30$, $p = .08$, $\eta_p^2 = .10$. However, the interaction between *Perspective* and *Consistency* held only for *HFA*, $F(1, 15) = 6.49$, $p < .05$, $\eta_p^2 = .30$, and not for

Control participants, $F(1, 14) < 1$, $p = .50$, $\eta_p^2 = .03$. Also, both altercentric and egocentric intrusions were present in both groups. *HFA* participants showed the effect of *Consistency* in the *Self* as well as in the *Other* condition, although somewhat stronger in the former ($F(1, 15) = 12.51$, $p < .005$, and $F(1, 15) = 8.52$, $p < .05$, respectively); *Control* participants likewise showed the effect for *Self* and *Other* ($F(1, 14) = 10.58$, $p < .01$, and $F(1, 14) = 12.71$, $p < .005$, respectively).

3.3 Ruling out task switching effects

Because we use a pseudo-randomized trial sequence instead of a blocked sequence, it is, in principle, possible that the judgment of the virtual character's perspective in one trial might be responsible for altercentric intrusions in the judgment of one's own perspective in the next trial or vice versa (see Samson et al. 2010). In order to exclude the possibility that the egocentric and especially altercentric intrusion effects were due to task switching effects between current and previous trials, we coded each trial in terms of the number of similar (same perspective judgment) or dissimilar (different perspective judgment) trials that preceded it. This led to roughly 25% of trials being preceded by just one similar trial and another 25% being preceded by two or more similar trials. Analogously, roughly 25% of the trials were preceded by just one dissimilar trial and 25% by two or more dissimilar trials. We re-ran our ANOVA with *Priming* as an additional within-participants factor with two levels (*Similar Primed* vs. D*issimilar Primed*). The analysis showed no main effect of *Priming*, and, more importantly, not a single significant interaction of *Priming* with any of our previously observed main and two-way interaction effects, and this for reaction times as well as error rates ($.07 < p < .92$). This shows that alter- and egocentric intrusions are not simply due to activation of the “intruding” perspective by the previous dissimilar trial in half of the experimental trials.

4 Discussion

Contrary to what could be expected from the literature on implicit impairments in autism, the data show that HFA participants take level 1 perspectives of others *spontaneously*, similarly to healthy control participants, as evidenced by longer reaction times and increased error rates when judging one’s own perspective in the presence of someone with a different perspective. Despite intact spontaneous perspective taking, persons with HFA appear to have difficulties when asked to intentionally take another's perspective that is not the same as their own, as indicated by longer reaction times and higher error rates. This latter effect, which did not present itself for control participants, is suggestive of a dissociation between implicit and explicit visuospatial level 1 perspective taking in HFA.

4.1 HFA participants take others’ perspectives spontaneously

Spontaneous perspective taking was measured by the degree to which inconsistent perspectives interfere with each other and is reflected in the factor *Consistency*. We found the same *Consistency* main effect as Samson et al. (2010), demonstrating that the verification of a perspective is more difficult for participants if other’s and own perspective are inconsistent. This was due to both “egocentric” and “altercentric intrusions.” As expected, participants’ own perspective interfered with verification of that of the other, reflecting spontaneous “egocentric intrusions.” Crucially, both control participants *and* HFA participants spontaneously take the level 1 perspectives of others in that the verification of one’s own perspective is influenced by the other's perspective, reflecting "altercentric intrusions." The importance of this finding is that it shows, for the first time, intact level 1 perspective taking measured implicitly, where taking the other's perspective goes against task demands.

Like Samson et al. (2010), we also found that when perspectives differ, the own perspective interferes more with verification of the other's than vice versa, reflected in an interaction of *Perspective* and *Consistency*, with the *Consistency* effect being less pronounced on *Self* trials than on *Other* trials. Importantly, the *Consistency* effect held both for the *Self* and *Other* conditions, and the absence of a three-way-interaction with *Group* as well as post-hoc tests show that that these effects do not differ between *HFA* and *Control* participants. Thus, we replicated the results of Samson et al. (2010) for both diagnostic groups studied here.

This is a surprising result because persons suffering from ASD are known to have problems with many similar tasks and need to mobilize conscious cognitive effort to solve them (Schilbach et al., 2012; Senju et al. 2009; Hamilton, Brindley, & Frith, 2009). It is well-known, that patients with ASD show high accuracy in level 1 perspective taking tasks (David et al., 2010; Leekam et al., 1997; Baron-Cohen, 1989; Leslie, & Frith, 1988; Reed, & Peterson, 1990; Hobson, 1984), but these tasks have not been used before to test whether level 1 perspective taking also occurs spontaneously. Our data clearly demonstrate that this is the case. Other studies show diverse findings regarding implicit processes relevant for social cognition in participants with ASD. For example, persons with ASD also track the tasks of other persons automatically (Sebanz, Knoblich, Stumpf, & Prinz, 2005), but children with ASD don't show an implicit false belief understanding as control children do (Senju et al, 2010; Senju et al., 2009). These diverse results on processing differences evident in other studies as well as our finding that participants with HFA adopt level 1 perspectives *spontaneously* can be seen as support for the idea that different cognitive processes may underlie level 1 perspective taking on the one hand and the processing of level 2 perspectives and higher level perspectives referring to social cognitive processes such as mentalizing on the other hand (Hamilton, Brindley, & Frith, 2009).

4.2 Problems with intentional perspective taking

Interestingly, despite the fact that altercentric intrusions on verification of the own perspective show that persons with HFA *spontaneously* take the other's perspective, they nevertheless have markedly slower reaction times and make more errors when they are explicitly asked to take the other's perspective. Intentional perspective taking, whereby participants are *asked* to judge their own or the other’s perspective, is reflected in the factor *Perspective.* We found a main effect of *Perspective*, showing that it is easier for participants to verify their own perspective as compared to the virtual character’s perspective. For *Perspective*, the interaction between *Perspective* and *Consistency* differed from the one found by Samson et al. (2010) in that we found the *Perspective* effect to be limited to the *Inconsistent* condition, meaning participants only had more difficulty verifying the other’s perspective as compared to their own when the perspectives differed. Samson et al. (2010) in contrast found a *Perspective* effect limited only to the *Consistent* condition suggesting instead a tendency for the verification of the other's perspective to be easier as compared to their own when the perspectives didn't conflict. We did not find such an effect, but did see the same trend in *Control* participants.

Crucially however, we found an interaction between *Perspective* and *Group* with respect to RT: Here only *HFA* participants showed a significant *Perspective* effect – which pairwise comparisons also confirmed for error rates. Their reaction times were significantly slower and their error rates higher when they verified the virtual character’s perspective as compared to their own. This result is different from earlier studies showing no evidence that persons with ASD have difficulties reporting on others' level 1 perspectives (David et al., 2010; Leekam et al., 1997; Baron-Cohen, 1989; Leslie, & Frith, 1988; Reed, & Peterson, 1990; Hobson, 1984). The crucial difference to these studies is that in our study participants have to take the perspectives under time pressure.

As both diagnostic groups have more difficulties verifying the others' compared to their own perspectives in the *Inconsistent* condition, people seem to have particular difficulty ignoring their own perspective. The *HFA* group had more difficulty with the perspective of the other, irrespective of the consistency of both perspectives. Samson et al. (2010) argue that under specific constraints basic computational processes allow implicit access on others' mental states and avoid the demand of explicit, conscious and effortful processes. As control persons as well as autistic persons track perspectives of others spontaneously, level 1 perspective taking seems to belong, at least partially, to the implicit processes of social cognition (Frith, & Frith, 2008). The apparent inconsistencies between spontaneous and intentional perspective taking, specifically for judgments of others' perspectives, can be explained if spontaneous and intentional level 1 perspective taking need processes that operate independently from each other, making the spontaneous activation of the other's perspective not necessarily available for intentional, explicit use. Indeed, explicit processes need not be informed or related to their implicit counterparts; for instance, it has been suggested that there might be two systems to track beliefs that cause differing results when perspective taking is measured implicitly compared to explicitly (Surtees, Butterfill, & Apperly, 2012; Apperly, & Butterfill, 2009). Similarly, implicit measures of Theory of Mind in a false belief task (such as gaze) need not inform explicit measures (Ruffman, Garnham, Import, & Connolly, 2001). However, in combination with the above mentioned finding that without time pressure, people with HFA *can* take others' perspective explicitly, this suggests that for HFA participants, explicit perspective taking takes more cognitive effort than for control participants.

This in turn could mean that, given the explicit instruction to take a perspective, HFA participants engage in an effortful explicit process notwithstanding their capacity at implicit perspective taking, whereas control participants, when explicitly asked to judge the other's perspective, may still rely more on less time-consuming implicit processes. Thus, if participants with HFA are explicitly asked to take a perspective, a specific explicit process might be activated and inhibit the implicit components, as they intentionally try to solve the task differently than other people do and consequently have greater difficulties with the task. This could be an unconscious process or an explicit strategy, although the response had to be given under time-pressure. In the *Self*-condition this process or strategy is not needed, which is why we don't find a difference here.

Alternatively, it could be that for the intentional task both control and HFA participants engage in a more deliberate, top-down process at which HFA participants are specifically impaired, leading to more errors or requiring more time. In the next section, we suggest that this top-down process might be intentional attention shifting.

4.3 Perspective taking as a shift of attention

In light of the present *HFA* group data, it is difficult to uphold the notion that level 1 perspective taking is governed by one single process, and the most likely impaired process would be one that is recruited not just in explicit perspective taking, but more so in explicit judgments of the other's than of the own perspective. When we take the perspective of another person and move away from our egocentric view, we have to shift our attention from our own perspective to the perspective of the other, and possibly also the reverse. Therefore, we propose that an intentional perspective shift is a voluntary, top-down attention shift from one perspective to another. This is consistent with findings showing that taxing executive control in a visuospatial perspective taking task increases the interference between the own and the other's perspective (Qureshi, Apperly, & Samson, 2010). As it is unlikely that participant's attention in our experiment lies on the other's perspective for longer than a trial lasts, top-down attention shifts are always needed when participants have to verify the other's perspective. Indeed, the absence of task switching effects shows that by the start of a new trial, the effects of the previous trial's perspective have dissipated. What we suggest is that, even if the other's perspective is always spontaneously activated, the top-down attentional focus lies on the own perspective by default, because this is, after all, in fact what we actually see. Thus, if people explicitly want to take another person's perspective, they voluntarily shift their attention from their own default perspective to the other's perspective. When participants judge their own perspective and other-perspective taking is measured implicitly, they are not explicitly asked to shift perspectives, and given altercentric intrusions we can assume the other's perspective was processed without voluntarily attending to it. It is known that persons with ASD have difficulties with attention shifts (Courchesne, Townsend, Akshoomoff, Saitoh, Yeung-Courchesne, Lincoln, James, Haas, Schreibman, & Lau, 1994; Allen, & Courchesne, 2001; Townsend, & Westerfield, 2010) and related to these impairments other findings suggest differences in the top-down control of attention in individuals with HFA (Greenaway, & Plaisted, 2005; Loth, Gómez, & Happé, 2008; Loth, Gómez, & Happé, 2010). A possible interpretation of our data would be that persons with ASD might have problems disengaging from and suppressing their own perspective when they have to verify the perspective of another person. As the ability of individuals with ASD to shift attention only seems to be impaired when they are under time pressure (Allen, & Courchesne, 2001; Courchesne et al., 1994), the time pressure in our paradigm could explain why we found that individuals with HFA have problems with intentional level 1 perspective taking that other studies did not find. This could explain their accurate responses with surprisingly high reaction times in our study’s conditions in which they had to intentionally shift their attention and perspective from their own to the other’s view of the scene.

4.4 Limitations and Future Research

While the results suggest that intrusions of the other’s perspective are not simply due to task-switching costs when people have to evaluate their own perspective after having rated the other’s on a previous trial, there remains a possibility that the overall task set was at least partly responsible for the activation of the other’s perspective. In the task we used, the demand to verify in each block both the own and the other’s perspective in an alternating manner could have triggered participants to explicitly activate the other’s perspective, knowing that it will be relevant in some trials. In the light of HFA participants’ difficulty on the explicit task, it seems rather unlikely that such explicit activation enhances implicit performance while attenuating explicit performance, but it remains a possibility. Samson et al. (2010) excluded this explanation by additionally testing the own and the other perspective in separate blocks. When presenting the *Self* trials in a first block and the *Other* trials in a second block, participants weren’t aware that the other’s perspective would become relevant for the task at one point. This blocked testing confirmed the spontaneity of the perspective taking process, and whereas we assume that this doesn’t differ in persons with HFA, this assumption needs to be confirmed in further work.

In addition, as people are unable to suppress this perspective even if it harms their performance, the data speak in favor of not only spontaneous but also automatic activation of the other's perspective. Nonetheless, this remains to be tested, since at no point are participants asked to actively suppress the other's perspective.

Whereas we propose that the HFA group has problems with top-down attention shifts away from their own perspective when explicitly asked to do so, this remains a hypothesis based on the present data. While the current data speak in favor of two processes underlying implicit and explicit perspective taking, the question whether attention really plays a role remains to be explored. But at least the process underlying explicit judgments then would have to be selectively recruited for *Other* as compared to *Self* judgments. More specifically, future research will have to show if the problems persons with HFA have with intentional level 1 perspective taking are caused by the difficulties they have shifting attention. If level 1 perspective taking really is a (social) shift of attention, it will be important to show if the impairments persons with HFA have with other types of perspective taking and with mentalizing, relate to their problems shifting attention.

Qureshi et al. (2010) suggest that effortful control, such as a top-down attention shift, is needed both for shifts from the own to the other's perspective and shifts from the other to the own perspective. While this may be the case, the fact that persons with HFA only seem to have problems rating the other's perspective suggests that top-down attention shifts are either more crucial for shifts away from the own perspective, or that persons with HFA have specific difficulties with shift away from the own perspective. This also needs to be explored further.

Another question to be addressed in the future is how level 1 perspective taking, level 2 perspective taking and mentalizing processes – both on an implicit as compared to an explicit level - are related to each other, whether they depend on each other or whether they refer to the same underlying cognitive processes. It is well known that performance in these processes ranges widely – to understand this diversity and the origin of the problems persons with HFA have, it is important to understand the underlying processes that play a role for these tasks and how they differ from each other. Here, it is important to distinguish whether people with HFA engage in explicit processes where control participants do not, or whether both engage in explicit processes, which are specifically impaired in people with HFA.

Another issue to address is whether level 1 perspective taking processes rely on the same neural mechanisms in individuals with HFA and in controls. When non-autistic individuals mentalize about a similar other, there is activation in medial prefrontal cortex areas that are also used during self-referential thoughts (Mitchell, Macrae, & Banaji, 2006). This finding is consistent with studies showing identical neural circuits involved in mentalizing about oneself and others (Lombardo, Chakrabarti, Bullmore, Wheelwright, Sadek, Suckling, MRC AIMS Consortium, & Baron-Cohen, 2009) and also with our control participants who show the same performance if they have to verify their own compared to the other's perspective and suggests that they are able to resort to comparatively similar processes, as if there was no difference between mentalizing about oneself and others. In contrast, the difference between the own and the other's perspective is more relevant in our HFA group. They are disproportionally faster at verifying their own compared to the other's perspective. This finding suggests processing differences and is in accordance with evidence supporting the view that different neural processes are involved during self-referential cognitive processing in people with HFA compared to controls (Lombardo, Chakrabarti, Bullmore, Sadek, Pasco, Wheelwright, Suckling, MRC AIMS Consortium, & Baron-Cohen, 2010; Lombardo, & Baron-Cohen, 2011). Thus, it would be interesting to see if the difference between oneself and others in a level 1 perspective taking task is more pronounced in specific brain regions in individuals with HFA compared to controls. Whether the implicit processes, which are comparable across diagnostic groups, do or do not rely on the same neural mechanisms is another issue that could be addressed by future research.

In conclusion, this paper shows that people with HFA may have difficulty explicitly solving a task at which they are good implicitly. Rather than being merely of relevance for autism research with respect to impairments in implicit processes, this finding suggests that in persons without HFA, explicit task performance may on some occasions be informed by more implicit knowledge, something which does not seem to be the case in HFA.

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