# Motion Perception and Social Cognition in Autism: Speed Selective Impairments in Socio-Conceptual Processing?

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**Abstract:** *Aim:* Research on Autism Spectrum Disorders (ASD) has mainly focused on the study of social behavioral deficits (*e.g.* imitation, eye gaze, play, etc.). These studies have emphasized the high-level impairments that lead to abnormal social interaction in ASD. However, as important as the study of social behavior in ASD, is research on lower-level processes that might contribute to the emergence and development of the atypical social behaviors that characterize this condition. Perceptual differences constitute one such factor. Here, we aim to investigate the possible influence of specific visual motion perception deficits in conceptual processing.

*Materials and Methods:* We compared the performance of children with ASD, with that of children with moderate to severe learning disorders (MLD) or typical development (TD) on a series of computerized tasks. These tasks assessed motion detection in non-social and socially embedded backgrounds or contexts.

*Results:* The results provide evidence for speed-selective impairments in processing socially embedded targets in ASD.

*Conclusions:* Based on these findings, we suggest that low-level perceptual deficits might play an important role in the development of social impairments.

**Keywords**: Autism spectrum disorder, Visual motion processing, Social cognition, Low level perceptual deficits, Stimuli processing speed.

## INTRODUCTION

Autism Spectrum Disorder (ASD) is a neuro-developmental disorder with a characteristic profile of social and communicative deficits. Most of the psychological theories of ASD have focused on deficits in high-level social behavioral competences. This occurs because there is a representation reference of typical behavior, from which deviation can be detected. However, high-level competences rely on sets of elementary mechanisms, some of which might develop in an atypical way. In a review about the impact of visual impairment in neurodevelopmental and neurobiological processes, Sonksen and Dale point to the interactions between neural, biological and psychological domains [1]. Thus, assuming the existence of interdependence between neurobiological components, it is probable that a developmental brain disorder would not result in an exclusive deficit in high-level competences. Support for this is given by studies showing that visual impairments at a young age can lead to deficits in social communication and social development [2] and by evidence of early differences in visual attentional processes in infants who later receive a diagnosis of ASD [3].

One high-level processing explanation for abnormal social interactions in ASD is the *Theory of Mind* (ToM) account. The ToM account of ASD underscores the importance of the representation of mental states for the understanding of other people's behaviour [4, 5]. However, ToM does not exclude the existence of lower-level perceptual integration deficits. Indeed, many visual perception abnormalities have been described in ASD: deficits in processing of configurations [6, 7] and faces [8-11]; "tunnel vision" [12, 13]; over numerous saccades [14]; ability to process parts of stimuli while ignoring distracting contextual features [15,16]; and deficits in processing visual motion [17-20]. The characteristic profile of motion processing deficits in ASD has led to the suggestion of a specific impairment in the functioning of the dorsal visual pathway [*e.g.* 18]. We were particularly interested in this type of low-level information processing. An adequate processing of visual motion can be extremely important for the learning and interpretation of social stimuli. Difficulties observed in adult ASD in understanding ToM animations have been attributed to failure in transmission of information about motion from V3 to STS [21]. Furthermore, children with ASD have been

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found to present deficits in detection of biological motion confirming the existence of a deficit in the dorsal stream. These findings support the idea that independently of the neural bases of motion deficits, higher-level social processing problems might have some foundation in perceptual abnormalities [17, 22, 23]. However, there is still no consensus regarding this issue. For example, in an exhaustive research investigating action perception in adolescent males with ASD, it was reported that, under controlled conditions, other people's actions are adequately interpreted, possibly failing to do so in real life social encounters [24]. Importantly, not only dorsal stream function, but also dorsal stream connectivity has been found to be impaired in ASD [25, 26]. Considering the essential role of cortical circuitry in the development of cognitive function [25], altered connectivity in ASD could lead to difficulties in integrating information from lower and higher-order functional systems [28, 29], a phenomenon consistent with the 'weak central coherence' (WCC) account of ASD [30].

If we consider the abnormalities in processing visual motion, and if these abnormalities concern the range of speeds involved in ecological motion, we should be able to predict consequences in imitation or recognition of gestures, both of one's self and a social partner. If deficits in visual perception exist at an early developmental stage, hindering the correct processing of very subtle social signs that involve motion, such as ocular saccades and facial expressions, then we should be able to better understand some of the mechanisms contributing to the social behavioral problems that persist later on in life. The aim of the current study was to establish whether impairments in low-level visual motion processing are observed in situations where motion is or is not associated with a human context. To address this question, we compared performance of children with ASD, with that of children with moderate to severe learning disabilities (MLD) or typical development (TD) in computerized tasks. These tasks assessed single mobile (SM) and form from motion (FFM) detection in non-social and socially embedded backgrounds or contexts. If we find a deficit in sensitivity to motion specific to ASD only when stimuli are embedded in a social context, we might conclude that social context is the crucial factor. If a deficit in sensitivity to motion is observed specifically in ASD independently of whether the stimuli are socially embedded, we will be able to conclude that motion processing *per se,* might be one of the factors contributing to the emergence of socio-cognitive deficits in ASD.

## METHODS

### Participants

Twenty-three participants with ASD (recruited from a Pediatric Hospital in Paris), aged between 5.08 and 15.67 years (mean chronological age = 10.4, SD = 3.24) were mental age-matched with a group of 36 children with MLD (recruited from a Special Needs School in London)aged between 5.58 and 15.33 years (mean chronological age = 11.4, SD = 2.54). Mental age was measured by the Raven's Colored Progressive Matrices (mean mental age ASD = 7.85, SD =2.39; mean mental age MLD = 7.17, SD = 2.72). MLD children had moderate to severe learning disabilities, some identified genetic syndromes such as Down Syndrome, Noonan Syndrome, or Turner Syndrome, but no ASD. All ASD children had previously been diagnosed by the Hospital clinical team, as having Autism/autistic disorder, according to DSM-IV criteria. Moreover, these children had no known focal brain anomaly (MRI scan) or clinical or EEG epileptic signs. The Pediatric Hospital's clinical team had assigned all ASD children to ahigh functioning group and all children understood the experimenter's instructions. Both ASD and MLD groups were compared with a group of 70 TD children (recruited from a Pediatric Hospital Day Care Department and from a Nursery School in Paris, and from a Primary School in Lisbon) aged between 4 and 10.5 years (mean age = 7.44). All participants had normal or corrected-to-normal vision and no motor problems. The Autism Screening Questionnaire was used to assure that all children from the ASD group fell above the cutoff for Autism and those from the MLD and TD groups fell below; no children had to be excluded from the sample for this reason. Signed consent was obtained by tutors or parents of all participants. The study was approved by the local ethics committee.

### Apparatus and Procedure

Sensitivity to single targets and FFM detection was assessed by performance on the computerized tasks (see Figure **1**), presented on a 15''LCD Elo$^{TM}$ touch screen monitor with a resolution of 1024 x 768 at 75 Hz. Participants were tested in Hospital, School and Home settings in plain and well-lit rooms. The participants were required to follow the targets with their index finger on the screen in the SM tasks or to choose the correct shape match in the FFM tasks. In the non-social SM task, an image of 'Nemo' Disney$^{TM}$(80 x 62pix) substitutes the point light dot


**Figure 1**: Schematic illustration of the stimuli: **i.** Non-social background embedded SM; **ii**. Socially embedded SM; and **iii.** Geometric FFM stimuli.

used in previous displays [31]. Nemo was set in motion and the participants were instructed to follow the target's rectilinear horizontal trajectory with their index finger until obtaining a 'tick' and a pleasant sound. Nemo's speed varied across conditions. In condition 1 Nemo moved at a speed of 50pix/sec; in condition 2, at a speed of 200pix/sec; and in condition 3 at a speed of 400pix/sec.

The touch screen monitor was at a distance of ~ 40cm from the participants. The spatial and temporal resolution of the sensitivity of the screen to finger contact was the same for all trials and conditions. The total number of finger contacts and their position were recorded automatically. Accuracy in performance was measured by the distance from the target of the participant's finger on the screen. Contact positions were divided into three classes depending on the length of the radius of the circle with the finger contact as center: 'on target': radius = 50pix; 'near'; 50pix < radius < 100pix; and 'far' radius > 100pix (Figure **1**.**i**. and Figure **1**.**ii**.). Each condition was composed of three trials. In the socially embedded SM task the participants were instructed to follow an actor's finger just as they had done with Nemo. The actor's finger trajectory was also horizontal but speed was human made and was approximately 400 pixels/s. In this task a social component was added by the introduction of an actor performing the movement.

Finally, in a new computerized version of a FFM task [32, 33] a series of dotted shapes was presented. There were four conditions with different degrees of social content associated to the dotted shapes: 'Geometrical shapes' (outer contour of a cross, triangle, square, circle); 'Things' (outer contour of a house, fish, duck, car); and 'Smilies' (schematic faces showing surprise, happiness, sadness, or neutral expression). A forth condition with 'Scrambled smilies' was used for comparison with performance in the 'Smilies' condition. The screen was divided as shown in Figure **1**.**iii**. In the larger section of the screen 2600 point lights were randomly fixed. The participants were instructed to fixate the cross that appeared on the screen for 1000ms. 2000ms after the disappearance of the cross, a previously fixed doted shape (one of the four presented on the upper section of the screen) was set in vertical motion (upwards and downwards) rendering the shape visible. The participants were instructed to touch the matching figure (one of the four presented in the upper section of the screen), as quickly as possible. A tick or cross would appear if the matching figure or a wrong shape were chosen, respectively. Each condition was composed of 9 trials. In three trials the target moved at 50 pix/sec, in three trials at 200pix/sec, and in three trials at 400pix/sec. A total of 46 trials and 6 (or more when needed) familiarization trials were conducted during a ~30-minute session. Performances were measured by the percent of correct shape matches and mean RT's for correct matches (Figure **1**.**iii**.).

## RESULTS

The percent of on-screen touching in the non-socially embedded SM task (given by onscreen touching duration / total trial duration) was higher in TD (41%) compared to ASD (29%) and MLD (33%). Children with ASD, like children with MLD, touched the screen less than TD children. On screen touching patterns followed a normal distribution and thus multiple t-tests were performed to test equality of means. All groups differed significantly (all $p \leq .017$).

Trial duration depended on the systematicity of on-screen touches; a child might frequently touch the target but always retract before obtaining a tick (signifying the end the trial), whereas another child might touch the target in a consistent manner until obtaining a tick; these two types of behavior would lead to two different trial durations despite similar on-target performances. In order to bypass this issue, satisfactory performance in SM tasks was given by the percentage of ('on target' + 'near') divided by ('on target"+'near'+'far'). A Friedman ANOVA (4 conditions as repeated measures) revealed that performance significantly decreased with speed (Chi2 = 128.74, df=3, N=129). This effect was significant in each Group separately (Friedman ANOVA. ASD: Chi2 = 29.71, df=3, N=23, p<.001; MLD: Chi2 = 50.81, df=3, N = 36, p<.001; TD: Chi2 = 63.62, df=3, N=70, p<.001). Conditions were compared two by two in each group separately with a Sign test. The patterns of responses emerging from these two-by-two comparisons is as follows: ASD and MLD showed exactly the same response pattern with (i.) no performance difference between the two slower conditions (50 vs. 200 pix/s, p>.05); (ii.) no performance difference between the two faster conditions (400pix/s and Human-made, p>.05); (iii.) Higher performances at 50pix/sec and 200pix/s compared to performance at a speed of 400pix/s (p<.001) and the Human-made condition (p<.001). The performance pattern by TD children followed the same trend but showed a slightly different picture: all conditions differed significantly one from the other. Performance of TD children significantly decreased from the 200pix/sec to the 50pix/s condition (from m=96.89 to m=94.96, Sign test, p<.001), from the latter to the Human-made condition (m=89.523 p<.001), from the latter to the 400pix/s condition (m=86.842 p<.03). In other words, for the ASD and MLD groups the conditions can be split into two groups: difficult (*i.e.*, 400 pix/s and Human-made) and easy conditions, whereas for TD children all 4 conditions differed between each other, with the Human-made condition being easier than the 400pix/s condition.

Groups were compared in each condition separately with a Kruskal-Wallis ANOVA. The 3 groups were found to differ significantly in each of the 4 conditions; 50 pix/s, 200 pix/s, 400pix/s and Human-made conditions (H=21.351; H=14.80; H=21.504; H=21 respectively, with df=2, N=129, p<.001). The only condition in which ASD differed from MLD performance was the 50 pix/s condition (Man-Whitney U, p=.001). In this slow condition, ASD perform at a lower level than the MLD group. Conversely, the sole condition in which MLD performed like TD was the 50pix/s condition. Otherwise MLD did not differ from ASD performance and both groups were worse than the TD group under the 3 conditions 200pix/s, 400pix/s and Human-made (Mann- Whitney, all U, p<.03). Given that in the human condition the motion speed was approximately 400pix/s, it can be concluded that the social context does not seem to constitute interference for participants with ASD anymore than for the MLD group. Participants belonging to the TD group were also handicapped in performance at 400 pix/s, but the Human condition was easier for them compared to the 400 pix/s condition. The speed at which the target is set in motion seems to be the main influence on performance for the ASD as well as for the MLD group. Performance in SM tasks for all groups is plotted in Figure **2**.

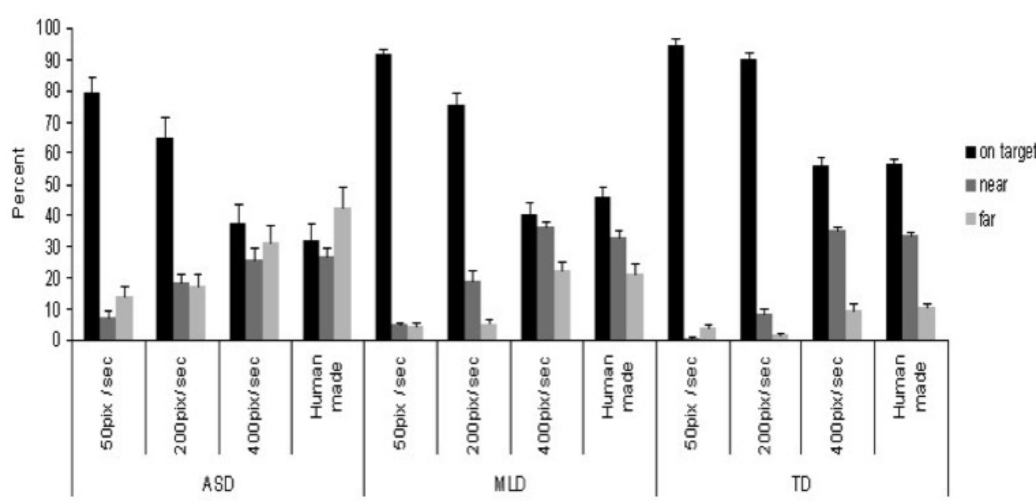


**Figure 2:** Percent of correct responses as a function of the distance from the target. Standard Error bars are represented.

The results of the FFM task are shown in Figure **3**. A Friedman ANOVA on all participants with 4 conditions x 3 speeds (12 repeated measures) showed a significant difference between conditions (Chi2 = 93.765, N=129, df=11, p<.001). Speed was a significant factor in only one condition: Smilies (Chi2 = 10.75, N=129, df=2, p < .005), but not in the 'Scrambled', 'Things', or 'Geometrical' conditions (Chi2 = 2.54, N=129, df=2, p>.10; Chi2 = 3.49, N=129, df=2, p>.10; Chi2 = 3.685, N=129, df=2, p>.10 respectively). The 4 conditions (Geometric, Things, Smilies, Scrambled) differed significantly when each speed was considered separately at 50, 200 and 400 pix/s (Friedman ANOVA: Chi2 = 27.99, N=129, df=3, p<.001; Chi2 = 33.93, N=129, df=3, p<.001; Chi2 = 38.63, N=129, df=3, p<.001, respectively).

In TD children, performance varied significantly with the 4 x 3 conditions and speeds. Performance varied with speed in the 'Smilies' and the 'Scrambled' conditions (Chi2 = 7.07, N=70, df=2, p<.03; Chi2 = 10,57, N=70, df=2, p<.01, respectively), but not in the other conditions. 'Smilies' and 'Scrambled' conditions were sensitive to speed in different ways: children performed poorly in the 'Scrambled'condition at the slowest speed; in the 'Smilies' condition, on the other hand, performance was poorer at 200pix/s compared to 50pix/s, which, in turn, was poorer compared to performance at 400 pix/s. Also, at a speed of 50 pix/s, performance decreased in the following order: 'Geometric' > 'Things' > 'Smilies' and 'Scrambled' (Chi2 = 15.12, N=70, df=3, p<.002); at 200 pix/s, performances also decreased in the same order (Chi2 = 22.31, N=70, df=3, p<.001) except that performances decreased significantly from Scrambled to Smilies (Sign test, p<.001); at 400pix/s no significant difference was observed between conditions (Chi2 = 0.35, N=70, df=3, p>.10). In other words, both speed and condition factors (main effects) affected performances differently for each group resulting in several distinct interaction effects as described above.

In children with ASD, the 4 x 3 conditions differed significantly (Friedman ANOVA, Chi2 = 53.20, N=23, df=11, p<.001). Speed was a significant factor in the 'Smilies' and 'Scrambled' condition (Friedman ANOVA, Chi2 = 16.548, N=23, df=5, p<.01) but not in the 'Things' nor in the 'Geometrical' Conditions (Friedman ANOVA ,Chi2 < 2, N= 23, df=2, p<.10 for each condition). Performances did not differ significantly between 200pix/s and 50pix/s conditions ('Smilies': Mean % of correct responses (M)=78% and M=87% respectively, 'Scrambled': M=77% and M=78%). Performance in the 'Smilies' but not in the 'Scrambled' condition was significantly lower at 400pix/s (M=65%) than at 200 pix/s (M=78%) (Sign test, p<.03). The 4 conditions ('Geometric', 'Things', 'Smilies', 'Scrambled') differed significantly only at 400pix/s (Chi2 = 22.97, N=23, df =3 p<.001,) but not at the two other speeds (50 pix/s: Chi2 = 6.59, N=23, df=3 p>.05; 200 pix/s: Chi2 = 6.8, N=23, df=3 p>.05). Performances on 'Smilies' and 'Scrambled' conditions did not differ significantly one from the other at any speed condition (Sign test: p>.10 in each speed condition).

MLD children showed a pattern of performance similar to that of the ASD children. The 4 x 3 conditions differed significantly (Chi2 = 72.21, N=37, df=11, p<.001). Speed was a significant factor in the 'Smilies' and 'Scrambled' conditions (Chi2 = 18.15, N=36, df=5, p<.01) but not in the 'Things' nor in the 'Geometrical' conditions (Chi2 < 5, N=36, df=5, p>.10 for each condition). Performances in the 'Smilies' condition decreased significantly from a speed of 50pix/s to speed 400pix/s (Sign test, p<.01). Performances differed significantly between the 4 conditions ('Geometric', 'Things', 'Smilies', 'Scrambled') at 400pix/s (Chi2 = 27.47, N=37, df=3 p<.001) and also, contrary to what was observed in the ASD group, under the two other speed conditions (50 pix/s: Chi2 = 13.48, N=37, df=3 p<.001; 200 pix/s: Chi2 = 22.53, N=37, df=3 p<.001). At 50 pix/s performance was lower in the 'Scrambled' condition (Mean % correct responses, M=77%) than in the 'Smilies' condition (M=91%) (Sign test, p<.02). No other significant differences were found between conditions at a speed of 50 pix/s. At 200 pix/s, comparison between conditions revealed no significant differences between the 'Geometric' and the 'Things' conditions and no difference between the 'Smilies' and the 'Scrambled' conditions. However, performance was lower in the 'Smilies' (M=73%) and 'Scrambled' (M=80%) conditions compared to the 'Geometric' (M=95%) and 'Things' (M=87%) conditions (Sign tests, p<.001). The same trend was observed for conditions at 400 pix/s; performance was significantly lower in the 'Geometric' (M=91%) and 'Things' (M=96%) conditions, compared to the 'Smilies' (M=75%) and 'Scrambled' (M= 72%) conditions (Sign test, p<.001).

We used a Kruskal-Wallis ANOVA to compare performances between groups. This analysis revealed, in the Smilies condition, a sole significant difference between groups at 400 pix/s (H=36.127, N=130, p<.001). This difference between groups was due to a difference between children with ASD and TD children (Man Whitney U=66, p>.001) and to a difference

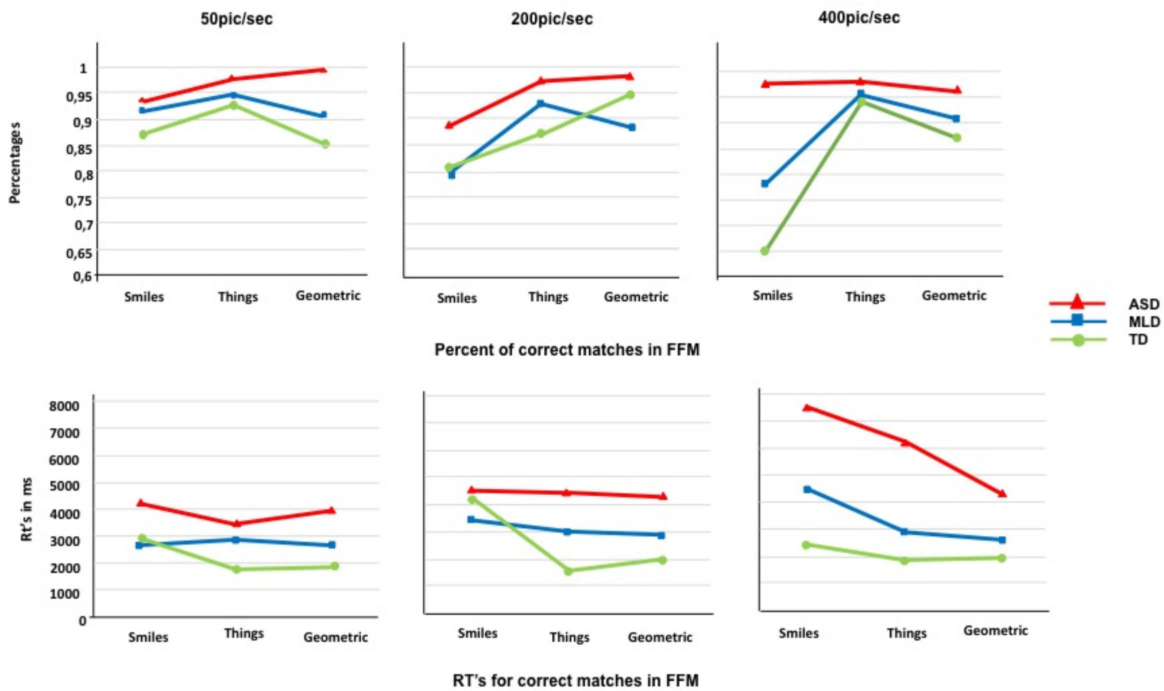


**Figure 3:** Percent of correct matches and respective RT's as a function of the target's speed.

between children MLD and TD children (U=687, p<.001). Children with ASD and MLD, on the other hand, presented very similar performance. Performance in the 'Scrambled' condition differed between groups at all speeds (50 pix/s: H=7.227, N=130, p<.05; 200 pix/s: H29.96, N=130, p<.001; 400pix/s: H=37,122, p<.001). The inter-group differences in the 'Scrambled' condition at 200pix/s and 400pix/s were related to performance differences between TD children and children with ASD as well as to differences between TD children and children with MLD (200pix/s - ASD vs. TD: U=576, p<.05; MLD vs. TD, U=647, p<001; 400pix/s: ASD vs. TD, U=427, p<.001; MS vs. TD, U=612, p<.001). No significant difference was found between ASD and MLD groups and the performance deficits that arise do not seem to be specific to ASD.

The reaction times were analysed with a parametric ANOVA (3 Groups x 4 Conditions x 3 Speeds, with the last two factors as repeated measures). Groups differed significantly (F(2,126) = 7.788, p<.001): ASD showed the slowest reaction time (m=6032ms), MLD showed intermediate RT's (m=3298ms) and TD presented the fastest RT's (m=2615ms). Condition and Speed were significant factors (F(3,378) = 7.89, p<.0001; F(2,252) = 3,857, p<.05 respectively). 'Geometric' and 'Things' conditions showed the fastest RT's (2696ms and 2638ms respectively); the 'Smilies' and 'Scrambled' conditions showed the slowest RT's (4239ms and 4387ms respectively). Post-hoc Tukey tests showed that only 'Geometric' and 'Things' conditions differed from the 'Smilies' condition (Tukey p=.0007 and .0004 respectively) and from the 'Scramble condition' (Tukey, p=.003 and p=.002 respectively). The Group x Speed interaction was significant (F(4,252)=4.465, p<.005). Reaction times were significantly slower in ASD compared to TD at all three speeds (50pix/s: F(1,126) = 14.496, p<.001; 200pix/s: F(1,126) = 7.842 p<.005; 400pix/s: F(1,126) = 20.217, p<.0001). RT's by children with ASD were also slower than RT's by children with MLD at all 3 speeds (50pix/s: F(1,126) = 4.86, p<.03; 200pix/s:F(1,126) = 6.618 p=.012; 400pix/s: F(1,126) = 9.165, p<.003).

No significant differences were found between MLD and TD. In MLD, no interaction was found between performance and condition speed, *i.e.*, RT's did not differ significantly with speed. In TD, RT's did not differ significantly at 50pix/s compared to 200pix/s or to 400pix/s; but they were significantly slower at 200pix/s compared to 400pix/s (F(1,126) = 4.963, p<.05. In children with ASD, RT's were significantly slower at 400pix/s compared to 50pix/s (F(1,126) = 12,986, p<.0005), and to 200pix/s ((F(1,126) = 3.968, p<.05).The ASD group was the only one showing a significant increase in reaction time with increasing speed, and the only group to show a major increase of reaction time in the 400 pix/s condition compared to the 2 other groups.

In summary, 400pix/s motion speed is the speed at which most children with ASD present slower RT's in the 'Smilies' and 'Scrambled' conditions. However, the same effect is not obtained with the 'Geometric' and 'Things' conditions. In these latter conditions, it is speeds of 50pix/s and 200pix/s which most contribute to slower RT's in ASD compared to RT's in the TD group.

## DISCUSSION

We compared performance of three groups of children (ASD, MLD and TD) in SM and FFM tasks to investigate the possible relationship between low-level motion processing and social components. A series of tasks with and without social context were presented (socially embedded or non-socially embedded conditions). It was reasoned that if children with ASD had difficulties in tracking specifically human produced motion [34], they would show more errors in this condition compared to non-social tracking conditions. If, on the other hand, children with ASD had difficulties with visual motion *per se* or within a specific range of speeds, they would not show a specific deficit in processing socially embedded conditions. The results were more complex than our initial predictions. All participants (ASD, MLD and TD) decreased inaccuracy of performance when the speed of the target increased. This could be related to the increased difficulty in eye-motor coordination with increased target speed. Performance in the 'Human made' and the 400pix/s tasks did not differ in ASD and MLD groups, but the TD group performed better in the 'Human made' than in the 400pix/s task. Just like in MLD group, the social context seems to create less interference in ASD than the speed at which the target is moving. Could then a selective difficulty in processing motion within this speed range render the processing of social contexts (where motion is by nature in the range of ~ 400pix/s) more difficult? Or is this deficit specific to single target detection?

The FFM task was designed to answer this second question. If the specific deficit for 400pix/s targets was related to single target tracking, then performances in the FFM tasks should not show any deficit. Results in the FFM task showed decreased performance at 400pix/s but only in ASD children. Matching performance and RT's for correct matches in the FFM tasks showed no difference between 'Smilies' and 'Scrambled Smilies' conditions at any of the 3 speeds in ASD. The decrease in performance at 400pix/sec was more severe in the ASD group. Interestingly, the RT pattern observed in the ASD group differs from the MLD's RT pattern, whereas the latter does not differ from the RT pattern of TD children. It is known that visual area 3 (V3) and the middle temporal area are involved in the perception of motion; perhaps these areas may develop in an anomalous way in ASD [35]? In spite of the same mean mental age in the 3 groups, participants with ASD showed longer RT's than the children with MLD or TD at all condition speeds. It has been established that information-processing rate (*i.e.* perceptual speed) is directly linked to differences in working memory, a mediator of fluid intelligence [36, 37]. Hence, a slower processing rate could have a negative impact in the development of higher cognitive abilities, such as the social cognitive function. The implications of these findings for motion processing are enormous. If one takes longer to process information, then adding motion should render more difficult the already impaired function of social processing, in the case of ASD. Increasing speed of motion, in particular, might lead to gaps in the processing of information. It is possible that participants with ASD do take into consideration the social meaning that aids in 'Smilies' recognition instead of making a piecemeal match as in the 'scrambled' condition. However the fact that they are not experts at social recognition and generally take longer in processing social input, might lead to a need to change to a longer and more inefficient piecemeal matching system when speed rises to 400pix/sec. This suggestion is confirmed by considering performance in 'Smilies' and 'Scrambled' conditions. Performance in the 'Smilies' and 'Scrambled' conditions by TD children varied with speed. In both conditions, TD children performed better at 400pix/s. In contrast, children with ASD as well as children with MLD were sensitive to speeds in the 'Smilies' condition, but not in the 'Scrambled' condition, and their performance was worse at 400pix/s compared to performances at 50pix/s and 200pix/s. Our results confirm previous work showing that children with ASD do present difficulties in processing motion [17, 8, 38, 39]. Here we exhibit groundbreaking data that supports the link between atypical socially-dependent behavior (such as face processing) and a deficit in processing "human-made" speeds (400 pix/s range).

Neurophysiological studies show that human perception of motion could be explained by direction-sensitive neurons. These neurons increase their response with increasing speed of the object in motion [40]. Might ASD individuals have some impairment in these neural networks?

In conclusion, the present research points to a speed-selective deficit in social processing in ASD children. Support for this is found in recent research showing that face processing is facilitated by slowing down the facial dynamics in ASD [10] and that adults with ASD are impaired in perceiving facial information rendered by motion, compared to TD adults, whilst not being vulnerable to inversion effects [41]. This gives support for the manifestation of deficits in processing socially embed visual information, when interacting with low level visual motion processing. However the deficit observed in participants with ASD is also partially observed in children with MLD. This may be explained by dorsal stream vulnerability theories; dorsally mediated functions are thought to be more vulnerable to development delay [42]. If, as it was hypothesized, there are perceptual influences on the development of social processing, then the present research might have implications for more directed materials for early intervention with children with ASD [38, 43]. More research needs to be done to clarify how low-level deficits might contribute to the impairments in social perception and, consequently, social understanding. Though little explored, perceptual problems are an area of key concern for parents and clinicians of children with ASD and a more precise characterization of low-level deficits, such as deficits in processing motion, might eventually afford an earlier diagnosis based on low-level perceptual differences detectable at a younger age.

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