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Recognition of Emotional and Non-emotional Biological Motion in Individuals with Autistic Spectrum Disorders

B. **Hubert [1], B. Wicker[1] D. G. Moore[2] E. Monfardini[1], H. Duverger[1], D. Da Fonséca[1], C. Deruelle[1]**

[1] Mediterranean Institute of Cognitive Neurosciences, CNRS, 31 Chemin Joseph Aiguie, UMR 6193, 13402 Marseille cedex 20, France

[2] School of Psychology, University of East London, Romford Road, London, UK E15 4LZ

Abstract

This study aimed to explore the perception of different components of biological movement in individuals with autism and Asperger syndrome. The ability to recognize a person's actions, subjective states, emotions, and objects conveyed by moving point-light displays was assessed in 19 participants with autism and 19 comparable typical control participants. Results showed that the participants with autism were as able as controls to name point-light displays of non-human objects and human actions. In contrast, they were significantly poorer at labeling emotional displays, suggesting that they are specifically impaired in attending to emotional states. Most studies have highlighted an emotional deficit in facial expression perception; our results extend this hypothesized deficit to the perception and interpretation of whole-body biological movements.

Keywords: Biological motion, Emotion, Autism

Introduction

Among the major impairments characterizing autistic disorders are deficits in emotional and social interactions (APA, 1994). Social meanings are known to be conveyed by faces but also by the movements of body parts (e.g., Clarke, Bradshaw, Field, Hampson, & Rose, 2005; Johansson, 1973; Pollick, Hill, Calder, & Paterson, 2003). Recognition of biological motion is known to be one of the essential ingredients of human evolutionary survival (Atkinson, Dittrich, Gemmell, & Young, 2004). As a consequence, in the normal population, even when human biological motion is presented solely as the motion of a set of point-lights attached to the joints of an invisible human in a dark room, the perceptual system rapidly and reliably identifies humans and distinguishes this movement from other similar motion patterns (e.g., Johansson, 1973).

Contradictory findings exist on the perception of biological motion by the people with autistic spectrum disorders (ASD). Blake, Turner, Smoski, Pozdol, and Stone (2003) presented participants with point-light displays which represented a human person engaged in actions such as throwing, jumping and kicking or out-of phase, scrambled, and thereby meaningless, versions of these original actions. Performance of children with autism aged from 8 to 10 years was compared to that of typically developing children matched on mental age. Children were asked to decide whether the display represented a person or not. Findings indicated that, compared to typically developing controls, children with autism were impaired in discriminating human from scrambled motion in point-light displays, while being similar in their performance on another visual discrimination task.

In contrast, Moore, Hobson, and Lee (1997) found similarities between children with and without autism in their basic perception of point-light displays alongside other intriguing differences. In a first experiment, they used point-light displays representing a walking human or moving objects (a rotating chair, rolling ball, moving bicycle, and a pair of scissors) to investigate the minimum exposure time required for the naı¨ve participants to recognize the point-light displays of people and familiar objects. For each type of display participants were presented with a sequence of brief video clips of increasing durations. After each clip participants were asked to say what was represented by the display. The duration of the clips were incrementally increased up to the point of correct recognition. Results showed that children with autism [mean chronological age (CA) = 14.1 years; mean verbal mental age: 7:11 years] were as able as non-autistic children with learning disabilities matched on verbal mental age and CA in recognizing point-light displays of walking people or moving objects, even after very brief exposures of less than that of half a second. This finding seems to contradict those of Blake et al. (2003).

The discrepancy between these data could originate from differences in the methods. Whereas Moore et al. (1997) used a task that required participants to identify from brief video clips an object or a person only once, Blake et al. (2003) employed a task in which participants had to discriminate over many trials between 1 s clips of point-light displays of a person or a scrambled version of a display. It may be that the identification task used by Moore et al. makes fewer attentional demands on children with autism than the prolonged discrimination task used by Blake et al. Unfortunately, as the control task used by Blake was very different from the target task, and their control group was not intelligence quotient (IQ)-comparable, it is not possible to discount effects that IQ-related information processing abilities might have had on the PLD task performance of the autistic children. Another explanation could rest in the different age range of the autistic participants in the two studies, participants being younger in the Blake et al. (2003) than in the Moore et al. (1997) study. It may be that the ability to recognize and discriminate between human and nonhuman point-light displays improves with age.

Interestingly, in two further experiments, Moore et al. evaluated the ability of the same participants to spontaneously describe five displays of a person showing happiness, anger, sadness, fear, and surprise in terms of the emotions depicted when just asked to say what was happening (Experiment 2); and then explicitly asked participants to say what people were doing when presented with point-light display that depicted ten actions (e.g., kicking, running, hopping, clapping, walking), and to say how the 'person was feeling' when shown the five emotional displays again along with five displays of other subjective states (i.e., cold, hurt, tired, itchy, bored—Experiment 3). Results revealed that while performance in naming simple actions such as running and walking was the same for the autistic and non-autistic mentally retarded controls, the children with autism were much poorer than the control groups in spontaneously referring to emotional states in Experiment 2 and also in naming emotional and subjective states when asked to do so in Experiment 3. Taken together, the results from Moore et al. (1997) suggest that sensitivity to biological motion and abilities to extract global coherence may have developed sufficiently in older autistic individuals to extract some meaning from these displays, but that there are still specific impairments in spontaneously commenting on the emotional and subjective states depicted.

Note that only children were tested in these studies and no data is available, to our knowledge, on the evolution of these competences in the autistic adult population. Yet, evidence of increasing abilities in recognition of simple actions in point-light displays with age comes from the comparison between Moore et al. and Blake et al. studies. Also in a similar vein, recent data have reported that perceptual abilities that may be involved in the recognition of point-light displays (such as configural visual processing) evolve with CA in autistic pathology (e.g., Deruelle, Rondan, Gepner, & Tardif, 2004; Rondan & Deruelle, 2004, 2005). Moreover, the understanding of communicative aspects of other's body movements is one of the symptoms that appears to improve the most between childhood and adulthood in people with autistic pathology (e.g., Fecteau, Mottron, Berthiaume, & Burack, 2003).

For all these reasons, it could be hypothesized that perceptual abilities involved in processing all types of human point-light displays will increase with age in the autistic population, with the performance of adults with autism reaching a similar level to that of adults without autism. If, however, similar problems are found for processing bodily movements as for faces (e.g., Hobson, Ouston, & Lee, 1988), adults with autism may show some specific problems with the perception of emotions and subjective states in bodily movements. Consequently, improvement with age may occur more for the recognition of basic actions in human point-light displays than for the recognition of emotional and subjective states. Alternatively, if, as Blake et al. (2003) propose, all abilities for the perception of human movement are impaired in people with autism, then one might expect poorer abilities in the perception of all types of human point-light displays relative to controls, but expect the perception of non-human point-light displays of non-human objects to be relatively unimpaired and similar to that of mental age controls.

Our study used a similar experimental paradigm to that of Moore et al. (1997) and aimed (1) to verify whether the recognition of basic human actions in point-light displays is intact or not in adults with autism and (2) to ascertain if the perception of point-light movements expressing emotional and subjective states is specifically impaired relative to the perception of simple actions in adult participants and shows the same pattern as found by Moore et al. for younger participants with autism. Note that only high functioning individuals with autism and Asperger syndrome were included in this study as it was necessary to have a reasonable level of language to be able to complete the task.

Method

Participants

Two experimental groups participated in this study. The first group included 19 high functioning adolescents and adults with autism or with Asperger syndrome (mean age = 21 years 6 months, SD = 6 years 1 month) ranging from 15 to 34 years. They will hereby be designated as the group of individuals with

ASD. They were diagnosed according to the DSM-IV (APA, 1994) and/or the ADI-R[1] (Lord, Rutter, & Le Couteur, 1994) criteria for autism. The ASSQ scale (Ehlers, Gillberg, & Wing, 1999) defined 15 participants with Asperger syndrome and four as high-functioning autistic individuals. IQ scores were measured with the WAIS-R or the WISC-R (Wechsler, 1981, 1996) and ranged from 60 to 112 (mean = 83.3; SD = 15.9). There were 17 men and two women. None of them had known associated medical disorders at the time of testing and visual examination was found to be normal. As the mean score of IQs were in the normal range, the ASD participants were individually matched to a control group of 19 typically developing individuals on the basis of gender and CA (mean age = 24 years; 4 months, SD = 8 years; 6 months).

Tasks and stimuli

Tasks and stimuli were similar to those used in Moore et al. (1997, Experiments 2 and 3). Stimuli were video clips each of 5 s duration showing dynamic point-lights displays of an actor performing 10 actions, five subjective states, and five emotional actions (see Table 1). Five movies of manipulated point-light displays of objects were also presented. These were taken from[1] Moore et al. (1994) and Moore (1994) and are described in Table 1.

Procedure

Participants were individually tested, in a quiet room at the National Centre for Scientific Research Office. They were seated in front of a TV monitor used for the presentation of the stimuli. Participants were asked to watch the movies and to describe orally what was happening. Verbal answers were recorded by the experimenter. Responses were scored as correct if participants accurately captured the actions and states portrayed by the point-light displays or provided a word that approximated the action or state. In the emotion condition, responses were scored as correct if they captured the emotional experience. Each subject underwent a total of 25 trials: 10 in the action condition (Act), five in the Subjective states condition (Subj), five in the emotional states condition (Em), and five in the object condition (Obj). The order of trials presentation was randomized for each subject.

Results

Table 2 shows the mean percentage of correct responses made by the two groups in the four conditions.

Table 1 List of the actions, subjective states, emotional states, and objects used (see Moore et al. 1997 for detailed descriptions)

Conditions	Actions/states
Action	Lifting Hopping Kicking Jumping Pushing Digging Sitting Climbing

[1] A neuropsychologist (CR) and a physician (H.D, 5th author) conducted the ADI-R interview.

	Running Clapping
Subjective states	Itchy Bored Tired Cold Hurt
Emotional states	Surprised Sad Frightened Angry Happy
Object	Ball rotating Kitchen scales moving as a weight was added Ironing board opened up and closed Dustpan and brush sweeping Saw in action

Table 2 Mean percentage of correct responses and standard deviation in the ASD and typically developing control groups for each condition

Group	Conditions			
	Act (±SD)	Obj (±SD)	Subj (±SD)	Em (±SD)
ASD Controls	79.25 (20.4) 92.84 (8.3)	61.42 (26.5) 61.42 (18.3)	51.17 (27.3) 89.27 (10.5)	31.42 (25.6) 77.14 (15.4)*

ASD autistic spectrum disorders, Act actions, Obj objects, Subj subjective states, Em emotional states, SD standard deviation
*Significant difference between groups ($p < .05$)

A 2 x 4 ANOVA with Group (ASD vs. Control) as a between subjects factor and condition (actions, subjective states, emotions, objects) as a within-subjects factor was conducted using the percentage of correct responses as the dependent variable. Main effects of both group and condition were found to be significant (respectively, $F_{(1,108)} = 12.5$, $p < .005$; $F_{(3,108)} = 24.5$ $p < .001$). There was also a significant group by condition interaction ($F_{(3,108)} = 8.3$, $p < .001$). Further analyses of this interaction were conducted with post hoc Tukey tests. A significant group difference was found for the emotion condition only ($p < .05$), whereas ASD and control groups performed equally well in action, subjective states, and object conditions (see Table 2) ($p > .05$). In addition, within the ASD group, performance in the emotional states condition was significantly poorer than in the action ($p < .001$) and object conditions ($p < .05$). In contrast, within the control group, performances in the object condition were significantly lower than in the action, emotion, and subjective states conditions (respectively, $p < .001$, $p < .05$, and $p < .05$).

In order to assess possible effect of both age and IQ on performance of the ASD group, an ANCOVA was performed on the percentage of correct responses for the ASD group alone, with condition (actions, subjective states, emotions, objects) as a within-subjects factor and with CA and IQ as covariates. This analysis revealed no significant effect or interaction of age or IQ on performance across conditions (p > .05).

Discussion

This study revealed two important findings. First, the ASD group performed as well as the control group in describing the point-light movies depicting simple actions and on those showing manipulated objects. This clearly indicates that adults with autism understood the task demands and were able to perceive point-lights displays as meaningful representations of people or objects. This finding appears in contradiction with the weak central coherence (WCC) theory. This theory argues that people with autism have an inherent bias towards processing parts of stimuli and an inability to integrate these into a gestalt (Frith & Happe´, 1994) with a local bias reported both for non-social stimuli (e.g., Happe´, 1996) and for social stimuli such as faces (e.g., Gross, 2005).

Surprisingly, our group of individuals with autism was perfectly capable of integrating the individual points of the point-light displays into a whole, at least when non-emotional stimuli is involved. These data are in accordance with several other studies showing that global processing of hierarchical stimuli (i.e., the integration of local elements into a coherent whole) is not specifically impaired in people with autism (e.g., Deruelle, Rondan, Gepner, & Fagot, in press; Mottron, Burack, Iarocci, Belleville, & Enns, 2003; Dakin & Frith, 2005 for a review). In these studies, children and adults with ASD performed in the same way as controls on tasks requiring the processing of the global level of hierarchical stimuli. Taken together these findings may help to better delineate the notion of WCC and suggest that under a range of conditions the integration of elements into a coherent whole is not affected in the autistic population. Note, this conclusion was also reached by Moore et al. (1997) whose study with children and adolescents with autism formed the basis for the study reported here.

Second, whereas no significant difference was found between the groups in the action, subjective state, and object conditions, ASD individuals performed significantly worse than controls in the emotion condition, with the adults with autism using fewer emotional words to spontaneously describe the emotional attitudes depicted. For instance, participants with autism would describe the point-light display depicting ‘afraid’ as: ‘someone who walks forwards and then goes back’ or ‘a person who walks sideways,’ or the point-light display depicting ‘anger’ as ‘someone who jumps.’ Such descriptions were never given by normal control subjects. Moreover, for the ASD group the number of correct answers was significantly greater for simple actions (79%) than when shown the emotions (31%). Note also that a subsequent detailed examination of the words produced for the action and object conditions showed that the participants with ASD did not differ from the control group either in quality or quantity of words.

These results are in accordance with previous studies that highlighted specific emotional face processing deficits in the autistic population (e.g., Celani, Battacchi, & Arcidiacono, 1999; Hobson et al., 1988). Our results extend these findings to the processing of emotional biological motion. These data also complement those of a set of studies that reported the reduced use of emotional or mental state language in people with autism to describe people attitudes from faces and bodies (e.g., Hobson, Ouston, & Lee, 1989; Moore et al., 1997) and from narrative stories (e.g., Baron-Cohen, Leslie, & Frith, 1986).

This deficit in the ability to describe emotional body actions may be conceptualized in different ways. It is possible that people with autism do not perceive correctly the emotional information contained in the dynamic properties of the movement (the exact same movements done at different speeds for example may convey different social meanings). On the other hand, it is possible that they do perceive adequately the meaning of these dynamic properties, but fail to associate them with the appropriate descriptive words.

This would mean that the deficit is at a semantic rather than a perceptual level. While a semantic deficit cannot entirely be ruled out, our experience of testing participants did not suggest a general semantic problem as ASD participants did not seem to be having any difficulty searching for a particular word, on the contrary, they were very fluent in the way they spontaneously described the emotional displays in terms of basic actions. Furthermore, a majority of the participants tested in this study had a verbal IQ within normal range and seemed to have, when put in other contexts, a reasonable working knowledge of the meanings and concepts associated with the emotional words they failed to use in the present study. Specifically in another recent study the same group of participants who took part in this study were able to explicitly recognize facial emotional expressions of anger and happiness and label them when asked (Hubert et al., in press)[2]

Thus, while in one context these participants can make the association between the appropriate emotional word and an emotional face, they do not seem to do so for bodily actions that depict emotions. While it is possible that the problem these participants have with describing point-light displays could be a lack of flexibility in applying emotional words in other situations; it is just as likely that these findings demonstrate that while people with ASD may be able to learn associations over time between faces and emotional words they may not have a sufficiently deep understanding of emotions to be able to apply this across modalities. Thus, when asked to make spontaneous emotional descriptions of unfamiliar representations of emotions these people have particular difficulties. This study did not allow us to test exactly at which level between action perception and semantic association a deficit lies, but we believe that it is most plausible that although actions may be well perceived and can be described in basic terms, emotional meanings are not well represented by people with autism.

At the developmental level, our study adds crucial information on the stability of these deficits by showing that the findings of Moore et al. (1997) may be extended to adults and adolescents. Although several aspects of visual processing such as configural processing are subject to evolution with age (e.g., Deruelle et al., 2004), emotion identification deficits seem to be characteristic of autism during the lifespan. These impairments are not related to the level of functioning, since both low (Moore et al., 1997) and high functioning (the current study) people with autism exhibited similar deficits in recognizing emotional states from point-light displays.

In everyday life, such a deficit may be crucial. Anecdotally, one of our high-functioning participants with Asperger syndrome who was a director of a factory, when briefed about the test afterwards and shown how it was possible to link a particular movement to a particular internal state, suddenly realized why he was so handicapped in meetings with his employees, and found this test very helpful in explaining to himself his difficulties and was motivated to learn more about this area of functioning. The ability to learn is characteristic of people with high-functioning autism or Asperger syndrome and the use of stimuli such as these may in fact help participants to focus on aspects of bodily movement that they do not normally attend. This in turn may mean that even though it may be difficult for people with autism to analyze the bodily movements of several people simultaneously, communication with one or two interlocutors may be enhanced through training.

These findings allow us to contribute to discussions of cognitive models of autism. Our finding of a preserved ability to integrate the individual points of the displays into a whole clearly raises questions regarding the WCC model of autism. Indeed as already outlined, our data suggest that under some

[2]Although the Hubert et al. task was administered to the same participants it is unlikely that carry over effects would be responsible for poorer performance. In fact it would be expected to improve performance. In any case only emotionswere used in the Hubert et al. (in press) study and some participants were enrolled in the current task before the Hubert et al. (in press) task.

circumstances adults with autism do not show a bias towards focusing on parts rather than the whole. Thus, WCC may not be the defining characteristic that underpins the social problems of adults with autism.

A specific emotion deficit is consistent with suggestions of a primary and specific problem for people with autism with emotional engagement with others that may then underpin a range of social and representational problems (Hobson, 1993). However, the findings are also consistent with theoretical frameworks that suggest a widespread empathizing deficit alongside a relative strength in systemizing (Lawson, Baron-Cohen, & Wheelwright, 2004). The adults' performance on the object and actions PLD tasks suggests that adults with autism are proficient in working out the basic 'system' behind the actions depicted in the displays, but may have problems when going beyond these basic meanings and understanding the emotions and engaging in 'empathizing' or in recognizing and dealing with the greater depths of the system (Lawson, 2003). The results also do not preclude the possibility that the ASD adults' lack of propensity for naming the subjective and emotional states of the people depicted by the PLDs could reflect general problems in engaging with mental content—although note that the displays did not represent specific desires or beliefs. Alternatively, this could reflect executive function problems that impair capacities for disengaging from the actions depicted by the displays. Further studies are required to determine the extent to which the specific performance problems found here in perceiving the emotional and subjective states in human PLDs are functionally related to empathizing, mentalizing, executive function, and depth accessibility, and whether these deficits are representative of a primary emotion recognition problem.

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