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A failure to grasp the affective meaning of actions in autism spectrum disorder subjects

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ABSTRACT

The ability to grasp emotional messages in everyday gestures and respond to them is at the core of successful social communication. The hypothesis that abnormalities in socio-emotional behavior in people with autism are linked to a failure to grasp emotional significance conveyed by gestures was explored. We measured brain activity using fMRI during perception of fearful or neutral actions and showed that whereas similar activation of brain regions known to play a role in action perception was revealed in both autistics and controls, autistics failed to activate amygdala, inferior frontal gyrus and premotor cortex when viewing gestures expressing fear. Our results support the notion that dysfunctions in this network may contribute significantly to the characteristic communicative impairments documented in autism.

1. Introduction

Watching someone running with the hands protectively in front of his/her face triggers in the observer a representation of the action of running away, but also prompts the recognition of the emotional context: that the person runs for cover because he/she is frightened. Grasping the emotional component of the various actions we observe around us is a crucial prerequisite for social communication. As the example shows, the skills needed to decode the emotional components of actions reach beyond the visuo-motor representation of the observed movements. Additional perceptual and cognitive abilities are required to represent the emotional significance of the observed movements. The observer needs to appreciate that running and hiding are significant components of a fear response. Grasping the fear dimension in the actions we observe directs our attention to potential social or environmental threat, which is important for preparing an appropriate adaptive reaction. While facial expressions provide information about feelings and mental states, emotionally elicited behavior is, as stressed by Darwin, at the core of the adaptative significance of experiencing emotions. Therefore, a focus on the perception of gestures and their emotional content provides a unique opportunity to investigate nonverbal aspects of inter-personal communication (de Gelder, 2006). Because fear is phylogenetically primitive and is processed relatively automatically and relatively independently of higher cognitive processes we deemed it is important to investigate how a population with social communicative deficits processes fear expressions communicated by social gestures.

Autism is a neurodevelopmental disorder characterized by a unique profile of impaired social communication and interaction (e.g. Lord et al., 1989) with a major impact on adaptive social behavior (American Psychiatric Association, 1996). Subjects with autism spectrum disorder (ASD) typically lack the ability to grasp the emotional dimension of human actions. Several biological hypotheses have been advanced to account for this problem including amygdala, fusiform and superior temporal gyrus dysfunction (Ashwin, Baron-Cohen, Wheelwright, O'Riordan, & Bullmore, 2007; Baron-Cohen et al., 1999; Pierce, Haist, Sedaghat, & Courchesne, 2004; Schultz, 2005; Zilbovicius et al., 2006), impaired functioning of mirror neuron system (Dapretto et al., 2006; Hadjikhani, Joseph, Snyder, & Tager-Flusberg, 2006; Theoret et al., 2005; Williams, Whiten, Suddendorf, & Perrett, 2001) or abnormal cerebral connectivity (Bachevalier & Loveland, 2006; Belmonte et al., 2004; Geschwind & Levitt, 2007; Frith, 2004; Horwitz, Rumsey, Grady, & Rapoport, 1988; Just, Cherkassky, Keller, & Minshew, 2004; Wickelgren, 2005). So far, these hypotheses have been pursued by

Abbreviations: BOLD, blood oxygenation level-dependent; fMRI, functional MRI; DCM, Dynamic Causal Modelling; AMG, amygdala; PM, premotor; IFG, inferior frontal gyrus; STS, superior temporal sulcus.

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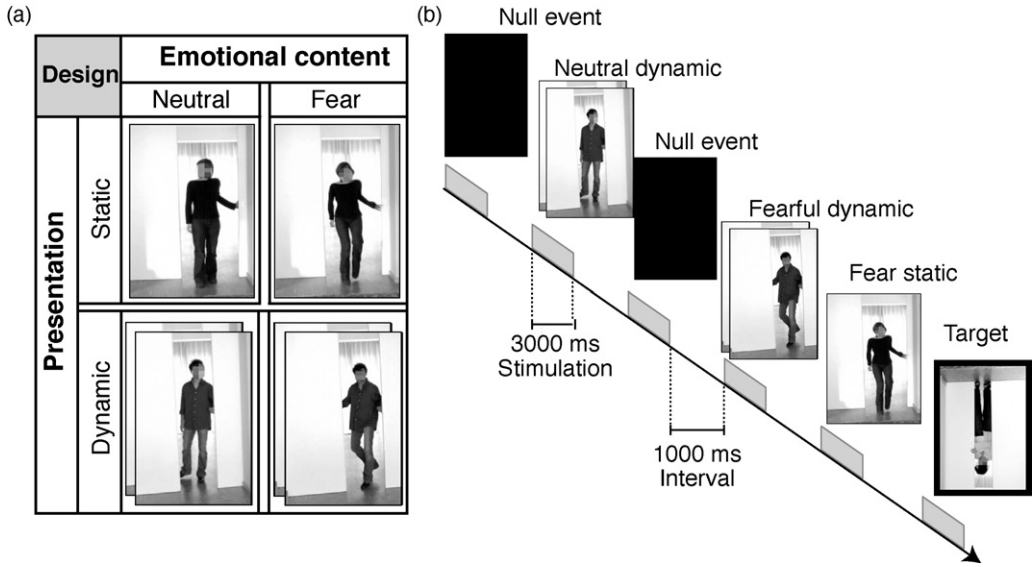

Fig. 1. Design and examples of stimuli. (a) 2 × 2 factorial design. Images were either static or dynamic and consisted of whole-body images of actors opening a door in a neutral or fearful mode. (b) Example of an experimental run and timing. Participants were given an explicit task being instructed to press a button when they saw an upside-down video-clip interspersed among normal videos of body expressions (50%), scrambled ones (25%) and null stimuli (25%). The targets represented 10% of all videos shown. Video stimuli were shown for 3000 ms each with a 1000 ms duration black screen between them.

investigation of deficits in visuo-motor abilities (Williams et al., 2001) and/or face perception (Schultz, 2005).

This study aimed at investigating the cerebral correlates of viewing actions with and without an emotional meaning in a group of normal subjects and a group of subjects with ASD. Additionally, we sought to address directly the hypothesis that autism-associated dysfunction may result from abnormal inter-regional 'effective' cerebral connectivity. Normal and ASD adults underwent fMRI scanning during passive observation of still images (static condition) and short movies (dynamic condition) of fearful or neutral actions (see Fig. 1). To ensure sustained attention during stimulus presentation, participants were instructed to detect occasional upside-down images occurring randomly during a block. This simple task performed equally well by both groups provided a control for visual attention. By contrasting movies to still images we identified brain regions activated by action perception, irrespective of their emotional content. Conversely, by comparing fearful (dynamic and static) to neutral (dynamic and static) stimuli, we revealed activations in the amygdala and other 'social' brain areas, irrespective of the presence of dynamic information. These comparisons allowed us to address directly whether brain areas associated with action perception and recognition of emotional messages were differentially engaged in the two groups.

2. Materials and methods

2.1. Participants

Twelve adults with a diagnosis of ASD (10 male and 2 female; 10 Asperger Syndrome and 2 High-functioning Autistic; age range: 18–56) participated in the experiment. All participants in the ASD group had been diagnosed according to conventional criteria and a review of available medical records confirmed that all met DSM-IV (American Psychiatric Association, 1996) criteria for ASD. Brief interviews ensured that none of them suffered from any mental or neurological disorder other than ASD and that they were free of medication.

The participants of the control group were recruited from a large sample of healthy individuals (see Berthoz, Wessa, Kedia, Wicker, & Grezes, 2008). Twelve controls (all adult males), free of current or past psychiatric or neurological disorders, with low levels of current depressive mood (mean depression score ± SD for the French version of the 13-item Beck Depression Inventory (Collet & Cotraux, 1986) = 2 ± 1.7) and state anxiety (mean anxiety score ± SD for the state portion of the French State-Trait Anxiety Inventory (Bruchon-Schweitzer & Paulhan, 1993) = 35 ± 11) on the day of the scanning session were included. Written consent was obtained after the procedure has been fully explained. The study was approved by the local Ethics Committee and was conducted in accordance with the Declaration of Helsinki. The participants were not specifically informed about the aim of the study. Control subjects were paid for their participation. The participants' descriptive statistics are presented in Table 1. The 2 groups did not differ on age or full-scale IQ (as measured by the Wechsler Abbreviated Scale of Intelligence, Wechsler, 1999).

2.2. Stimuli and experimental design

2.2.1. Materials

48 full-light videos (24 fear and 24 neutral) of 3 s were used for the present experiment. Videos were chosen from a wider set of stimuli on the basis of the reliability of responses from subjects in a pilot study. Details about this validation and the edition of stimuli can be found elsewhere (Grèzes, Pichon, & de Gelder, 2007; Pichon, de Gelder, & Grèzes, 2008). The recordings of stimuli involved 12 professional actors (6 females, 6 males) performing the simple action of opening a door and facing a threat for the "fear" script", opening the same door in a relaxed natural manner and looked ahead for the "neutral script". Actors were filmed in frontal view. Importantly, faces were blurred afterwards such that only information from the body was available. 48 static stimuli (24 fear and 24 neutral) were obtained by selecting a frame at the perceived height of emotional expression.

2.2.2. fMRI experimental design (cf. Fig. 1)

A factorial design with one between-group factor (ASD and controls) and two within group factors ('stimuli': dynamic and static stimuli; 'emotion': fearful and neutral actions) was tested. The experiment consisted of two scanning sessions. During each, a total of 136 stimuli were presented corresponding to 24 stimuli from each category (dynamic fear, static fear, dynamic neutral, static neutral), 10 oddball stimuli (upside-down video-clips) and 30 null events (black screen). A stimulus lasted 3 s and was followed by a black screen of 600 ms. Order of stimuli was fully randomized. Subjects were asked to press a button each time the image was upside-down so that trials of interest were uncontaminated by motor response. A between groups comparison for accuracy and reaction times in the oddball task was performed. For technical reasons, the motor responses were only recorded for 8 subjects per group. There was no difference between groups either in terms of number of responses (Mean Controls = 98%, Mean Autistics = 85%; Two-sample T-test, $p > 0.05$) or in terms of reaction times (Mean Controls = 1029.53; Mean Autistics = 1288.57; Two-sample T-test, $p > 0.05$). The same results were obtained with the non-parametric Mann–Whitney test (Performance: $p = 0.279$; Reaction Times: $p = 0.161$). Although it is possible that the small sample size may mask a behavioral

Table 1
Summary of age and IQ characteristics of the ASD and control groups.

Measure	ASD ($n = 12$)		Control ($n = 12$)		Mann–Whitney test
	M	S.D.	M	S.D.	
Age (years)	26.6	10.4	21	1.6	$p = 0.410$
IQ	102	20.6	119	6.6	$p = 0.195$