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The "Reading the Mind in Films" Task: Complex emotion recognition in adults with and without autism spectrum conditions

Ofer Golan, Simon Baron-Cohen, Jacqueline J. Hill, and Yael Golan
Autism Research Centre, Psychiatry Dept, Cambridge University, UK

Background: Individuals with autism spectrum conditions (ASC) have difficulties recognizing mental states in others. Most research has focused on recognition of basic emotions from faces and voices separately. This study reports the results of a new task, assessing recognition of complex emotions and mental states from social scenes taken from feature films. The film format arguably is more challenging and ecologically closer to real social situations. **Sample and method**: A group of adults with ASC ($n = 22$) were compared to a group of matched controls from the general population ($n = 22$). Participants were tested individually. **Results**: Overall, individuals with ASC performed significantly lower than controls. There was a positive correlation between verbal IQ and task scores. Using task scores, more than 90% of the participants were correctly allocated to their group. Item analysis showed that the errors individuals with ASC make when judging socioemotional information are subtle. **Conclusions**: This new test of complex emotion and mental state recognition reveals that adults with ASC have residual difficulties in this aspect of empathy. The use of language-based compensatory strategies for emotion recognition is discussed.

Autism Spectrum Conditions (ASC) are neurodevelopmental conditions, characterized by cognitive and behavioral difficulties in communication and social interaction (American Psychiatric Association, 1994; World Health Organization, 1994). The effects of ASC are lifelong, and although learning occurs throughout development, social and communication difficulties remain even among individuals diagnosed with Asperger Syndrome (AS) or High Functioning Autism (HFA; Attwood, 1998; Baron-Cohen, Tager-Flusberg, & Cohen, 2000b; Frith, 1989; Hobson, 1993).

One key cognitive theory of autism views the social dysfunction in ASC as a result of a deficit in what is variously referred to as "theory of mind" (ToM; Astington, Harris, & Olson, 1988), "mind-reading" (Wellman, 1992), or "mentalizing" (Frith, 1989), that is, the ability to understand other people's minds, to decipher their intentions, emotions and thoughts. Impaired in this ability, individuals with ASC are bound to feel confused by other people's behavior, failing to understand the motives that underlie human action, and experiencing degrees of "mind-blindness" (Baron-Cohen, 1995) or degrees of deficit in "empathizing" (Baron-Cohen, Wheelwright, Lawson, Griffin, & Hill, 2002).

The neural network that underlies these abilities was first described by Brothers and Ring as

Correspondence should be addressed to: Ofer Golan, Autism Research Centre, Douglas House, 18b Trumpington Road, Cambridge CB2 2AH, UK. E-mail: og211@cam.ac.uk
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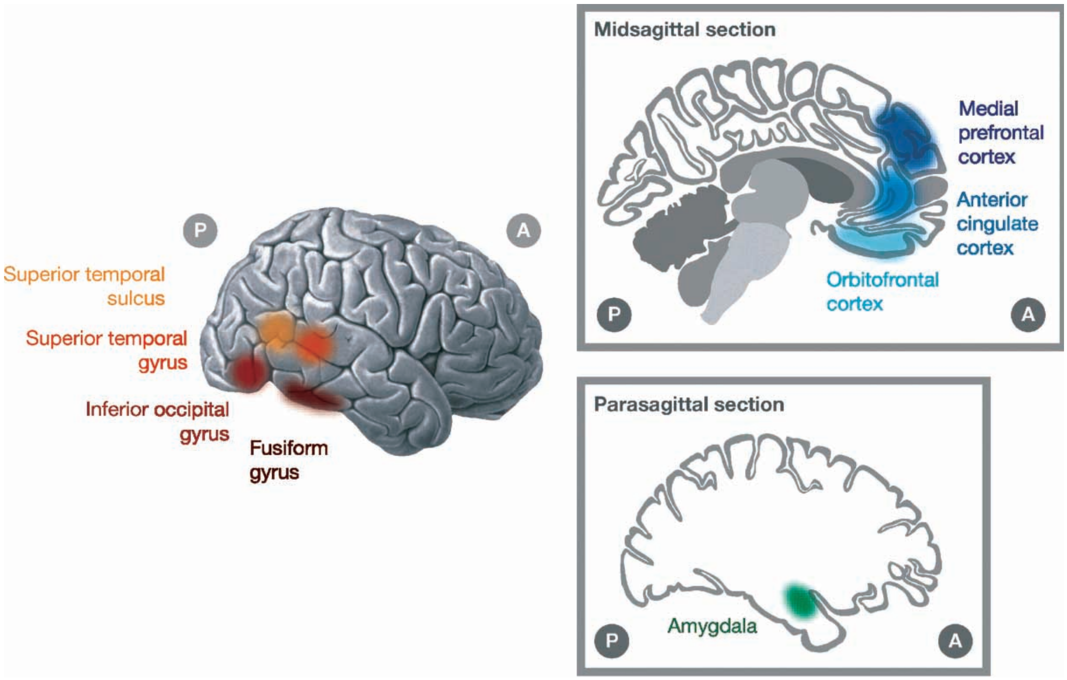

Figure 1. The social brain network (from Baron-Cohen & Belmonte, 2005; reprinted with permission).

''the social brain'' (Brothers & Ring, 1992), and is illustrated in Figure 1. The medial, inferior frontal and superior temporal cortices, along with the amygdala, form a network of brain regions that implement computations relevant to social processes. Perceptual inputs to these social computations may arise in part from regions in the fusiform gyrus and from the adjacent inferior occipital gyrus that activate in response to faces.

Neuroimaging studies of ToM in ASC reveal that individuals with autism show less activation than controls from the general population in these ''social brain'' areas, e.g., lower activation of the left medial prefrontal cortex when reading stories that require attribution of mental states (Happe et al., 1996; Nieminen-von Wendt et al., 2003), or lower activation in the medial prefrontal cortex, the superior temporal sulcus and the temporal poles when watching geometric shapes moving in a way that can be interpreted as social (Castelli, Frith, Happe, & Frith, 2002). In an MRI study using a task of emotion and mental state recognition from pictures of eyes, participants with ASC had less extensive frontal activation than controls, and no activation of the amygdala (Baron-Cohen et al., 1999b). This latter finding prompted the amygdala theory of autism (Baron-Cohen, Ring, Bullmore, Wheelwright, Ashwin, & Williams, 2000a). In addition, the control group had a significantly stronger response in the left amygdala, the right insula and the left inferior frontal gyrus (Baron-Cohen et al., 1999b). A related study using mental state vs. non-mental state words in an auditory paradigm involving SPECT found the orbito-frontal cortex was less active in autism, compared to controls (Baron-Cohen, Ring, Moriarty, Schmitz, Costa, & Ell, 1994). A recent MRI study scanning parents of children with ASC during the same ''Eyes'' task demonstrated that reduced activations in parts of the social brain during this task are evident in first-degree relatives, suggesting this may represent an ''endophenotype'' (Baron-Cohen et al., 2006).

Another key cognitive theory of autism views the socioemotional deficit in terms of ''weak central coherence'' (WCC; Frith, 1989; Happe, 1999), suggesting that ASC are characterized by an increased focus on detail and difficulties integrating information into a coherent whole. According to this theory, without the ability to group details in context to derive meaning, individuals with autism experience a fragmented world. Social functioning, which requires fast integration of context-dependent information in real time, would be seriously hampered under such conditions.

Models of brain function in autism suggest that WCC is the cognitive manifestation of altered connectivity between local ''low-level'' perceptual brain systems and frontal brain regions in charge of integration or "coherence". If brain regions that control integration are less connected to their perceptual inputs, the resulting cognitive-behavioral outcome would be enhanced local, on account of reduced global, processing (Baron-Cohen & Belmonte, 2005; Belmonte, Allen, Beckel-Mitchener, Boulanger, Carper, & Webb, 2004a). In a visual signal detection MRI study adults with ASC showed heightened ventral occipital brain activation and lowered pre-frontal, parietal, and temporal activation, compared to controls (Belmonte & Yurgelun-Todd, 2003). A related MRI study using the Embedded Figures Task with adults with ASC found a similar pattern of differences (Ring et al., 1999). Although these findings relate to low level visual information processing, such under-connectivity between brain regions could explain the social deficit in ASC in terms of failure to utilize social cues to understand socioemotional phenomena (Belmonte et al., 2004a, 2004b; Critchley et al., 2000).

The current study focuses on the recognition of emotions and mental states in others, which is a fundamental part of empathizing. In addition, emotion recognition strongly depends on the ability to integrate multimodal information in context. Hence, both ToM and WCC theories would predict difficulties in this domain in ASC. Indeed, research shows that emotion and mental state recognition are core difficulties in children and adults with ASC (Baron-Cohen, 1995; Hobson, 1994). Such difficulties have been found through cognitive, behavioral and neuroimaging studies, and across different sensory modalities (Frith & Hill, 2004). Neuroimaging studies reveal that people with ASC show less activation in brain regions not just related to emotion recognition but to face processing in general, such as the fusiform gyrus (Critchley et al., 2000; Pierce, Muller, Ambrose, Allen, & Courchesne, 2001; Schultz et al., 2003). As mentioned above, there is evidence of reduced activation in brain areas that play a major role in processing of emotion, such as the amygdala (Ashwin, Baron-Cohen, Wheelwright, O'Riordan, & Bullmore, in press; Baron-Cohen et al., 1999b; Critchley et al., 2000). These studies suggest that the processing of socioemotional input in ASC is qualitatively different to that of controls from the general population.

Most emotion recognition studies carried out with individuals with ASC have focused on the recognition of six emotions, considered "basic" (happiness, sadness, fear, anger, surprise and disgust). These "basic emotions" are expressed and recognized cross-culturally (Ekman, 1993; Ekman & Friesen, 1971) and may be neurologically distinct (Adolphs, 2002; Griffiths, 1997). Studies assessing the recognition of these emotions report inconclusive findings with children and adults with ASC. Some studies report difficulties in recognition of basic emotions from dynamic or static facial expressions, from voice recordings, and from matching of stimuli from the two modalities (Celani, Battacchi, & Arcidiacono, 1999; Deruelle, Rondan, Gepner, & Tardif, 2004; Hobson, 1986a, 1986b; Loveland, Tunali Kotoski, Chen, & Brelsford, 1995; Macdonald et al., 1989; Yirmiya, Sigman, Kasari, & Mundy, 1992). Other studies have found no such difficulties in recognition of the basic emotions in children and adults with ASC (Adolphs, 2001; Baron-Cohen, Spitz, & Cross, 1993; Boucher, Lewis, & Collis, 2000; Grossman, Klin, Carter, & Volkmar, 2000; Loveland et al., 1997).

These inconclusive findings may be due to ceiling effects in basic emotion recognition tasks that focus on faces or voices alone. In other words, though they are delayed in recognition of basic emotions compared to typically developing controls, many adults with ASC may compensate for their early deficit in this area and thus pass these tasks to a similar level seen in controls, if the tasks are not too challenging (Adolphs, Sears, & Piven, 2001; Grandin, 1995).

This possible ceiling effect in basic emotion recognition tasks raises two questions: First, can adults with ASC recognize emotions and mental states that are more complex? These could be cognitive, belief-based rather than situation-based emotions (Harris, 1989), e.g., *troubled*, or *resigned*. They could also be social emotions, e.g., *caring* or *embarrassed* (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997a; Kasari, Chamberlain, & Bauminger, 2001).

The second question deals with the ability of individuals with ASC to recognize emotions from more ecological, life-like situations. These usually require integration of facial expressions, body language, intonation, verbal content and the contextual cues into a coherent picture, rather than relying on discrete emotional stimuli like faces or voices, or specific features of these. Typically developing children and adults integrate all these features automatically and unconsciously when processing social situations, but can individuals with ASC do this?

The first question has been addressed in several studies conducted with children and adults with ASC in which they were asked to recognize complex emotions and mental states from visual emotional stimuli. Tasks included pictures of eyes (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001a; Baron-Cohen, Wheelwright, & Jolliffe, 1997b; Baron-Cohen, Wheelwright, Spong, Scahill, & Lawson, 2001c), and static and dynamic facial expressions (Baron-Cohen et al., 1997b; Golan, Baron-Cohen, & Hill, 2006b). Auditory tasks have used short utterances (Golan, Baron-Cohen, Hill, & Rutherford, in press; Kleinman, Marciano, & Ault, 2001; Rutherford, Baron-Cohen, & Wheelwright, 2002). Other tasks have assessed the ability to detect mental states from contextual cues (Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999a; Fein, Lucci, Braverman, & Waterhouse, 1992; Happe, 1994). In all of these studies, individuals with ASC performed at a significantly lower level compared to controls, matched for age and IQ. These results suggest that recognition of basic emotions might be relatively preserved (or compensated for) in individuals with ASC, but that they show difficulties recognizing more complex emotional and mental states.

The second question has received less empirical attention. As far as we are aware, only two studies have assessed the ability of adults with ASC to recognize emotions and mental states from more ecological stimuli. "The Awkward Moments Test" (Heavey, Phillips, Baron-Cohen, & Rutter, 2000) presented participants with seven short social situations, all taken from television advertisements. They were asked to judge the protagonist's mental state at the end of each scene. Participants with ASC performed at a significantly lower level compared to general population controls. In another study (Klin, Jones, Schultz, Volkmar, & Cohen, 2002a, 2002b), a single social scene from a feature film was presented to adults with ASC, while tracking their gaze. Compared to typically developed controls, participants with ASC looked less at the eyes of characters, and more at characters' mouths and surrounding objects, thus missing socioemotional information pertinent to the understanding of the social situation. Both of these studies suggest high-functioning adults with ASC are impaired on more ecological tests of social understanding. However, both studies involved tasks with a relatively small number of scenes (seven in one, and one in the other), which limits their validity and power and risks floor or ceiling effects. "The Awkward Moments Test" also used adverts, which are by definition exaggerated. A more subtle collection of social situations may better represent the complexity of socioemotional interactions that we typically encounter, and provide a more valid measure of the ability of adults with ASC to interpret them.

In this study, we report the "Reading the Mind in Films" (RMF) task, which assesses complex emotion and mental state recognition. We compare the ability of adults with Asperger Syndrome (AS) or High Functioning Autism (HFA) with that of adults from the general population. The task uses 22 short scenes, taken from feature films (with permission). The scenes include visual input (facial expressions, body language, action), auditory input (prosody, verbal content) and context, thus making the task more ecological than previous tasks testing each modality separately. The emotions and mental states selected vary in valence, intensity and complexity. They were chosen for their relevance to everyday social interaction. Hence, any recognition deficit could impede one's functioning in social situations. For example, if the speaker fails to recognize the listener's embarrassment in a conversation, she or he may not attempt to change the subject, and may, without realizing it, offend or cause distress in the listener (Grandin, 1995).

Judging complex emotions from ecological social stimuli requires integration of multimodal information into a coherent holistic picture as well as attribution of mental states to others. Therefore, based on the ToM or WCC models of autism, we predicted that participants with ASC would score significantly lower than controls on the RMF task. In addition, we hypothesized that the more autistic traits one possesses, the lower one's score on the task. In order to rule out that difficulties in responding to the task are simply due to working memory problems, we tested for a correlation between task performance and item length, with the number of characters appearing in the item. We also tested for a correlation between task score and age or IQ. We hypothesized that a positive association between task scores and verbal IQ would be found for both groups, given that the task involves matching a mental state word to a character's action. Lastly, we tested for correlations between the RMF task score with other complex emotion recognition tasks (from faces and voices separately), to validate our new task.

METHOD

Participants

The AS/HFA group comprised 22 adults (17 males and 5 females), aged 17–52 ($M = 29.0$, $SD = 9.8$). Participants had all been diagnosed with AS/HFA in specialist centers using established criteria (American Psychiatric Association, 1994; World Health Organization, 1994). They were recruited from a local clinic for adults with ASC, and from a research volunteer database. The control group comprised 22 adults (18 males and 4 females) from the general population, aged 18–51 ($M = 25.4$, $SD = 9.5$). They were recruited from a local employment agency. All participants were given the Wechsler Abbreviated Scale of Intelligence (WASI), comprising the vocabulary, similarities, block design and matrix reasoning tests. The WASI produces verbal, performance and full scale IQ scores, with correlations of .88, .84 and .92 with the full Wechsler scales (Wechsler, 1999). All participants scored above 85 on both verbal and performance scales. Their IQ scores are shown in Table 1. To screen for autism spectrum conditions, participants also filled in the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001b). Replicating Baron-Cohen et al.'s (2001b) finding, 86.4% of the AS/HFA group and none of the control group scored above the cut-off score of 31. The two groups were matched on sex ($\chi^2(1) = 0.14$, *ns*), age, verbal IQ, and performance IQ. The groups' background data appears in Table 1.

Instruments

Reading the Mind in Films (RMF): Task development

The film clips are available at www.autismresearchcentre.com/tests. Thirty short scenes (5–30 seconds long, $M = 14.8$, $SD = 9.2$), were sampled from three feature films and one mini series by two of the authors. The films were picked for their dramatic value and frequent occurrence of emotional scenes. The selected scenes involved emotional interaction between 1–4 characters, and the expression of complex emotions and mental states (e.g., *smug*, *awkward*, *concerned*). In each scene, a protagonist was identified and their emotion or mental state at the end of the scene was labeled. Three foils were selected for each item. In order to match the foils and the target word for verbal difficulty, an emotion taxonomy was used (Baron-Cohen, Golan, Wheelwright, & Hill, 2004). The taxonomy comprises 412 emotions and mental states, in six developmental levels. Selected foils were either in the same or easier levels than the target. Foils were selected so that they matched some of the emotional information in the scene but not all of it, e.g., matching the content of the language but not the intonation or the context. The labels and foils were then reviewed by two independent judges. A handout with definitions for all the target and foil words in the items included was prepared for participants' use before and during the task.

The items were then played to 15 adults (7 men and 8 women) randomly selected from the general population. They were played to them on a laptop computer, using DMDX experimental software (Forster & Forster, 2003). Two examples of items from the task are shown in Figure 2.

TABLE 1
Means, standard deviations and ranges of AQ, chronological age and WASI scores for the AS/HFA group and the control group

	AS/HFA group (n = 22)			*Control group (n = 22)*			
	Mean	*SD*	*Range*	*Mean*	*SD*	*Range*	*t(42)*
AQ	38.5	7.8	16–49	14.0	5.4	6–26	12.11**
Age	29.0	9.8	17.4–52.0	25.4	9.6	17.6–51.2	1.25
Verbal IQ	110.6	10.8	87–129	116.4	14.5	86–138	1.49
Performance IQ	114.8	12.5	97–140	113.1	8.4	92–129	0.51
Full scale IQ	114.2	10.8	91–130	116.5	11.0	97–138	0.71

Note: ** $p < .001$. For all the other measures $p > .1$.

Figure 2. Two items from "Reading the Mind in Films" (showing only one frame each out of the full clips). (A) At the end of the scene, how is the older woman feeling? (1) Sociable; (2) Admiring; (3) *Overcome*; (4) Liked (screenshot taken from *The Turn of the Screw* [1999] courtesy of Granada International). (B) At the end of the scene, how is the man feeling? (1) Ashamed; (2) Unsure; (3) *Awkward*; (4) Annoyed (screenshot taken from *Lost for Words* (1999) courtesy of ITN Archive).

Example (A), labeled *overcome*, depicts a young woman complimenting an older woman on the way she educated the children. The older woman thanks her several times calmly, then runs towards her with tears in her eyes saying, "Oh miss, I'm so glad you're here". Example (B), labeled *awkward*, depicts a man walking into a living room full of women watching him looking for the lady of the house, and then saying, "I seem to have picked the wrong time".

Next, an item analysis was carried out. Items were included if the target answer was picked by at least half of the participants, and if no foil was selected by more than a third of the participants. Six items were excluded after failing to meet these criteria. Hence, the final task comprised 22 items and the task score varied between 0 and 22.

In addition, several other measures were administered.

Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001b)

The AQ is a self-report questionnaire, which measures the degree to which any individual (adult) of normal IQ possesses traits related to the autistic spectrum. Scores range from 0 to 50, and the higher the score, the more autistic traits a person possesses.

The Cambridge Mindreading Face–Voice Battery (CAM; Golan et al., 2006b)

This battery tests recognition of twenty complex emotions and mental states from short silent video clips of faces and from voice recordings. The face task comprises silent clips of adult actors, expressing the emotions in the face. The voice task comprises recordings of short sentences expressing various emotional intonations. The battery provides an overall facial and an overall vocal emotion recognition score, as well as an overall number of the emotions correctly recognized. Individuals with AS/HFA score significantly lower than controls on all three measures in the battery (Golan et al., 2006b). Test–retest correlations, calculated for individuals with AS/HFA were $r = .94$ for the face task and $r = .81$ for the voice task.

Procedure

Participants were tested in the second session of an intervention study (Golan & Baron-Cohen, 2006), in which they all served as controls (i.e., no intervention). They were tested at the Autism Research Centre in Cambridge University. The final version of the task was presented to the participants on a computer screen, using DMDX experimental software. Headphones were given, to improve perception. An instructions slide and a practice item preceded the task. The definition handout was given to participants and was available throughout the task with no time limit to answer each item. Completion of the task took about twenty minutes, including a short break.

RESULTS

Task scores were calculated by counting the number of correct answers for each participant.

TABLE 2
The 22 target emotions and mental states included in the task, and the percent of participants who selected them for the two groups

	Correctly recognized (%)	
Emotion/mental state	*AS/HFA group*	*Control group*
Annoyed	77	73
Awkward	64	86
Belittled	45	68
Bitter	18	18
Concerned	55	77
Disconcerted	45	91
Disliking	50	82
Embarrassed	64	68
Enjoying	64	100
Exasperated	64	82
Incensed	68	86
Overcome	59	82
Pleased	77	91
Prickly	36	14
Reflective	50	64
Resentful	36	41
Resigned	59	73
Smug	73	86
Stern	64	55
Troubled	50	59
Unassuming	73	95
Worried	73	73

All the participants in the control group and all but three of the participants in the AS/HFA group scored above chance (i.e., above 9, $p <$ .05, Binomial test) on the RMF task. The proportion of correct responses to task items did not correlate significantly with the items' length ($r_{\text{spearman}} = .05$, *ns*) or with the number of characters appearing in them ($r_{\text{spearman}} = .25$, *ns*).

A review of percentage of correct responses for the 22 items of the task (see Table 2) shows that no item was answered correctly by 100% of the participants with AS/HFA, and that only one item was answered correctly by all the participants in the control group. In two items, the target emotion label was picked by less than a third of the typically developing participants. In the first, 55% of the control group preferred the foil *intimate* to the target *bitter*. This foil was designed to match all aspects of the emotional information except intonation, which distinguished the target from it and from the other foils. In the second item, participants preferred any of the foils to the target *prickly*, possibly due to it being an uncommon label for an emotion. However, since problems with these items did not occur in the original validation phase, these items were not excluded from the analysis.

To compare the performance of the two groups on the RMF task, an analysis of covariance (ANCOVA) was performed on task scores, with group as the independent variable and with Verbal IQ, performance IQ, and age as covariates. The analysis yielded a significant group main effect, $F(1, 39) = 10.52$, $p < .005$. As hypothesized, the AS/HFA group ($M = 14.96$, $SD = 3.28$) performed significantly lower than the control group ($M = 18.77$, $SD = 2.41$). In addition to the group main effect, the ANCOVA also yielded a significant effect of verbal IQ $F(1, 39) = 10.93$, $p <$ .005. Correlation analysis revealed a significant positive correlation between task scores and verbal IQ ($r = .48$, $p < .005$). Task scores were not significantly correlated with age ($r = .09$, *ns*), or with performance IQ ($r = -.08$, *ns*). As predicted, RMF scores were negatively correlated with AQ scores ($r = -.52$, $p < .001$). However, when computed separately for the two groups, only the control group had a significant correlation ($r = -.51$, $p < .02$), whereas in the AS/HFA group the correlation became non significant ($r = -.07$, *ns*). Correlations of RMF scores with CAM scores were, as predicted, positive for the CAM face task ($r = .63$, $p < .001$), CAM voice task ($r =$ .62, $p < .001$) and number of CAM emotional concepts recognized ($r = .61$, $p < .001$).

Power calculations for the task (two tailed, with $\alpha = .01$) revealed a power level of $1 - \beta =$ .948. In a discriminant analysis, the significant discriminant function, $\chi^2(22) = 34.5$, $p < .05$, successfully classified 90.9% of the participants (86.4% of participants with AS/HFA and 95.5% of controls) into their original groups.

DISCUSSION

This study reports the "Reading the Mind in Films" (RMF) task, a new "ecological" task for assessing recognition of complex emotions and mental states, using social scenes from films. Results show that high-functioning participants with autism spectrum conditions (ASC) scored significantly lower than matched controls in the general population. This effect was not simply due to the association of task scores with verbal ability. The task quantifies the difficulties that individuals with ASC experience in recognizing complex emotions and mental states in everyday life.

The task has a wide score range in both groups, with no ceiling or floor effects. Power calculations and discriminant analysis showed it is sensitive and that more than 90% of the participants could be correctly allocated to their groups, based solely on their task performance. RMF scores significantly correlated with existing complex emotion recognition tasks, confirming its validity. Performance on the task was not correlated with length of its items or the number of characters appearing in the scenes, suggesting that there was no working memory confound.

The significant group difference on task scores replicates previous findings of difficulties among high-functioning adults with ASC on tasks involving recognizing complex emotions and mental states in film tasks (Heavey et al., 2000; Klin et al., 2002a, 2002b). Compared to the instruments used in these studies, our task includes a larger number of items and covers a wider range of complex emotions and mental states. It adds to existing evidence of the deficit in complex emotion and mental state recognition in ASC. This deficit is viewed as part of the cognitive component of empathy (Baron-Cohen, 2003; Baron-Cohen & Wheelwright, 2004; Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004) and can explain, in part, the lack of empathy that is often reported in ASC (Gillberg, 1992; Hobson, 1993; Wing, 1981).

The RMF task is an ecological socioemotional task, which requires the integration of multimodal information from faces, eye direction, prosody, verbal content and context. As such, performance on it is likely to associate with functioning, as well as with connectivity between areas in the social brain network. Previous studies have depicted reduced functionality of social brain areas in ASC during processing of socioemotional stimuli (Critchley et al., 2000; Dalton et al., 2005; Howard et al., 2000; Wang, Dapretto, Hariri, Sigman, & Bookheimer, 2004) as well as altered connectivity in social brain areas (Welchew et al., 2005). However, most studies of emotion processing in the brain focused on one modality, and it is possible that when multimodal integration is required, additional brain areas will be recruited. Indeed, in an imaging study of typical adults, Iacoboni et al. found that watching ecologic social (compared to non-social) scenes activated the inferior frontal cortex, the superior temporal cortex, and the fusiform gyrus, but also the medial parietal (precuneus) and dorsomedial prefrontal cortices (Iacoboni et al., 2004). Another study, using still facial expressions in conjunction with vocal emotional expressions, reported increased activation in the medial temporal gyrus in the bimodal, but not in any of the unimodal, conditions (Pourtois, de Gelder, Bol, & Crommelinck, 2005). Differential activation was found even within the same (visual) channel, between static and dynamic facial stimuli. When compared to static emotional expression, dynamic facial expressions of emotion were associated with differential V5, superior temporal sulcus, periamygdaloid cortex, cerebellum extrastriate cortex, and middle temporal cortical activation (Kilts, Egan, Gideon, Ely, & Hoffman, 2003). These studies suggest the investigation of multimodal processing of socioemotional stimuli may result in new findings about the functionality and connectivity in the social brain.

We are unaware of brain imaging studies that have used ecological multimodal films with individuals with ASC. One study that attempted to increase the salience of emotional faces using supporting prosodic information found that not only did the prosodic information fail to increase performance of participants with autism, their performance actually decreased due to the presentation of stimuli in both channels. Participants with ASC showed not only reduced activity in the right fusiform region, as observed previously, but also reduced inferior frontal activation. These results suggest that when recognizing emotion, high-functioning adults with autism place less processing emphasis on the extraction of facial information and the assembly and evaluation of an integrated emotional experience than do participants without autism (Hall, Szechtman, & Nahmias, 2003). It will be important to use the RMF task in brain imaging studies in the typical and the autistic brain.

The task scores' correlation with verbal IQ, which was predicted due to the task's verbal nature, is also indicative of the participants' use of verbal content to pick up the protagonists' mental states. Previous studies report that individuals with ASC use verbal content as a way to compensate for their difficulties in theory of mind tasks (Tager-Flusberg, 2000), labeling basic emotions from facial expressions (Adolphs et al., 2001; Grossman et al., 2000), and noticing socioemotional cues in situations (Kasari et al., 2001; Klin et al., 2002b). In the typical brain, whereas processing of language occurs in the speech areas of the left hemisphere, processing prosody happens in the right posterior superior temporal sulcus (extraction of specific acoustic cues from complex speech signals), and the dorsolateral and orbitobasal frontal areas (evaluation of emotional associations; Pell, 2006; Wildgruber et al., 2005). Therefore, if verbal ability is retained and used to compensate for prosodic and visual cue deficits among individuals with ASC, we might expect lower activation in the right hemisphere areas, but intact and perhaps increased activation in the left verbal areas (Sabbagh, 2004). This compensatory mechanism is likely to be utilized more the higher one's verbal abilities.

However, on the RMF task, since foils were designed to match the verbal content but not other social cues in the scene, relying on language alone may have resulted in misinterpretation of protagonists' mental and emotional states. The following examples show how failing to integrate verbal content with prosody and facial expression in context leads participants with ASC to mislabel emotions: In example (A), presented in Figure 2, 59% of the AS/HFA group members labeled the protagonist's emotional state as *overcome*, compared to 82% of controls. While 23% of the participants in the clinical group labeled the protagonist's emotion in this scene as *admiring*, only 9% of the participants in the control group gave this label. Participants who chose this distracter might have relied on the verbal content only (''Miss, I'm so glad you're here''), while missing the strong emotional component of the protagonist's communication, which could be picked up from her facial expression, intonation and gestures.

Similarly, the item presented in example (B) of Figure 2 was correctly recognized by 86% of the controls and 64% of the participants with AS/HFA. In the clinical group, 27% chose the label *unsure* as the protagonist's mental state, compared to only 9% of the controls. In this example too, the distracter *unsure* represents a more cognitive and less affective label, which mostly relies on the protagonist's verbalization and fails to acknowledge the social situation that he found himself in.

Yet another example was the mislabeling of a protagonist being *concerned*, which was correctly recognized by 77% of controls and 55% of participants with ASC. The scene shows the protagonist's concerned face, though when asked if she is enjoying herself she answers, ''Yes, I am'', in a concerned tone of voice. In the AS/HFA group, only 5% of the participants relied on the verbal content of the protagonist's response and chose *enjoying* as their answer. However, 36% labeled this contradiction between the verbal content, facial expression and tone of voice as *mysterious*. Whereas this example shows that participants with ASC may have spotted the mismatch between verbal and non-verbal communication in the scene, many of them still had difficulties in realizing which modality better represents the protagonist's emotional state. These examples demonstrate the kind of errors that adults with ASC make when interpreting others' mental states, some more subtle than others, which in real life situations could lead to wrong interpretation of the interaction and to inappropriate responses. These subtle differences stress the importance of an ecological assessment of socioemotional understanding in high-functioning adults with ASC, as they may be able to pass more basic emotion recognition tasks.

Further investigation is needed of the strategies that adults with ASC use in order to interpret emotional and mental states in social situations. Our task employed a forced-choice paradigm, which may explain the relatively good performance by the participants with ASC. The use of open-ended descriptions of situations, as well as neuroimaging and eye-tracking techniques, could reveal the behavioral and neuropsychological aspects of any compensatory strategies. Using imaging and gaze tracking techniques could also eliminate the need for any verbal component to the task, which had a significant effect on performance in the current study.

Studies conducted with typically developing preschoolers have shown that children who have more siblings perform better on theory of mind measures (false-belief tasks; Flavell, 1999; Lewis, Freeman, Kyriakidou, Maridaki-Kassotaki, & Berridge, 1996). In addition, anecdotal reports of high-functioning adults with ASC describe how they consciously collect examples from past social experiences and implement them in current interactions (Grandin, 1995). Hence, it will be interesting to examine to what extent this knowledge can be acquired through training (Golan & Baron-Cohen, 2006). If age is a rough measure of social experience, then we might expect a positive association between age and complex emotion recognition. In this study, no correlation was found between age and task performance. A larger clinical sample, as well as a study investigating complex emotion recognition among children with ASC could help clarify this question.

Our lab is currently running such a study (Golan, Baron-Cohen, & Golan, 2006a).

Another interesting finding was the differential correlation between task scores and self-reported level of autistic traits as measured by the AQ. In the control group, where the range of AQ scores was wider, a negative correlation was found, suggesting that the more autistic traits one possesses, the harder is the recognition of complex emotions and mental states. The lack of such a correlation in the clinical group may have been due to the relatively narrow range of AQ scores. Again, a larger clinical sample may help reveal whether such an association exists within this group. A full understanding of the integrative processing of cross-modal socioemotional information in ASC is still needed.

We conclude that the ‘‘Reading the Mind in Films’’ task allows quantification of the complex emotion recognition skills, which distinguish individuals with ASC from controls in the general population. This new task may be useful in intervention research, to monitor improvements in this skill, or to augment diagnostic assessments. The task also lends itself to neuroimaging and gaze tracking and developmental research is being standardized and validated. It will be of interest to apply the task to clinical groups other than ASC in order to establish the sensitivity and specificity of the instrument in detecting both deficits and talents.

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