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The 'Reading the Mind in the Voice' Test-Revised: A Study of Complex Emotion Recognition in Adults with and Without Autism Spectrum Conditions

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Abstract This study reports a revised version of the 'Reading the Mind in the Voice' (RMV) task. The original task (Rutherford et al., (2002), *Journal of Autism and Developmental Disorders*, *32*, 189–194) suffered from ceiling effects and limited sensitivity. To improve that, the task was shortened and two more foils were added to each of the remaining items. About 50 adults with Asperger Syndrome (AS) or High Functioning Autism (HFA) and 22 matched controls took the revised task. Results show the revised task has good reliability and validity, is harder, and more sensitive in distinguishing the AS/HFA group from controls. Verbal IQ was positively correlated with performance, and females performed worse than males in the AS/HFA group. Results are discussed with regard to multi modal empathizing deficits in autism spectrum conditions (ASC).

Keywords Emotion recognition · Complex emotions · Voice perception · Theory of mind · Autism spectrum · Adults

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Introduction

The difficulties individuals with Autism Spectrum Conditions (ASC) have in recognizing emotions and mental states in others have been widely studied during the last two decades. These difficulties are part of the more general deficit individuals with ASC have in 'theory of mind' (Baron-Cohen, Leslie, & Frith, 1985; Baron-Cohen, Tager-Flusberg, & Cohen, 1993, 2000) or 'empathizing' (Baron-Cohen, 2002, 2003). The majority of emotion recognition studies in adults and children with ASC have tested recognition of the six 'basic' emotions (happiness, sadness, fear, anger, surprise and disgust) from faces and voices. These 'basic emotions' have been found to be expressed and recognized cross culturally (Ekman & Friesen, 1971; Ekman, 1993) and are to some extent neurologically distinct (Griffiths, 1997; Adolphs, 2002). Studies assessing the recognition of these emotions by individuals with ASC have been inconclusive. Some studies report difficulties in recognition of basic emotions from dynamic or static facial expressions, from voice recordings and from the matching of stimuli from the two modalities (Hobson, 1986a, b; Hobson, Ouston, & Lee, 1988; Baron-Cohen, Spitz, & Cross, 1993; Loveland, Tunali Kotoski, Chen, & Brelsford, 1995; Celani, Battacchi, & Arcidiacono, 1999; Deruelle, Rondan, Gepner, & Tardif, 2004). However, other studies have found no such difficulties in recognition of the basic emotions in children and adults with ASC in either faces (Buitelaar, Van der Wees, Swabb Barneveld, & Van der Gaag, 1999; Grossman, Klin, Carter, & Volkmar, 2000; Adolphs, 2001), voices (Boucher, Lewis, & Collis, 2000), or the matching of faces and voices (Loveland et al., 1997).

As shown above, in some cases individuals with ASC who are high-functioning (i.e. of average or above average IQ) recognize basic emotions relatively well. Their emotion recognition deficit only becomes apparent when recognition of more complex emotions and mental states is required. Complex emotions and mental states are distinguished from basic emotions by being belief-based rather than situation-based emotions (Harris, 1989), e.g. *confused*, or *resigned*. They could also be social emotions such as *friendly* or *embarrassed* (Kasari, Chamberlain, & Bauminger, 2001). Generally, complex emotions involve attributing a cognitive state as well as an emotion, and are more context and culture dependent (Griffiths, 1997). Some examples of difficulties recognizing complex emotions and mental states in ASC include recognition of mental states from pictures of the eye region only (Baron-Cohen, Wheelwright, & Jolliffe, 1997; Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001), judging trustworthiness from pictures of faces (Adolphs, Sears, & Piven, 2001), recognizing emotions and mental states from films depicting ecologic social situations (Heavey, Phillips, Baron-Cohen, & Rutter, 2000; Klin, Jones, Schultz, Volkmar, & Cohen, 2002a, b), and recognizing irony, sarcasm or faux pas from descriptions of social situations (Happe, 1994; Baron-Cohen, O'Riordan, Stone, Jones, & Plaisted, 1999).

Very few of the studies investigating emotion recognition in ASC have studied recognition of emotions and mental states solely from vocal stimuli. Studies conducted with participants from the general population have evaluated use of the linguistic content of vocalizations, versus paralinguistic features when recognizing emotions. These two features of emotional speech have been found to be processed separately in the brain, with verbal content being processed in the left hemisphere and intonation being processed in the right hemisphere (McNeely & Parlow, 2001; Wildgruber et al., 2005). From developmental studies we know that the perception of emotional content in the voice is evident as early as 5 or even 4 months of age. Using a habituation paradigm, it was found that 7 month olds could discriminate some emotion pairs if the voice information was present, while they could not make the same discrimination based on a visual face presentation alone (Caron, Caron, & MacLean, 1988). Another study showed that when young children are presented with contradictory emotional information in the linguistic and paralinguistic domains (e.g. a happy sentence uttered in an angry intonation), they rely mostly on the linguistic content to label the speaker's emotional state. In contrast, adults who are faced with the same task label the speaker's emotional state based on the paralinguistic features of the verbalization. The older the children tested, the more they relied on the speaker's intonation in their answers (Morton & Trehub, 2001). These findings demonstrate the ability of typical adults to process these two aspects of emotional speech and make use of both in labelling the speaker's mental state. Recently, a study conducted with individuals with ASC found they had difficulties using intonation and pragmatic/emotional stress in speech to make socio-emotional judgments, such as whether the speaker is calm or excited, or whether she/he is talking to a child or to an adult (Paul, Augustyn, Klin, & Volkmar, 2005). It is possible that in an emotion recognition task, which includes both verbal content and intonation, adults with ASC will focus only on the linguistic content.

The studies assessing emotion recognition from voices described above focused only on basic emotions. We are only aware of two studies assessing complex emotion recognition from voices in ASC: Kleinman, Marciano, and Ault (2001) created an advanced theory of mind task that was based on the 'Reading the Mind in the Eyes' task (RME) (Baron-Cohen et al., 1997) but in the vocal domain. Their vocal task tested the recognition of six basic and six complex emotions, using a neutral sentence read with different intonations. Rutherford, Baron-Cohen, and Wheelwright (2002) created the 'Reading the Mind in the Voice' (RMV) task, in which 40 segments of speech, taken from different BBC dramas, were played on audio tape to participants, who were asked to choose one out of two possible words, each describing the speaker's possible mental state. This tested recognition of a wider range of complex emotions, and included both intonation and verbal content, and was arguably more ecologically valid than the task reported by Kleinman et al. (2001). Both studies tested high-functioning adults with ASC and found a deficit in their complex emotion recognition. However, some limitations were found with both instruments.

Kleinman et al. used only a small number of complex emotions, and only a small number of items overall. Each of the items had only two answers to choose from, so that correct performance could be achieved by chance alone. In a 12 item task with two possible answers per item, the minimum score that is above chance is 10 (Binomial test, $p < 0.05$). This meant that the range of above-chance scores for this task is just 10–12, which weakens the task's sensitivity and risks ceiling effects. Indeed, from the results reported by the authors, it seems that many participants in the control group scored at ceiling.

The study by Rutherford et al. (2002), while including a wider range of complex emotion items, still had only two possible answers per question. As the authors themselves suggested, the task's sensitivity could have been improved by adding foils to each item. In addition, the authors noted that some of the items did not differentiate between the ASC group and the control groups. By removing these items, the task could have been made more sensitive, as well as briefer to administer.

In the study reported below, these suggested amendments have been implemented, thus constituting a revised version of the 'RMV' task. The revised task (RMV-R) was tested on a group of adults with Asperger Syndrome (AS) and High Functioning Autism (HFA), and matched typically developed controls. Further to the results of the original study, and other studies of complex emotion recognition in ASC mentioned above, we predicted that task scores of the AS/HFA group would be significantly lower than those of the control group.

Based on the extreme male brain theory of autism, and the reports of female superiority in empathy and emotion recognition tests (Baron-Cohen, 2002, 2003; Baron-Cohen & Wheelwright, 2004; Lawson, Baron-Cohen, & Wheelwright, 2004), one would predict that typical females would perform better than typical males on our task, who in turn should perform better than individuals with ASC. However, no studies have tested sex differences in emotion recognition among individuals with ASC. These were examined on the revised task scores.

Due to the lack of complex emotion recognition tasks using voices, we validated our revised task against the revised 'Reading the Mind in the Eyes' ('RME-R') (Baron-Cohen, Wheelwright, Hill, Raste & Plumb 2001a). As emotion recognition difficulties are characteristic of ASC across perceptual modalities (Hobson, 1993), we predicted a positive correlation between the two tasks. Levels of empathic ability on complex emotion recognition tasks were previously found to correlate negatively with level of autism spectrum symptoms, suggesting that the more autistic traits one possesses, the more difficulties they will experience recognizing emotions and mental states in others (Baron-Cohen et al., 2001a; Baron-Cohen & Wheelwright, 2004; Golan, Baron-Cohen, & Hill, 2006). We predicted a similar negative correlation between the revised task score and self reported levels of symptoms, using the Autism Spectrum Quotient (AQ) (Baron-Cohen et al., 2001b).

Both Rutherford et al. (2002) and Baron-Cohen et al. (1997, 2001a) reported no correlation between RMV or RME scores and IQ. No such correlation was found in our study of complex emotion recognition from faces and voices (Golan et al., 2006), suggesting that recognition of complex emotions and mental states is independent of intellectual ability. Hence, we predicted that no such correlation would be found for the revised task. Finally, we aimed to calculate the power, reliability and validity of the revised task, and compare this with the original task.

Methods

Participants

The AS/HFA group comprised fifty adults (40 males and 10 females), aged 17–50 ($M = 27.5$, $SD = 8.5$). Participants had all been diagnosed in specialist centres using established criteria (American Psychiatric Association, 1994; World Health Organisation, 1994). They were recruited from several sources, including a local clinic for adults with ASC, support organizations and colleges for individuals with ASC around the UK. 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 0.88, 0.84 and 0.92 with the full Wechsler scales (Wechsler, 1999). All participants scored above 80 on both verbal and performance scales. Mean verbal IQ score was 112.4 ($SD = 11.6$) and mean performance IQ score was 112.5 ($SD = 12.7$).

The control group comprised 26 adults recruited from a local employment agency. After screening for autistic spectrum conditions using the AQ (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001b), four participants were excluded for scoring above cut-off of 32. The remaining 22, 17 males and five females, matched the clinical group in age (range = 17–51, mean age = 24.3, $SD = 7.7$) verbal IQ (mean = 114.5, $SD = 13.5$) and performance IQ (mean = 111.5, $SD = 8.4$). The groups were also matched on employment status and education. Chi-square tests for sex, employment and education, and t tests for age, verbal and performance IQ revealed no significant differences between the groups at the $p < 0.05$ level (see Table 1).

Instruments

Reading the Mind in the Voice-Revised Task Development

As the original task created by Rutherford et al was recorded on audio cassettes, our first step was to

Table 1 Means, standard deviations and ranges of chronological age and WASI IQ scores for the AS/HFA and control groups

	AS/HFA group (n = 50)	Control group (n = 22)	t(70)
Age	27.51 (8.49)	24.30 (7.71)	1.52
	17.4–49.9	17.6–51.2	
Verbal IQ	112.38 (11.60)	114.45 (13.49)	0.67
	84–132	86–138	
Performance IQ	112.54 (12.68)	111.50 (8.44)	0.35
	88–135	92–128	
Full Scale IQ	113.82 (11.51)	114.45 (9.94)	0.22
	92–138	97–138	
			$\chi^2(1)$
Percentage of females	20.0%	22.7%	0.07
Percentage of Employed	38.0%	45.5%	0.35
Percentage have A levels or above[a]	54.0%	54.5%	0.002

p > 0.1 for all tests

[a] A levels are the first component of non-compulsory education in Britain

sample the 40 items onto a computer and digitally 'clean' tape recording noise. Two items, which were completely distorted, were excluded at this point. Next, two of the authors allocated two more foils for each item. Foils were selected to match the content of the verbalizations but not the intonation, thus making the task harder. For example, for the verbalization ''Yeah, well, I know nothing about that'', for which the original task two answers were 'Defensive' (correct) and 'Joking' (incorrect), had two foils added: 'Unconcerned' and 'Indignant'.

In order to keep word difficulty similar to the existing target and foil of each item, an emotion taxonomy was used (Baron-Cohen, Golan, Wheelwright, & Hill, 2004). The taxonomy comprises 412 emotions and mental states, each in one of six developmental levels. Foils were selected on the basis that they were at either the same level, one level above, or one level below, the level of the correct answer. This way, we avoided having a foil that was a much easier or harder word than the others. Next, items were independently reviewed by a third author. Five items were removed at this point, either because of disagreement between the authors, or because the correct answers were judged as inappropriate for the verbalizations. 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 revised items were then played to 15 adults (seven men and eight women) selected at random from the general population. The items and answers were played in random order on a computer, using DMDX experimental software (Forster & Forster, 2003). An item analysis was then carried out. Items were included if the target answer was picked by at least half (i.e. at least 8) of the 15 participants, and if none of the foils was selected by more than a third (i.e. more than 5) of the participants (p < 0.05, binomial test). Eight more items were excluded after failing to meet these criteria. Hence, the final task comprised 25 items. Table 2 presents the revised task items with the correct answer and three foils for each item.

Procedure

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 two practice items preceded the task. The definition handout was given to participants in advance. The handout was available for participants during the task with no time limit. The items were presented in a random order. For each item, the four possible answers were presented on the screen, followed by the verbalization, which was played only once. Participants were then asked to press a number from 1 to 4, to choose the answer which ''best describes how the speaker is feeling''. The computer played the next item 500 milliseconds after an answer was selected, to allow participants to prepare for the next item. Task score ranged from 0 to 25. In addition, several other measures were taken.

Autism Spectrum Quotient (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. The AQ has subscales for communication (e.g. 'I frequently find that I do not know how to keep a conversation going'), social skill (e.g. 'I find it difficult to work out people's intentions'), imagination (e.g. 'I do not particularly enjoy reading fiction'), attention to detail (e.g. 'I tend to notice details that others do not'), and attention switching (e.g. 'I frequently get so strongly absorbed in one thing that I lose sight of other things'). Scores range from 0 to 50, and the higher the score, the

Table 2 The 25 items included in the revised version of 'Reading the Mind in the Voice' (*RMV-R*), their correct answers and foils

	Spoken phrase	Answers			
1	"No, honestly I do."	Defiant	Alarmed	*Earnest*	Convinced
2	"Collie said you were up here."	Surprised	Grateful	*Friendly*	Interested
3	"Your brother? I do not remember you ever speaking of a brother."	Desperate	*Confused*	Threatening	Angry
4	"Where did you get them?"	Frustrated	*Suspicious*	Intrigued	Doubtful
5	"Please! We must go."	*Worried*	Shy	Upset	Insulted
8	"I am afraid he is gone out, sir."	Concerned	*Apologetic*	Dazed	Hurried
9	"I swear I have."	Despairing	*Pleading*	Assertive	Horrified
10	"What on earth do you mean?"	*Perplexed*	Awe	Accusatory	Lured
11	"There's...uh,...there is something I want to ask you."	Assured	*Nervous*	Puzzled	Serious
12	"Keep the damn thing!"	Bossy	*Irritated*	Cruel	Surprised
14	"What a pair!"	*Joyous*	Scared	Playful	Desperate
15	"I have not doctor, but I will."	Decided	*Embarrassed*	Unsure	Furious
16	"Oh, my god!"	*Terrified*	Broken	Frustrated	Angry
17	"Why should I? Why should any of us?"	Arrogant	*Enraged*	Appalled	Scared
18	"But I had hoped..."	*Disappointed*	Unsure	Apologetic	Tearful
20	"I really am most grateful."	Impatient	Admiring	Bitter	*Sincere*
21	"I have no idea what she thought of me."	*Melancholy*	Ambivalent	Aggrieved	Resolved
24	"So, where are you off to now?"	Relaxed	Displeased	Competitive	*Concerned*
25	"I won't harm him, I promise you."	Deceitful	Menacing	Determined	*Sincere*
27	"I think she was trying to make some sort of...gesture."	Angry	*Derogatory*	Resentful	Nostalgic
28	"But I rather think that we have a few things to discuss."	*Stern*	Oppressive	Curious	Complacent
30	"Yeah, well, I know nothing about that."	Unconcerned	Joking	*Defensive*	Indignant
32	"What sort of people do you think we are?"	Impatient	*Insulted*	Disappointed	Curious
33	"Life must go on, Mr. Wilson."	Pitying	Brooding	Irritated	*Resigned*
37	"Katherine, perhaps you'd come to help."	Bossy	Fond	*Hopeful*	Irritated

Item numbers match those of the original task (Rutherford et al., 2002). Target answers are in italics.

more autistic traits a person possesses. Subscales' internal consistency ranges between 0.63 and 0.77 and test retest reliability for the AQ is $r = 0.7$. The AQ was recently reported to have good discriminative validity when validated against diagnostic interviews in a clinical setting (Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005).

'Reading the Mind in the Eyes' Task (Revised, Adult Version) (Baron-Cohen et al., 2001a)

This task has 36 items, in which participants are presented with a photograph of the eyes region of the face and must choose one of four adjectives or phrases to describe the mental state of the person pictured. A definition handout is provided at the beginning of the task and a practice item precedes the first trial. In the present study, the pictures and adjectives were presented on the computer screen (using DMDX software), to avoid possible difficulties due to communication with a human examiner (Ozonoff, 1995). Items were presented in a random order. There was no time limit for answering.

Participants were tested at the first meeting of an intervention study (Golan & Baron-Cohen, 2006) either at the Autism Research Centre in Cambridge, or at local support centres and colleges for individuals with ASC. Participants were seated in front of IBM compatible computers with 15 inch monitors and were given headphones for the RMV-R. Definition handouts for the voice and eyes tasks were given to participants. Administration of the RMV-R and the RME-R took about 20 min each. The two tasks were administered in a random order, followed by the WASI. Participants filled in the AQ at home and brought it with them to the assessment.

Results

Task scores were calculated by counting the number of correct answers for each participant. All the participants in the control group and all but four of the participants in the AS/HFA group scored above chance (i.e. above 10, $p < 0.05$, Binomial test) on the RMV-R. Similarly, all participants in the control group and all but nine in the clinical group scored above chance (i.e. above 13) on the RME-R. Three univariate analyses of covariance (ANCOVA) were conducted for RMV-R, RME-R and AQ scores, with group (ASC/control) and sex as independent variables. Verbal IQ, performance IQ and age were entered as covariates.

Reading the Mind in the Voice-R

As hypothesized, a significant main effect of group was found for RMV-R scores ($F[1,65] = 28.77$, $p < 0.001$). The scores of the AS/HFA group ($M = 15.08$, $SD = 3.21$) were significantly lower than those of the control group ($M = 18.77$, $SD = 2.41$). No main effect of sex was found ($F[1,65] = 0.68$, n.s.), however a sex by group interaction was found significant ($F[1,65] = 5.15$, $p < 0.05$). Post hoc comparisons revealed a sex difference in the AS/HFA group ($t[48] = 2.52$, $p < 0.05$). Task scores of females with AS/HFA ($M = 12.9$, $SD = 3.93$) were significantly lower than those of males with AS/HFA ($M = 15.62$, $SD = 2.81$). No sex difference was found in the control group ($t[20] = 1.09$, n.s.). In addition to the group main effect and the group by sex interaction, a significant effect was found for verbal IQ as a covariate ($F[1,65] = 5.74$, $p < 0.05$).

Reading the Mind in the Eyes-R

Similar to the RMV-R results, a group effect was found for the RME-R scores ($F[1,65] = 16.98$, $p < 0.001$), with the AS/HFA group ($M = 21.86$, $SD = 7.17$) scoring significantly lower than the control group ($M = 28.50$, $SD = 3.13$). No sex difference was found for this task either ($F[1,65] = 0.22$, n.s.). Unlike RMV-R, no group by sex interaction ($F[1,65] = 3.0$, n.s.) and no Verbal IQ effect ($F[1,65] = 0.80$, n.s.) were found for the eyes task.

Autism Spectrum Quotient

As expected, group differences were also found for the AQ scores ($F[1,65] = 94.45$, $p < 0.001$). The AS/HFA group ($M = 34.40$, $SD = 9.52$) scored significantly higher than the control group ($M = 13.59$, $SD = 5.80$). As with the two other measures, there was no main effect of sex ($F[1,65] = 1.56$, n.s.). Similar to the RMV-R results, a sex by group interaction was found significant ($F[1,65] = 7.45$, $p < 0.01$). Post hoc comparisons revealed that in the AS/HFA group AQ scores were higher for females ($M = 40.1$, $SD = 6.59$) than for males ($M = 33.0$, $SD = 9.67$; $t[48] = 2.20$, $p < 0.05$). In the control group, a marginally significant effect ($t[20] = 1.85$, $p = 0.079$) was found in the opposite direction, i.e. males (M=14.76, $SD = 5.99$) scored higher than females ($M = 9.6$, $SD = 2.7$). The group differences on all three measures are shown in Fig. 1, and mean scores of males and females in the AS/HFA & control groups are presented in Table 3.

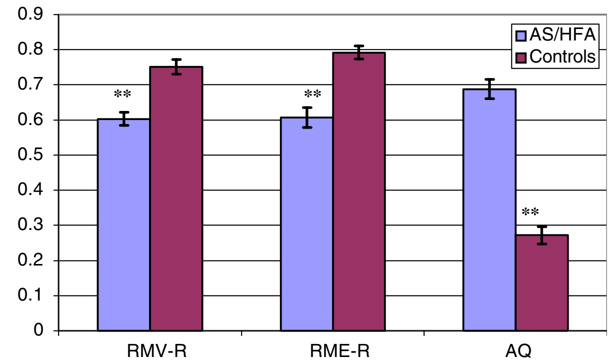

Fig. 1 Average group percent scores on the Revised 'Reading the Mind in the Voice', and 'Reading the Mind in the Eyes' tasks, and on the Autism Spectrum Quotient, with *error bars* $**p < 0.001$. *RMV-R*, Reading the Mind in the Voice-Revised; *RME-R*, Reading the Mind in the Eyes-Revised; *AQ*, Autism spectrum Quotient. Since task score ranges vary, the bars represent percentages of the task scores

Task Inter-Correlations

Bivariate correlations were calculated for the RMV-R with RME-R, AQ, Verbal and Performance IQ. They are presented in Table 4. As predicted, RMV-R scores were positively correlated with RME-R scores, ($r = 0.39$, $p < 0.01$), suggesting a common basis for emotion and mental state recognition abilities across perceptual domains. Negative correlations with the AQ were found for both the RMV-R ($r = -0.47$, $p < 0.001$) and RME-R ($r = -0.43$, $p < 0.001$), i.e. the more autistic traits one has, the lower their scores on both tasks. Against our prediction, verbal IQ scores were positively correlated with RMV-R scores, beyond the effect of group ($r = 0.30$, $p < 0.05$). In contrast, RME-R scores were not correlated with Verbal IQ ($r = 0.12$, n.s.), which matches the result reported by Baron-Cohen et al. (2001a). There were no significant correlations of RMV-R or RME-R with performance IQ or with age.

Power, Reliability and Validity

Power calculations for the RMV-R task (two tailed, with $\alpha = 0.01$) revealed a power score of $1-\beta = 0.998$. As a comparison, the power level of the original task (two tailed analysis with $\alpha = 0.01$) was $1-\beta = 0.853$ for the college control group and $1-\beta = 0.668$ for the matched non-college control group (calculated using results reported by Rutherford et al. 2002). Therefore, the revised task is more powerful in distinguishing an AS/HFA group from controls.

In general, the percentage of correct answers was lower compared to the original task. This was expected

Table 3 Mean scores of males and females in the AS/HFA & control groups

		AS/HFA			Controls		
		Females (n = 10)	Males (n = 40)	Total (n = 50)	Females (n = 5)	Males (n = 17)	Total (n = 22)
RMV-R	*M*	12.90	15.62	15.08	19.80	18.47	18.77
(Max = 25)	(SD)	(3.93)	(2.81)	(3.21)	(2.17)	(2.45)	(2.41)
RME-R	*M*	18.60	22.68	18.60	30.60	27.88	28.50
(Max = 36)	(SD)	(8.09)	(6.79)	(6.79)	(1.95)	(3.18)	(3.13)
AQ	*M*	40.10	32.97	32.97	9.60	14.76	13.59
(Max = 50)	(SD)	(6.59)	(9.67)	(9.67)	(2.70)	(5.99)	(5.80)

Table 4 Correlations of Reading the Mind in the Voice-R (*RMV-R*) and Reading the Mind in the Eyes-R (*RME-R*) with AQ, age and IQ scores

	RMV-R	RME-R
RME-R	0.391**	
AQ	–0.473**	–0.429**
Verbal IQ	0.299*	0.120
Performance IQ	0.125	0.104
Age	0.032	-0.200

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

given that two more foils were added to each item. The number of items, which a 100% of the participants answer correctly decreased from eight items to one in the control group, and from four items to zero in the AS/HFA group, thus minimizing ceiling effects. Table 5 presents the percentage of correct responses for each item in the ASC and matched control group for the current study and for Rutherford et al.'s original task.

The RMV-R's test retest reliability was calculated for a subgroup of the AS/HFA group (n = 24), who took the task twice at the beginning and the end of a 10 week period. Test–retest correlation was $r = 0.8$. In a discriminant analysis we conducted, the significant discriminant function ($\chi^2[25] = 38.3$, $p < 0.05$) successfully classified 86.1% of the participants (90% of participants with AS/HFA and 77.3% of controls) into their original groups.

Discussion

The aim of this study was to provide an improved version of Rutherford et al.'s (2002) 'RMV' task, and to evaluate it. Results show that individuals with AS or HFA scored significantly lower on the revised task, compared to matched controls. The revised task was found to have good reliability and discriminative validity. It is more sensitive in differentiating the AS/HFA group and general population controls, in addition to being shorter and quicker to administer. High scores on it are correlated with high scores on a visual mental state recognition test ('RME-R', Baron-Cohen et al. 2001a) and with low scores on the AQ (Baron-Cohen et al. 2001b). These findings match previous reports of complex mental state recognition difficulties from vocal stimuli, even among high-functioning adults with ASC (Kleinman et al., 2001; Rutherford et al., 2002; Golan et al., 2006). This deficit in the auditory domain, together with similar deficits in recognition of mental states from visual stimuli and from context, support the existence of an underlying mechanism for empathizing which is

Table 5 Percentage of correct responses to the revised task items in the ASC and matched control groups in the current and the original samples

Item number	Revised task		Original task	
	AS/HFA group	Matched controls	AS/HFA group	Matched controls
1	50	73	81	75
2	54	68	74	100
3	92	91	84	100
4	74	86	79	100
5	74	86	79	90
8	78	91	74	85
9	50	55	89	95
10	78	91	84	85
11	38	68	68	90
12	68	86	100	100
14	40	55	74	100
15	34	45	89	100
16	60	86	74	85
17	56	45	84	95
18	62	100	89	90
20	62	86	79	100
21	54	68	79	90
24	60	64	100	95
25	68	82	63	95
27	42	77	84	85
28	46	59	84	100
30	48	73	100	95
32	82	95	89	95
33	62	68	100	80
37	76	77	95	95

Original task data taken from Rutherford et al. (2002), with permission impaired in individuals with ASC (Baron-Cohen, Wheelwright, Lawson, Griffin, & Hill, 2002; Lawson et al., 2004).

The auditory aspect of this empathizing deficit in ASC has not been extensively studied. Studies which have been conducted focus more on the perception of sound and voice in ASC (Gomot, Giard, Adrien, Barthelemy, & Bruneau, 2002; Alcantara, Weisblatt, Moore, & Bolton, 2004; Gervais et al., 2004; Gomot et al., 2006), and the recognition of basic emotions (Loveland et al., 1995; Phillips et al., 1998; Boucher et al., 2000) but not on the recognition of complex emotions and mental states in vocal stimuli.

Imaging studies of vocal perception in ASC are also scarce. In a recent neuroimaging study, PET was used to measure brain activity of participants with AS and matched controls whilst listening to theory of mind stories. Both groups showed similar patterns of brain activity, but activation in the medial frontal area of the brain was less intensive and extensive in the AS group, compared to controls (Nieminen-von Wendt et al., 2003). Another study tried to increase the salience of emotional faces using supporting prosodic information, and found that not only did the prosodic information fail to increase performance of participants with autism, their performance has actually decreased due to the presentation of stimuli in both channels (Hall, Szechtman, & Nahmias, 2003). Such difficulties in processing inter modal emotional information in ASC have been reported elsewhere (e.g. Heavey et al., 2000; Klin et al., 2002a; Golan, Baron-Cohen, Hill, & Golan, in press). This deficit may relate to difficulties integrating information from different perceptual modalities, due to weak central coherence (Frith, 1989), or to under connectivity between brain regions (Critchley et al., 2000; Belmonte et al., 2004a, b; Welchew et al., 2005).

Our findings show the ASC group had greater difficulties recognizing complex emotions and mental states from stimuli, which include both verbal content and intonation. In light of the findings about the role of the right hemisphere in interpreting emotional intonation and the left hemisphere in verbal content (McNeely & Parlow, 2001; Wildgruber et al., 2005), and further to findings of atypical left hemisphere dominance when participants with ASC make emotional judgement from faces (Ashwin, Wheelwright, & Baron-Cohen, 2005), it would be interesting to investigate whether difficulties in complex emotion recognition from voices in ASC are related to less right hemisphere activity and more left hemisphere activity, compared to controls.

One reason for the scarcity of studies of complex emotion recognition in voices is the unavoidable inclusion of language in these type of stimuli, which makes it a task of intonation and language derived context, rather than intonation alone. Whereas presenting participants with non-verbal intonation may suffice for the recognition of basic emotions, more complex emotions and mental states may involve context in addition to prosody. When a choice between several verbal foils is needed, the involvement of verbal ability may become even greater, as participants need to distinguish several potentially correct emotions and mental states' verbal labels to find the most suitable one. This might explain the significant effect that verbal IQ had on the task scores in our study. Such an effect was not found for the 'RME-R' task, in which the eye stimuli are non-verbal, and require less verbal processing. Rutherford et al.'s original task had no verbal IQ effect too, but it had only two answers per item. Therefore, although having four answers per item increases the task's sensitivity, it also makes it more dependent on verbal ability, which may limit its use to higher functioning participants.

Another interesting result found in this study is the difference between males and females with AS/HFA on the RMIV-R scores. Female superiority on empathizing tasks, found in the general population (Baron-Cohen, 2002, 2003) was not significant for the control group, probably due to the small number of females in this group. However, in the AS/HFA group, males were found to perform better on the task than females. The significant difference between males and females with AS/HFA in AQ scores might explain this sex difference, i.e. if females in the AS/HFA group had more autistic symptoms, and since these are associated with lower task scores, this may explain why females scored lower than males in the AS/HFA group. As far as the authors are aware, sex differences in emotion recognition or theory of mind have not been studied within the autistic spectrum. Two studies (Tsai & Beisler, 1983; Volkmar, Szatmari, & Sparrow, 1993) reported that among individuals with autism, females show a more severe manifestation of the condition than males. However, their assessments did not test for emotion recognition differences. While our findings suggest such differences may exist, they are limited by the small number of females in both groups. There is need for further examination of sex differences in emotion recognition abilities within the autistic spectrum.

The positive correlation found between the auditory task scores and scores on the visual 'RME-R' task was significant, though not very strong ($R^2 = 0.14$). This relatively weak correlation could be related to the different perceptual modalities the two tasks involved. In addition, the two tasks test recognition of different emotions and mental states, which could by itself account to a weak correlation. It will be interesting to study the ability to recognize the same complex emotions and mental states from both visual and auditory stimuli. This will allow an investigation across modalities in recognizing complex emotions, to study the recognition of specific emotions, and to analyse brain activation patterns in response to these emotions in the different modalities. Our lab has recently completed evaluation of a battery of visual and vocal complex emotion recognition tasks (Golan et al., 2006).

We conclude that the 'RMV-R' task is a more sensitive and briefer task for assessing complex emotion recognition in speech segments. Although somewhat dependent on verbal ability, it is well correlated with an established complex emotion and mental state recognition task, and with autism spectrum traits, and reveals an empathy deficit even in adults with high functioning ASC.

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