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Evaluation of a new computer intervention to teach people with autism or Asperger syndrome to recognize and predict emotions in others

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ABSTRACT This randomized controlled trial looked at the effect of a new computer program designed to teach people with autistic spectrum disorders to better recognize and predict emotional responses in others. Two groups of 11 children (age 12–18) with autism or Asperger syndrome at two special schools participated: one group used the computer program for 10 half-hour sessions over 2 weeks. Within-program data showed a significant reduction in errors made from first to last use. Students were assessed pre- and post-intervention using facial expression photographs, cartoons depicting emotion-laden situations, and non-literal stories. Scores were not related to age or verbal ability. The experimental group made gains relative to the control group on all three measures. Gains correlated significantly with the number of times the computer program was used and results suggest positive effects. Further research could assess whether these gains generalized into real life or improved performance on theory of mind measures.

KEYWORDS *Asperger syndrome; autism; computer; emotion; intervention*

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Development of emotional understanding

Effective human communication and interaction require understanding of words, tone of voice, facial expression, posture, gaze, gesture and context (Brumback et al., 1996). Infants of only a few days old can imitate facial expressions and by 2 months of age can perceive and respond to emotional signals (Tanguay, 1990). By the age of 3 most children use various emotion terms in their vocabulary, and can distinguish happy, angry and scared faces from each other and differentiate the causes and consequences of these emotions, although there is some overlap between anger and sadness early on (Stein and Levine, 1989). Emotions triggered by the situation (e.g. having been given a gift) are normally understood by the age of 3 (Harris, 1989). Desire-based emotion (an emotional reaction to whether a person gets what they want) is also usually understood by the age of 3 (Yuill, 1984). Belief-based emotions (those based on thoughts rather than physical events) are normally understood by the age of 5 or 6 (Hadwin and Perner, 1991; Harris et al., 1989).

Emotional understanding in people with autistic spectrum disorders

Difficulties with understanding emotion are widely acknowledged as a key feature of autism and Asperger syndrome and appear in the diagnostic criteria of DSM-IV and ICD-10. Some even argue that a lack of emotional understanding is the primary deficit in autistic spectrum disorders (e.g. Fein et al., 1992; Hobson, 1989).

There is evidence of deficits and idiosyncrasies in autistic children's facial, vocal and gestural expression of emotion (Hobson, 1989). Evidence also suggests that children with autism have difficulty in predicting emotion based on a person's beliefs (Hadwin et al., 1996) and in matching different modes of emotional expression, such as facial expressions, gestures, vocalizations and contexts (Hobson, 1986). People with Asperger syndrome require considerable intellectual effort to make or read facial expressions during social interactions (Attwood, 2000). Even very able adults with autism had significant difficulties inferring the emotional state of a person from a photograph of their eyes compared with controls, with only half the autistic group scoring above chance (Baron-Cohen et al., 1997). Celani et al. (1999) interpret the research to indicate that people with autism have good perceptual strategies and can observe emotional cues, but may lack a holistic understanding of emotion and its meaning.

Experimental evidence shows performance on emotion recognition tasks to relate to non-verbal ability (Raven's Matrices, Peabody Picture Vocabulary Test), to inversely relate to scores on the Childhood Autism Rating Scale and to distinguish between children with autism, PDD-NOS and psychiatric and typically developing controls (Buitelaar et al., 1999; Hobson, 1986). Emotion recognition on facial expression photographs has also been shown to correlate with theory of mind task performance (Muris et al., 1999). Children with pervasive developmental disorders who perform poorly on emotion recognition tasks have been shown to perform poorly on other measures of social skills (Fein et al., 1992) and also to have poorer long-term adjustment and prognosis (Ozonoff and Miller, 1995).

Interventions to improve emotional understanding

Effective behavioural treatments have been shown to reduce some of the secondary problems associated with autism, but social and communicative abnormalities have so far proved more resistant to intervention (Howlin et al., 1999). Traditional teaching, which involves a social interaction between student and teacher, may confound the information and make it more difficult to learn (Gray and Garand, 1993). The interventions that have proved successful have in common a high degree of structure and a focus on the development of more appropriate social and communication skills (Howlin and Rutter, 1987).

Most studies have found problems in generalization of newly acquired skills beyond training conditions. This may partly be due to stimulus overselectivity in people with autism, so teaching multiple exemplars is thought to be beneficial (Koegel et al., 1995). For the same reason some newer interventions aim to teach social understanding rather than specific social skills (Howlin et al., 1999). The key features of successful interventions appear to be repetition of the task with feedback, making the tasks enjoyable to complete, and breaking the task down into a sequence of small steps, beginning with simpler skills that are learnt earlier in normal development (Howlin et al., 1999).

Hadwin and colleagues (1996; 1997) looked at whether children with autism could be taught to understand emotions, belief and pretence. Their research showed that children could be taught to pass tasks assessing understanding of emotion and belief. This effect was maintained at 2 month follow-up, but did not generalize to untaught domains or tasks with a different structure to the instruction task. The intervention also did not improve communication in terms of increased use of mental state terms or the ability to expand on conversation. Swettenham (1996) queries whether this reflects an inability to generalize or a deficit in central coherence (that they are processing local rather than global information).

Computer interventions in autism

Children with learning disabilities have been shown to prefer computer programs with higher interaction requirements, where the child is able to direct the program and make choices, and those that use multi-media including animation, sound and voice features (Huntinger, 1996; Lahm, 1996). These authors note how technology can equalize opportunities for children with disabilities, encourage cognitive and social development and lead to improved independence and self-esteem.

Computer interventions appear to be particularly appropriate for people with autistic spectrum disorders for several reasons (see Moore, 1998; Panyan, 1984):

- It is widely believed that people with autism have difficulty screening out unnecessary sensory information (e.g. Rutter and Schopler, 1987). Focusing on a computer screen where only necessary information is presented may minimize such difficulties.
- People with autistic difficulties often find the world confusing and unpredictable, and have difficulty dealing with change. Computers are free from social demands and can provide consistent and predictable responses, which can be repeated indefinitely without fatigue. Items can be selected from a pool to maintain interest and repeated until mastery is achieved.
- The program can provide explicit routines and clear expectations, with immediate consistent consequences for responding. It encourages engagement by allowing the learner to take active control over the pace of learning and to make choices.
- The material can be selected to be matched to the student's cognitive ability and relevant to their environment. Photographs make stimuli as close to the real world as possible, assisting potential generalization.
- Computers can also be programmed to build on learning experiences in small logical steps, progressing at the rate of the student and incorporating reinforcement. Thus the entire learning experience can become a conditioned reinforcer, increasing motivation. Integral data collection can help assess students' progress.

It is acknowledged that there is a need for intensive one-to-one instruction in children with autism and computer-based instruction may be a way to provide some of this (Higgins and Boone, 1996). In several studies, children with autism showed more enthusiasm for computer use than toys, as well as increased learning, motivation, attention, response rate, intentionality, problem solving and referential communication and reduced behaviour problems when using a computer compared with personal instruction (Bernard-Opitz et al., 1990; Chen and Bernard-Opitz, 1993). The important question is therefore not whether computer-based teaching is better than one to one personal instruction, but how to optimize the use of computers, in addition to personal instruction, given teacher time is limited and expensive.

There is a lack of computer programs written specifically for people with autism (Moore, 1998) although this is improving, particularly in the area of reading and language skills, where computer programs have been shown to be beneficial for children with autism (Heimann et al., 1995; Tjus et al., 1998). However, commercial software has not yet made full use of research evaluated interventions, strategies and methods for working with children with autism (Higgins and Boone, 1996). Only two computer interventions mentioned in the literature are relevant to emotional understanding. Swettenham (1996) looked at whether children with autism could be taught to understand false belief using a computerized version of the Sally–Anne task (Baron-Cohen et al., 1985). Although he showed gains on the task used in the instruction period (on the computer or a parallel task with dolls), there was no generalization to similar tasks. The other program, 'Gaining Face' (www.ccoder.com/GainingFace), is designed to help children with autistic spectrum diagnoses learn about facial expressions; however there is no published evidence as to its effectiveness.

The research presented here is part of an evaluation of a new computer program designed to help people with autism learn to recognize and predict emotions in others, called the 'Emotion Trainer'. Obviously, being able to recognize and predict simple emotions in others is only one component of emotional understanding and, although necessary, is not sufficient to understand emotions and apply this information usefully in context. However, in a novel area of research it is necessary to take one step at a time.

Method

The research took the form of a randomized controlled study with measurements taken pre- and post-intervention.

Participants

Participants were recruited from two special schools catering for children with autistic spectrum disorders. Owing to the small number of pupils attending the schools and the requirement for moderate language ability it was only practical to recruit 12 participants per group. All participants had a clear diagnosis of an autistic spectrum disorder (autism or Asperger syndrome), an age equivalent of 7 years or greater on the British Picture Vocabulary Scale (Dunn et al., 1982) and a chronological age of 10 to 18 years. No information about history or diagnostic process was collected, as this was not available through the schools.

Participating children were then paired by age, gender and school class, to control for the effect of normal teaching. One of each pair was randomly selected to receive the computer intervention. The experimental group used the Emotion Trainer during 10 daily computer sessions (over 2 to 3 weeks), whereas the control group had only their normal lessons.

Children in the experimental group used the program a mean of 8.4 times, with one child only using the program twice (owing to organizational complications) and another child enjoying the program so much she used it 15 times! Two pupils did not complete the research. One pupil in the control group was integrated into a mainstream school during the study and was not available for assessment at the second time point. One pupil from the experimental group was excluded from school for aggressive behaviour and did not participate in the intervention or second assessment. This left a total sample of 11 experimental and 11 control children.

Measures

The British Picture Vocabulary Scale (BPVS: Dunn et al., 1982) was used to assess verbal ability. One school kept BPVS scores for all children and these were taken from the records if completed within the previous year. Children assessed more than a year ago and those at the second school were given the BPVS as part of the first assessment.

Before and after the intervention period, the first author assessed all the participating children. Assessments included:

- The Facial Expression Photographs from Spence (1980), a set of 10 black and white photographs of facial expressions from which the child has to point to each expression when named. Scores range from 0 to 10.
- Happé's Strange Stories, a set of stories in which something non-literal is said that the child is asked to explain (Happé, 1994). Responses to stories were transcribed and scored from (–3 to +3 according to how much understanding of the story characters' mental states the child demonstrated (see Appendix for scoring hierarchy). Twenty stories were used (omitting the forgetting and double-bluff stories), giving a score from (–60 to +60. The new scoring system was designed to pick up subtle changes that may occur as a result of an intervention. The inter-rater reliability of the new scoring method was good (e.g. the total scores for each child by two independent raters were highly correlated: rho = 0.967, $n = 22$, $p < 0.0005$).
- Emotion Recognition Cartoons: eight situation-based emotions, six desire-based emotions and eight belief-based emotions from *Teaching Children with Autism to Mind-Read: A Practical Guide* (Howlin et al., 1999). Administration followed the procedure of Hadwin et al. (1996). An error score of one point was given for each cartoon where the child did not give a correct feeling that was reasonably justified. The error scores on situation-based emotions could range from 0 to 8, desire-based emotions from 0 to 6 and belief-based emotions from 0 to 16

(as each item has two emotion questions). As so few errors were made the total number of errors across all cartoons was summed to give a possible score from 0 to 30.

The computer program also collected data during each use by each child as to the items presented and the number of errors made on each section. The number of errors was summed across the 20 items in each section.

Design of the computer intervention

The Emotion Trainer is a multimedia computer program in five sections (see Silver, 2000). On each page of the program a digital photograph of a face, a scene or an object is shown, with a short text question and either two or four response buttons. The version of the program used in the research had no sounds; therefore the children needed sufficient reading skills to decipher the questions (hence the minimum verbal IQ requirement in the selection procedures). An example screen is shown in Figure 1.

The user has to correctly complete 20 items in each section to pass to the next section (these items include random amounts of items on each emotion). Correct responses are rewarded with a 'well done' message and

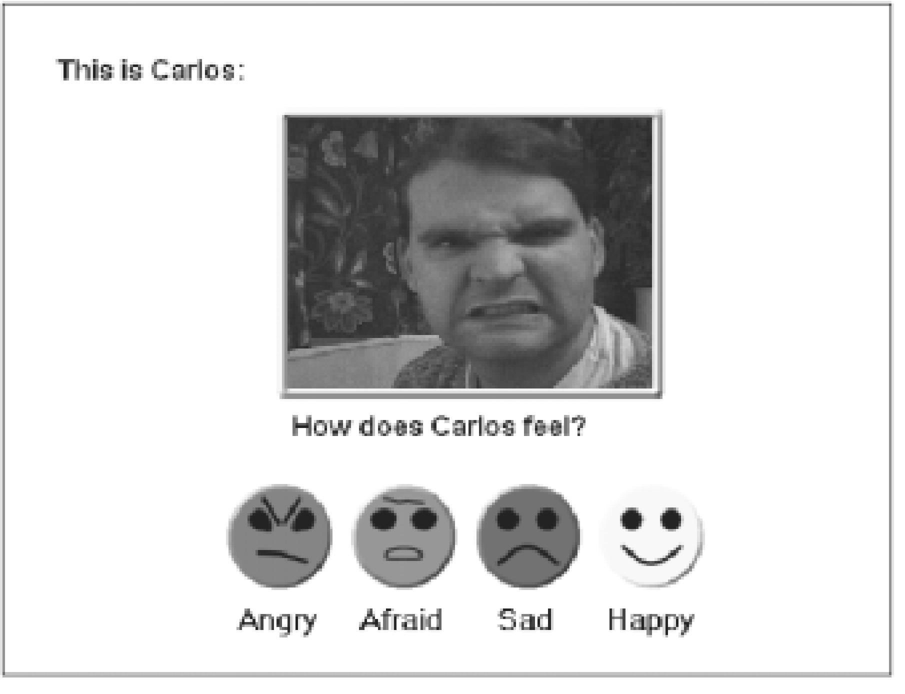

Figure 1 **Screen from Emotion Trainer, section 1**

an animation of coloured balls bouncing. Incorrect responses are immediately given a 'try again' message and a hint to the correct response. A second incorrect response gets another 'try again' message and a direct cue to the correct response. This is repeated until the correct response is selected.

Items in each section are randomly selected from a large pool and the answer buttons and names are randomly ordered for each item; thus the person using the program is unlikely to see the same screen again in many runs through the program. When a section is completed the user gets a 'well done you have completed the section' message and an animation of a happy face bouncing around the screen. On completing all five sections the user gets a 'congratulations you have completed the program' message and an animation of a colourful aeroplane, car and hot air balloon travelling alternately across the screen.

In section 1 the user is shown photographs of facial expressions and asked to decide whether the person looks happy, sad, angry or afraid and to click on the appropriate button at the base of the screen. The photographs show adults and children of both genders. The section is designed to allow the user to become familiar with many examples of how key emotions look as a facial expression.

In section 2 the user is shown photographs with captions referring to a person in a situation that is likely to trigger an emotion (e.g. angry, 'James's drink was stolen by the school bully', with a picture of a can of cola; happy, 'Angela came first in the race', with a picture of a race; sad, 'Carlos's pet rabbit died', with a picture of a rabbit; afraid, 'Keshia saw the spider creeping closer', with a picture of a big spider). The task is to pick whether the situation would make the person happy, sad, angry or afraid and click on the appropriate button at the base of the screen. The section is designed to teach that situations and events can trigger an emotional response.

In section 3 the user is shown a picture of what a character wants and a picture of what they get, and asked whether this would make them happy or sad (e.g. sad, 'Carol wants a pizza, but gets a beefburger'; happy, 'Greg wants an apple and gets an apple'). The section is designed to teach the principle that getting what you want is likely to make you happy and not getting what you want is likely to make you sad.

Section 4 is similar to section 2, but mental states rather than physical events are described (e.g. afraid, 'Kathy thought the graveyard was haunted'). In some items reality distracters are used to show that mental representations can induce an emotional response even if they are wrong (e.g. sad, 'John thought his rabbit had died, but really it was just sleeping'). The task is to pick whether the belief would make the person happy, sad, angry or afraid and click on the appropriate button at the base of the screen.

The aim of the section is to teach that mental states can provoke an emotional response, even when the event does not occur in reality.

Section 5 shows an illustration of an object or event that the character is said to either like or dislike. The caption then says whether this object or event occurred to them (e.g. disappointed, 'Lisa hates snakes, she saw the snake at the zoo'). The task is to choose whether the result would make the character pleased or disappointed. The section is designed to teach that absence of disliked events/objects or presence of liked events/objects pleases people, whereas absence of liked events/objects or presence of disliked events/objects disappoints.

Results

Analysis of variance and other parametric statistics were used, as despite the small numbers the nature of the data was best modelled by a normal distribution. Scores on the Facial Expression Photographs and Emotion Recognition Cartoons are error scores from a set number of items; they therefore follow the Poisson distribution, which is statistically approximated to a normal distribution. The Strange Stories give a compound Likert score, which is again statistically approximated to a normal distribution. One-sample Kolmogorov–Smirnov tests for all data showed no significant deviation from normality. The Bonferroni correction for experiment-wise error rate was not applied, as the small numbers of participants mean that a huge effect size is needed to reach significance and reducing the criterion for significance might cause real effects to be missed (Cohen, 1992).

There were no significant differences between the experimental and control groups prior to intervention. Descriptive statistics are given in Table 1. Scores on the emotion measures were not found to correlate significantly with age or BPVS score.

Data from the computer program were analysed for 10 of the 11 children from the experimental group (one child's data were lost in a technical error at the school). As not all the children completed exactly 10 repeats of the computer program, the results are based on a comparison between first and last attempt (with a range of two to 15 repeats). The data showed improvement on all sections from first to last session when comparing mean number of errors made; however there was a lot of individual variation (see Table 2). The improvement reached statistical significance on sections 2 and 4 ($t = 1.90$, $p = 0.045$ and $t = 3.37$, $p = 0.004$ respectively).

Repeated measures ANOVAs showed a significant time by group interaction (meaning the experimental group improved significantly more than the control group) on the number of errors made on the Emotion Recognition Cartoons ($F = 4.785$, $p = 0.041$) and on the Strange Stories score

Table 1 **Descriptive statistics for whole sample prior to intervention**

	Whole sample (N = 22)		*Experimental group (N = 11)*		*Control group (N = 11)*	
	Mean	*(SD)*	*Mean*	*(SD)*	*Mean*	*(SD)*
Chronological age	14 y 4 m	(19 m)	13 y 11 m	(11 m)	14 y 9 m	(24 m)
BPVS age equivalent	11 y 4 m	(34 m)	10 y 8 m	(27 m)	12 y 0 m	(40 m)
Errors in Emotion Cartoons	3.81	(2.68)	4.36	(3.35)	3.27	(1.79)
Facial Expression Photos	4.36	(2.06)	4.27	(1.85)	4.45	(2.34)
Strange Stories score	19.5	(19.5)	18.3	(16.4)	20.8	(22.9)

Table 2 **Errors made on computer program**

Section	*Errors at first attempt*		*Errors at last attempt*	
	Mean	*(SD)*	*Mean*	*(SD)*
1	8.4	(4.1)	7.9	(5.1)
2	9.0	(8.5)	4.7	(4.5)[a]
3	1.9	(3.0)	1.1	(2.6)
4	10.1	(5.9)	6.0	(4.6)[a]
5	5.3	(3.9)	3.3	(3.6)

[a] Significant improvement.

(F = 6.881, p = 0.016). There was only a time effect on the Facial Expression Photographs (F = 5.571, p = 0.029), meaning that both groups improved their scores over time and the effect of the intervention was not significantly greater than this. Figure 2 shows how scores on these measures changed during the intervention period.

The number of times the child used the computer program significantly correlated with their improvement in score on the Emotion Recognition Cartoons (rho = 0.511, p = 0.015) and the Strange Stories (rho = 0.480, p = 0.24), but not with improvement on the Facial Expression Photographs (rho = 0.335, NS).

Discussion

This comparative trial showed that using the Emotion Trainer had significant positive effects on participants' performance, both within the program and on the assessment tasks. There was improvement on all sections of the program, reaching significance on the sections focusing on predicting emotions generated by external stimuli and by mental states. There was also

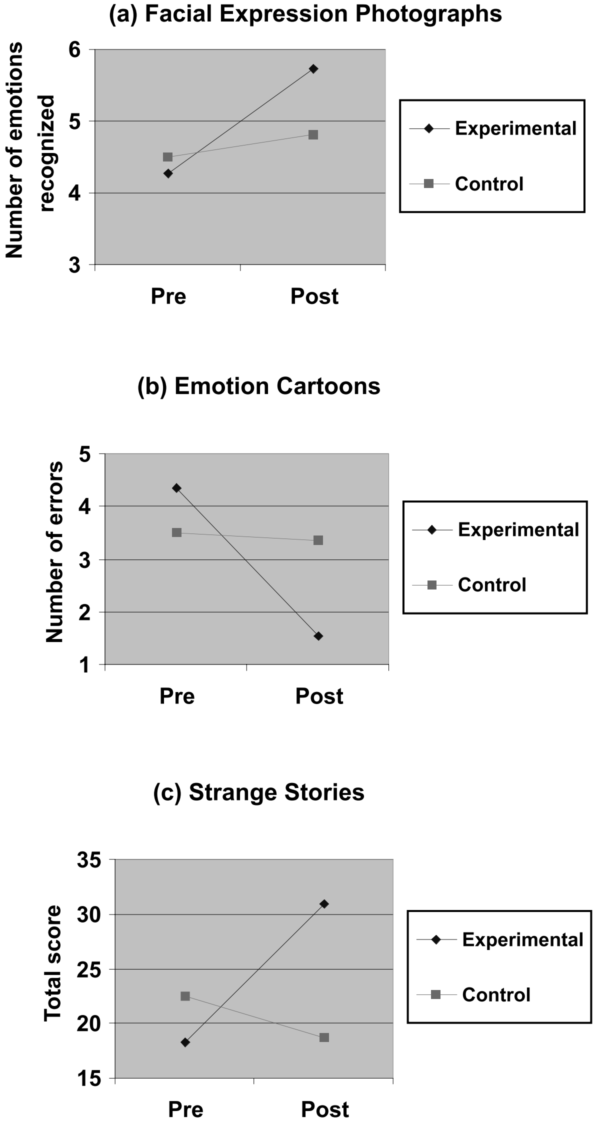

Figure 2 **Change on measures over intervention period**

improvement on all the measures used, despite the difference in format between the teaching tasks (computer based) and the assessment tasks (paper based). This is a very positive result as previous research has shown no evidence of generalization from the training task, even to closely related tasks in different media (see Swettenham, 1996). The improvements reached significance on the Emotion Recognition Cartoons and Strange Stories, but not on the Facial Expression Photographs.

The lack of a significant improvement on section 1 or on the Facial Expression Photographs could be attributed to limitations of the program or measure and may not indicate that it is not possible to teach this skill. Further research will establish whether the validity of the Facial Expression Photographs used in section 1 of the program can be improved. Although Spence states that her measure has been 'cleared for acceptable intra-rater reliability and validity' (1980, p. 18) only six of her 10 facial expressions are those validated by Eckman and Friesen (1975), and it is notable that in the 1995 version of the measure only these six expressions are used. Closer analysis of the data shows that the happy and afraid faces were recognized by most children (70 and 73 percent) before the intervention and hence had a ceiling effect (like Muris et al., 1999). The angry face, however, was recognized by very few children (9 percent) and did not have the typical salient features of clenched teeth and frown (shown by most of the angry faces in the computer program). The 'blank', 'bored' and 'thinking' faces were found to be difficult to distinguish from one another. Ideally it would have been desirable to use a more thorough measure to assess recognition of facial expressions, such as that used by Tantam et al. (1989) who used the large set of photographs validated by Eckman and Friesen (1975), or the more recent version of Spence (1995).

The positive change on the Strange Stories was unexpected, as these do not deal directly with the recognition or prediction of emotions, but rather with mentalizing ability (see Happé, 1994). It is possible that in the later sections of the Emotion Trainer the user is gradually introduced to the process of considering mental states in a way that helps them interpret the Strange Stories. It would be interesting to see whether performance on other theory of mind tasks is improved by use of the Emotion Trainer.

The current study also adds to the information generated by each of the measures, so these will be discussed in turn.

In contrast to many previous studies, scores on the emotion measures were not found to correlate significantly with age or BPVS score (e.g. Hobson, 1986). Similarly in this study performance on the Strange Stories was not related to age or BPVS score, whereas previous studies have shown theory of mind ability to correlate with chronological age, verbal mental age or both (see Happé, 1995; Celani et al., 1999). This may be due to the smaller range of age and ability in the current study.

BPVS scores were not related to the amount of change on any measures over the intervention. This means that the effect of the intervention was independent of the verbal ability of the child (given that all children were able enough to understand the language and task requirements of the program).

The participants in this study had a mean score of 1.9 correct responses on the happy, sad, angry and afraid faces from Spence (1980). Only two of the 22 children in the present study were able to label the angry face. In Muris et al. (1999) 20 children aged 9–12 recognized a mean 3.9 of the 4 photographs, showing a ceiling effect. The children in the current study performed significantly worse on this measure than even the 5- to 6-year-old NT children in Muris (1999), confirming that autistic children have a marked deficit or delay in this skill.

Very few errors were made by participants on the Emotion Recognition Cartoons compared with the group studied by Hadwin et al. (1996), despite the increased task requirement of having to explain their responses. It may be that the children in this study already had relatively good emotional understanding (in terms of the assessment tasks). This suggests that performance on this task improves with age, as participants in the current study were 5 years older than those in Hadwin et al. (1996) and had higher VMA. Therefore it is possible that the Emotion Trainer could also be used with younger or less able users (particularly if the program is adapted to limit the need for reading skills).

In order to compare the results on the Strange Stories with those published by Happé (1994), the percentage of correct and incorrect mental responses (including partial/implied mental) were calculated from the whole sample prior to the intervention. The results were very similar to Happé's able autistic group, confirming the pattern of results she found, with a high number of incorrect mental responses and a low level of correct mental responses compared with NT controls. Participants in the present research gave fewer incorrect mental responses than the group who failed theory of mind tasks in Happé's study, indicating that they were probably able to pass some theory of mind tasks. However, this sample was younger and had lower VMA than is typical of autistic children with this level of theory of mind (see Happé, 1994).

The main strengths of this study lie in the innovation of the Emotion Trainer computer program itself and the fact that it was based on solid empirical methodology, which has not been widely used in this field (Heimann et al., 1995; Ozonoff and Miller, 1995). The randomized controlled trial revealed significant positive effects for able children with autism from using the Emotion Trainer computer program.

The Emotion Trainer itself is unique in the field, combining an intervention that teaches how to recognize and predict emotions in others according to established psychological theory, with a computer-based presentation that has been shown to appeal to people with autistic spectrum diagnoses. The format of the program allowed the use of full colour photographs and integral reinforcement, with colourful animated sequences to reward correct responses. The computer design meant that material could be repeated indefinitely without fatigue and at the pace of each individual child. The intervention was very efficient in terms of not requiring any teacher input to be successful. The computer removed the social aspects of teaching that some students with autism are known to find confounding and also enabled integral data collection to monitor the progress of each child. The Emotion Trainer was presented in a way that was simple to use and appealing to the participants, gaining very positive feedback from the children who used it. The children all took to the program quickly without external instruction or more than minimal supervision. The schools commented that the children readily engaged, stayed focused on task and expressed enthusiasm for using the program.

The main limitations of the study include the relatively small sample size and the focus on a very homogeneous sample of participants in terms of age, verbal ability and educational placement, rather than participants who represent the full breath and diversity of the autistic spectrum. Hopefully future research can ascertain whether the Emotion Trainer is useful to this wider population and indeed to people who do not have autistic spectrum disorders. It would also be useful to know whether the Emotion Trainer can be used in people's own homes as effectively as it was used in the school sessions in this study. The other limitation is that the research did not establish whether the gains from the intervention showed in the daily life of the participants, or whether the knowledge was purely theoretical. Further research could establish whether any of the improvements generalized into the real-life social skills of the children using the program and evaluate whether the program has any broader effects, as the measures used in the current study were necessarily focused on the targeted skills.

It is acknowledged that being able to recognize and predict simple emotions in others is only one component of emotional understanding. Many skills are necessary to understand emotions and apply this information usefully in context. Future interventions may use a similar format to target other skills in this area (e.g. teaching children with autism to recognize and predict their own emotions).

Conclusion

This study presented a randomized controlled trial of a computer program to improve students' ability to recognize and predict emotions in others. Overall the results suggest positive effects of the Emotion Trainer computer program, in terms of improved performance on all measures and significant group by time interaction effects on the emotion cartoons and strange stories. Given the small sample size and short intervention, this is a surprisingly strong effect in a field where previous interventions have had very limited effects (see Howlin et al., 1999). Furthermore, the magnitude of the improvements was related to the number of times that the child used the program. This indicates that the Emotion Trainer program may have positive effects on users' understanding of emotion, particularly with repeated use. Replication of this finding with larger samples would confirm whether this is the case. It would also be interesting to know whether these changes generalized into 'real-life' use (see Silver, 2000) as social skills are associated with long-term prognosis (Ozonoff and Miller, 1995).

Appendix: scoring hierarchy for Strange Stories

–3 for an answer showing clear misunderstandings of mental states
–2 for an answer with partial or implied misunderstanding of mental states
–1 for an answer making errors about physical events in the story
0 for refusing to answer or saying 'I don't know'
+1 for a correct answer that does not mention or imply mental states
+2 for an answer showing partial or implied understanding of mental states
+3 for an answer showing good understanding of mental states.

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Notes
Further information about the Emotion Trainer computer program is available on the Internet at www.emotiontrainer.co.uk or by sending a stamped addressed envelope to the first author.

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