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Enhancing Emotion Recognition in Children with Autism Spectrum Conditions: An Intervention Using Animated Vehicles with Real Emotional Faces

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Abstract This study evaluated *The Transporters*, an animated series designed to enhance emotion comprehension in children with autism spectrum conditions (ASC). $n = 20$ children with ASC (aged 4–7) watched *The Transporters* everyday for 4 weeks. Participants were tested before and after intervention on emotional vocabulary and emotion recognition at three levels of generalization. Two matched control groups of children (ASC group, $n = 18$ and typically developing group, $n = 18$) were also assessed twice without any intervention. The intervention group improved significantly more than the clinical control group on all task levels, performing comparably to typical controls at Time 2. We conclude that using *The Transporters* significantly improves emotion recognition in children with ASC. Future research should evaluate the series' effectiveness with lower-functioning individuals.

Keywords Autism spectrum · Children · Emotion recognition · Intervention · Animation · Intrinsic motivation

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Autism spectrum conditions (ASC) are neurodevelopmental conditions characterized by social-communication difficulties alongside circumscribed interests ('obsessions') and a strong preference for sameness and repetition (APA 1994). Difficulties understanding the emotional and mental states of others play a major role in the social and communicative characteristics of ASC (Baron-Cohen 1995). Fundamental to this is the ability to recognize and discriminate emotional expressions, a skill present from at least 10 weeks of age in typically developing infants (Haviland and Lelwica 1987) and that continues to develop across childhood (Harris 1994; Herba and Phillips 2004; Herba et al. 2006).

Individuals with ASC show delays in the development of this ability. These delays are demonstrated through tasks assessing emotion recognition from facial expressions, vocal intonation, and body language (Baron-Cohen et al. 2001a, b; Hobson 1986a, b; Yirmiya et al. 1992), and in ecological, life-like tasks that require integration of emotional cues from different perceptual channels in context (Golan et al. 2008; Klin et al. 2002). Although some individuals with ASC develop compensatory strategies, enabling them to recognize basic emotional expressions and situations (Baron-Cohen et al. 1993; Grossman et al. 2000), a general impairment in identifying more complex emotions persists into adulthood (Baron-Cohen et al. 2001a; Baron-Cohen et al. 1997).

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These emotion recognition difficulties are associated with altered attentional, perceptual, cognitive and neural processes. Individuals with ASC process faces differently and show reduced attention to faces and facial expressions (Dawson et al. 2004; Klin et al. 2002). This may be due to the mentalistic and emotional information conveyed by the eyes (Baron-Cohen 1995) and facial expressions, which may be hard to read for people with ASC. It is unclear if the reduced orienting to faces is the result or the cause of such early 'mindblindness' (Dawson 1999). Children with autism may also not find others' facial expressions intrinsically rewarding. Certainly, there is evidence of reduced attention to faces and to looking at eyes in particular (Swettenham et al. 1998). This reduced interest in faces is likely to impair their face processing skills, so that children with ASC do not become 'face experts' like their typically developing peers (Dawson et al. 2005). For example, whilst the typically developing child shows the N170 wave form expected during ERP when presented with upright faces, children with ASC show a reduced N170 (Grice et al. 2005).

Children with ASC may also engage in less face processing because they adopt a more feature-based approach, with a particular preference for mouths rather than the preference for eyes seen in typically developing children (Langdell 1978). Such a strategy may be less efficient for face identification and interpretation. The failure of individuals with ASC to orient to the eyes may help explain why they have difficulties discriminating emotions, particularly complex ones, since much information about mental states is conveyed by the "language of the eyes" (Baron-Cohen et al. 1997). It has also been suggested that those with ASC focus on the mouth during social exchanges because they may be trying to obtain verbal information, in the absence of attending to the eyes, as an alternative 'scaffold' with which to interpret social interactions (Klin et al. 2002).

In contrast to their difficulties in emotion recognition, individuals with ASC have been shown to have intact—and even enhanced—abilities in 'systemizing', compared to controls (Baron-Cohen 2002, 2006). Systemizing is the drive to analyze or build systems, allowing one to predict the behaviour of the system and control it. Systems may be mechanical (e.g., vehicles), abstract (e.g., number patterns), natural (e.g., the tide), or collectible (e.g., a library classification index). This attraction for systems is apparent in that the 'obsessions' or narrow interests of children with ASC cluster in the domain of systems (Baron-Cohen and Wheelwright 1999). These include vehicles, spinning objects and computers, all of which are attractive to individuals with ASC. The systemizing theory of autism relates this affinity to their systematic and predictable nature. It has been suggested that these special interests could be harnessed when teaching children with ASC, in order to keep them intrinsically motivated (Attwood 2003).

The systemizing theory of autism has been supported by different studies: children with ASC have been found to out-perform matched controls on tests of 'intuitive physics' (Baron-Cohen et al. 2001b), and adults with ASC were at least intact on such tests (Lawson et al. 2004), as well as on other tests that involve excellent attention to detail, a prerequisite for good systemizing (Jolliffe and Baron-Cohen 1997; O'Riordan et al. 2001; Shah and Frith 1983). In addition, individuals with ASC score above average on the Systemizing Quotient (SQ), a self-report measure of how strong one's interests are systems (Baron-Cohen et al. 2003; Wheelwright et al. 2006; Wakabayashi et al. 2007). Theories that argue the strengths individuals with ASC demonstrate are a result of enhanced attention to detail (Happe and Frith 2006; Mottron et al. 2006) are not necessarily incompatible, since as mentioned above, good systemizing requires excellent attention to detail (Baron-Cohen 2008).

If children with ASC possess intact or enhanced systemizing skills, it may be possible for them to use such skills to compensate for some of their difficulties in empathy, particularly in the domain of emotion recognition. Intervention programs that aim to enhance socio-emotional skills in ASC have attempted to harness these systemizing abilities to improve their effectiveness. One example of an intervention that does this is Lego® Therapy (Owens et al. 2008), in which young children with ASC who are intrinsically motivated by Lego® because it involves constructional systems are encouraged to build Lego® models in groups of 3, thereby introducing opportunities for social interaction in an autism-friendly way.

Mind Reading is a second example of an intervention that works using the same principle. It comprises educational software designed to be an interactive, systematic guide to emotions (Baron-Cohen et al. 2004) (www.jkp.com/mindreading). It was developed to help people with ASC learn to recognize both simple and complex emotions and mental states from facial and vocal expressions. It covers 412 distinct emotions and mental states, organized developmentally and classified taxonomically to be attractive to a mind that learns through systemizing. Results from a treatment trial of *Mind Reading* (Golan and Baron-Cohen 2006) found that over a 10 weeks intervention (2 h usage per week), individuals with ASC improved in their ability to recognize a range of even complex emotions and mental states. Training with the software led to improvement on 'close' generalization tasks using stimuli from the software, though there were problems with 'distant' generalization tasks, using stimuli not included in the software.

Generalization difficulties have been found both in computer-based intervention programmes (Bölte et al. 2002; Silver and Oakes 2001) and in social skills training courses (Barry et al. 2003; Bauminger 2002). The limited effectiveness of these interventions could be related to participants' age, or to lack of intrinsic motivation. Dawson and Zanolli (2003) and others argue that, due to brain plasticity, *early* intervention to enhance emotion and face processing may prove more effective in helping children with ASC develop their face expertise and socio-emotional skills. However, young children with ASC need to be motivated (preferably intrinsically) to ensure they attend to the socio-emotional stimuli presented to them. The study reported below evaluates the effectiveness of an animation series created to motivate young children with ASC to learn about emotions and facial expressions by embedding them in mechanical vehicles that move *systematically*.

The Transporters DVD

According to the Empathizing–Systemizing (E–S) theory, the reason children with ASC love to watch films about vehicles is that they are strong 'systemizers' (Baron-Cohen 2006, 2008). They are drawn to predictable, rule-based systems, whether these are repeating mathematical patterns, or repeating electrical patterns (e.g., light switches), or repeating patterns in films. This theory can make sense of a range of phenomena associated with ASC, from obsessions to repetitive behaviour and the increased likelihood of savantism. It could also explain the common observation that a favourite film for young children with autism to watch is a series about a toy train (National-Autistic-Society 2002). Kanner's first descriptions of autism drew attention to their "need for sameness" and their "resistance to change" (Kanner 1943). At the core of autism may be an ability to deal effortlessly with systems because they do not change and produce the same outcome every time; and by the same token, a disabling difficulty to deal with the social world because it is always changing unpredictably and because the outcome is different every time.

According to the hyper-systemizing theory (Baron-Cohen 2006), vehicles whose motion is determined only by physical rules (such as vehicles that can only go back and forth along linear tracks) would be much preferred by children with autism over vehicles like planes or cars whose motion could be highly variable, moving at the whim of the human driver operating them. The distinction in vision neuroscience is between physical-causal/mechanical motion (Michotte 1963) versus animate/biological motion (Castelli et al. 2000; Premack 1990). The former requires intuitive physics (Saxe et al. 2004; Wellman and Inagaki 1997) whilst the latter requires intuitive psychology, in particular the ability to detect others' goals, desires and intentions (Baron-Cohen 1995).

We therefore created a children's animation series, called *The Transporters* (www.thetransporters.com), based around eight characters who are vehicles that move according to rule-based motion. Such vehicles, it was hoped, would readily attract the attention of young children with ASC, both *high*-functioning children—who have developed age appropriate language and cognitive abilities, and *low*-functioning children, who have significant learning difficulties. Onto these vehicles we grafted real-life faces of actors showing emotions, and contextualized them in entertaining social interactions between the toy vehicles. We aimed to explore whether creating an autism-friendly context of predictable mechanical motion could introduce facial expressions of emotion that could then be learned more easily than is possible in the real world. We created a whole family of different toy vehicles running on tracks or cables, which have limited degrees of freedom of motion: two trams, two cable cars, a chain ferry, a coach, a funicular railway, and a tractor. All the characters were depicted as toys in a child's bedroom, and their motion was constrained in a Scalextric® -like manner.

The assumption was that through hours of repetitive watching of *The Transporters*, children with ASC, instead of avoiding faces, might tune into them without even realizing they are doing so, allowing them to pick up crucial information for learning about emotional expressions. This is because, unlike the faces of the people in their everyday lives that are attached to human bodies that move unpredictably in a potentially stressful and confusing way, the faces on the vehicles in *The Transporters* are attached to mechanical bodies that move repetitively and predictably. The wheels turn round and round repetitively. The gears on the wheels lift up and down repetitively. The vehicles move back and forth repetitively.

The related assumption is that such predictable, repetitive motion is soothing for a child with autism because of their 'need for sameness'. In the clinical literature this is sometimes called 'stimming', when a child or adult with ASC becomes over-focused by repeating patterns, and which is either very calming or very arousing in a pleasurable way (Wing 2003). Repeating patterns are systems which, far from being confusing, are easy to understand because they are 100% lawful, following the laws of mechanics (cause and effect) or of invariant temporal order. All that is needed in order to understand such mechanical motion are concepts like causality, temporal sequence, and contingency (If A, then B), unvaryingly, over and over again. Such *low variance* is at the heart of the systemizing theory (Baron-Cohen 2006). A child who has difficulties with 'theory of mind' or 'empathy', who might find it puzzling to understand why a person's facial expression has suddenly changed, might

become familiar with how people look when they are surprised or afraid or proud through repeated exposure to such unvarying patterns.

The Transporters is a high-quality 3D children's animation series created specifically to enhance the understanding and recognition of emotions by children with ASC between the ages of three and eight. The series consists of fifteen 5-min episodes, each of which focuses on a key emotion or mental state. The 15 key emotions are *happy, sad, angry, afraid, disgusted, surprised, excited, tired, unfriendly, kind, sorry, proud, jealous, joking* and *ashamed*. The emotions selected include the six 'basic' emotions (Ekman 1999), emotions that are more 'complex' but still developmentally appropriate (e.g., *jealous, proud, ashamed*), and emotions and mental states that are important for everyday social functioning (e.g., *kind, unfriendly, tired, joking*). These emotions were chosen because typically developing children recognize and understand these between 2 and 7 years of age (Bretherton and Beeghly 1982; Ridgeway et al. 1985). Such a wide developmental range ensured that the series would be relevant as a teaching tool for children with ASC across early childhood.

The eight characters in the series, all vehicles, are part of a toy set in a boy's bedroom, an environment designed to be predictable and therefore again appealing to children with ASC. The vehicles have real human faces grafted onto them of different ages, sexes and ethnicities, to enhance generalization. By having real faces grafted onto vehicles (mechanical systems) it was assumed that this would encourage children with ASC to look at the faces more often than they would under normal circumstances, enhancing learning. In addition, the use of a narrator instead of talking characters aimed to allow children to focus on facial expressions as a whole rather than focusing on the mouth area to obtain affective information from the character's speech.

The DVD allows the child to watch the episodes in a fixed order, or to select specific episodes as they wish. The DVD also includes a selection of quizzes that relate to each episode. Quizzes can also be accessed directly from the main menu where they can be selected by episode, emotion, or as a mix of questions from different episodes of different emotions. Each quiz has two levels of difficulty, easy and hard, hard quizzes repeating the easy quiz questions but with three potential answers instead of two. The quizzes consist of three types of question, all worded to suit a young audience. These are: matching faces to faces, matching faces to emotions, and matching situations to faces. When a question is answered correctly the child is congratulated (by the narrator) and a reward appears, this being one of three animations of the characters' wheels or cogs turning, selected specifically to appeal to those with ASC. If the question is answered incorrectly, the question is asked again until it is answered correctly, at which point the reward appears.

Parents and carers are given a detailed guide to the DVD which, in addition to providing operating instructions suggests various ways in which the child's learning can be facilitated; they are for example encouraged to let the children repeat episodes in order to reinforce their understanding. Advice is also given on how to approach discussions on the theme of a particular episode, or on a particular emotion across episodes, with questions that may help to broaden the child's understanding of the emotional concepts. If the child's language abilities permit, it is suggested that these discussions are extended to look at the causes and consequences of emotions, and why different people may respond to the same situation in different ways. The guide also suggests that, when watching the DVD with the child, parents encourage him or her to look at the faces for emotional information, using eye direction, facial features and expressions.

This study assessed whether independent use of *The Transporters* DVD, with parental supervision, improves emotion recognition and contextual understanding of emotions in children between the ages of four and seven with ASC. The intervention took place over a period of 4 weeks, with participants tested before (Time 1) and after (Time 2) the intervention. Two control groups, one with ASC the other typically developing, were matched to the intervention group for age, sex, verbal ability, and time spent between the two assessments.

Predictions

1. The ASC groups would perform worse than typical controls on emotion recognition tasks at Time 1.
2. The ASC intervention group would perform better at Time 2 than at Time 1 on all emotion recognition tasks.
3. Improvement of the ASC intervention group from Time 1 to Time 2 would be greater than any such improvement in an ASC control group who had received no intervention over and above the standard school curriculum.

Method

Design and Instruments

All three groups described above were assessed twice: at Time 1 and then 4 weeks after at Time 2. In each assessment participants were tested at four levels of generalization, one

testing participants' emotional vocabulary, and the other three testing their ability to match a socio-emotional situation to the appropriate facial expression.

Emotional Vocabulary

Participants were asked to define 16 emotion words and give examples of situations that evoked them. These were the 15 key emotions from the series (see above), in addition to *worried*, which was included as it was mentioned frequently in the episodes.

Situation-Facial Expression Matching

This was tested using three tasks, each consisting of 16 items (one for each emotion). Each item included a photo depicting a scene with a short description. The objects or characters taking part in the scene were shown in the photo, but no facial expressions were shown. At the bottom of the screen, three video clips of the protagonist character's facial expressions were played (when clicked), and the children were asked to point to the face that best describes how the character was feeling in this scene. In every item, apart from the target face, there were two foils—one face of the same and one of the opposite emotional valence. The three tasks represented three levels of generalization:

1. *Familiar close generalization*: Participants had to match familiar situations taken from the intervention series to facial expressions of familiar characters from the series.
2. *Unfamiliar close generalization*: Participants had to match novel situations with novel expressions from *The Transporters* characters. These expressions were **not** shown by these characters in the intervention series.
3. *Distant generalization*: To test generalization to facial expressions that are not attached to vehicles, participants had to match novel situations with novel expressions using a selection of human non-*Transporters* faces taken from the *Mind Reading* software (Baron-Cohen et al. 2004).

All of the facial expressions presented in the tasks were shown to a panel of 20 judges from the general population. They were included in the task if at least 15 of the 20 confirmed that the expression matched its emotional label ($p < 0.05$, binomial test). Different versions of these three level tasks were shown at Time 1 and Time 2, so that memory did not play a factor. The order of presentation according to version was also counterbalanced to prevent an order effect. Examples of items from Levels 1 and 3 are shown in Fig. 1.

Participants

Three groups took part in the study: an ASC intervention group, an ASC control group, and a typically developing control group. Participants in the two clinical groups had been diagnosed with ASC in specialist centres using established criteria (APA 1994). They were recruited by placing an advert in National Autistic Society magazine *Communication*, and via the Cambridge Autism Research Centre website (www.autismresearchcentre.com). All the children attended mainstream schools. They were randomly assigned into two groups:

1. *ASC intervention group*: The parents of 20 participants (15 male, 5 female) were given the intervention series and DVD guide to use with their child at home. Children were asked to watch at least three episodes per day over a period of 4 weeks. Parents were encouraged to use the material provided in the guide to help with consolidation of the child's learning and with its generalization to other settings. The child was allowed to watch more than the minimum number of episodes if they wanted, and parents filled out a report form to indicate how many episodes their child had watched on each day. Participants' ASC diagnosis was confirmed using the ADI-R (Lord Rutter and Le Couteur 1994) and the Children's Autism Spectrum Test (CAST)[1] (Scott et al. 2002).
2. *ASC control group*: 19 participants (15 male, 4 female) did not participate in any intervention during the 4-week interval, except for their standard school curriculum. Participants were assessed using the CAST to confirm their diagnosis. All of them scored above the cut-off point of 15. One participant dropped out of the study after the first session.
3. *Typical control group*: 18 participants (12 male, 6 female) were recruited for this group using local adverts in shops, libraries and leisure centres. They were screened for ASC using the CAST and none scored above the cut-off for ASC. In addition, participants' parents and teachers confirmed they had no history of learning difficulties, neurological, or psychiatric disorders, and that no family members were diagnosed with ASC.

The three groups were matched for sex, age, verbal ability (using the 2nd edition of the British Picture Vocabulary Scale (BPVS) (Dunn et al. 1997). As shown in Table 1, there were no significant differences between the groups on any of these variables. The two clinical groups

[1] The CAST was formerly the Childhood Asperger Syndrome test but was renamed as it is used to screen the whole autistic spectrum (Baron-Cohen et al. 2009).

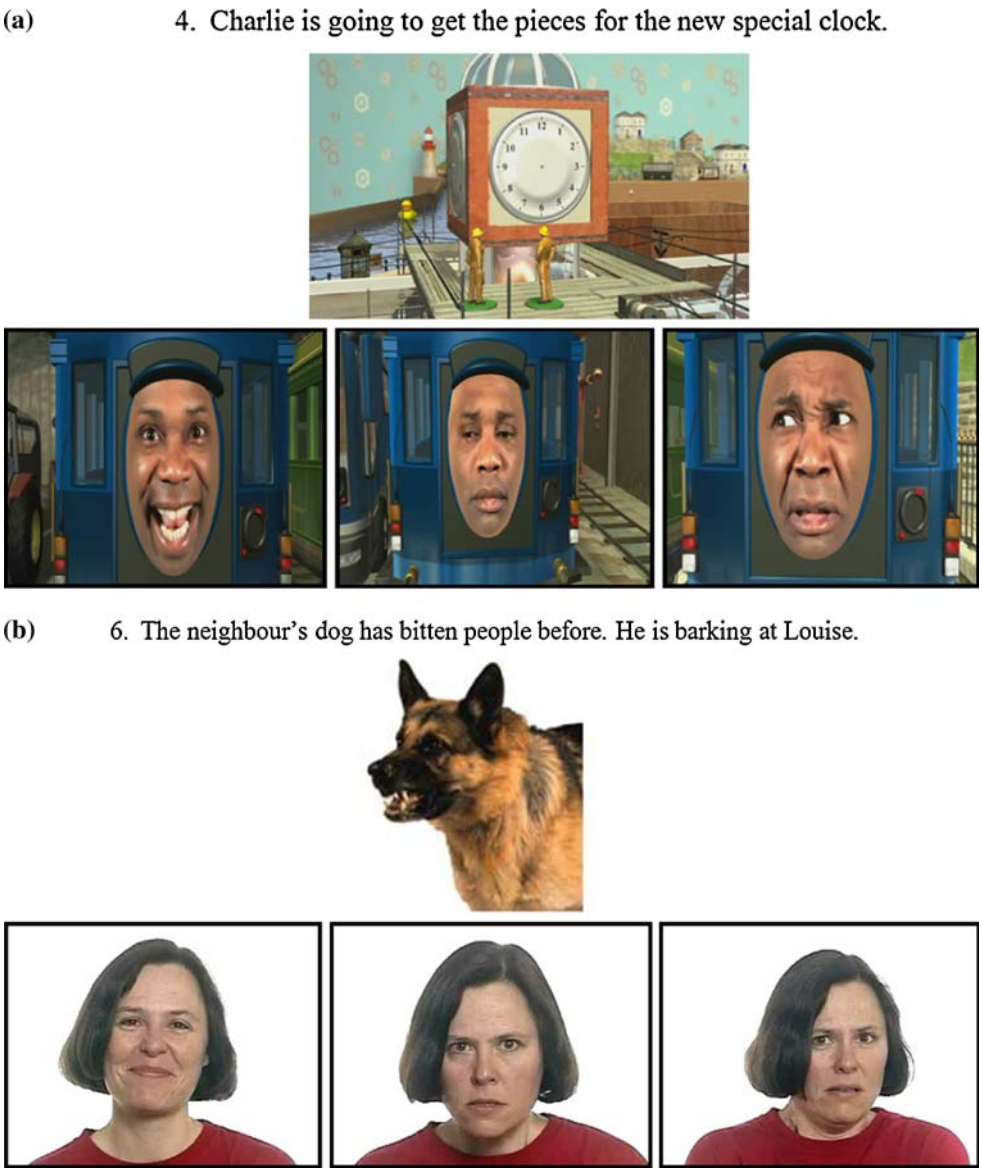

Fig. 1 Examples of questions from two of the three emotion recognition task levels. **a** Level 1 Task: match familiar scenes from the series with familiar faces. **b** Level 3 Task: match novel scenes and faces using real human faces

Table 1 Means (SD's) and ranges of background variables for the control and intervention groups

	ASC intervention group ($n = 20$)	ASC control group ($n = 18$)	Typical control group ($n = 18$)	$F(2,53)$
Age	5.6 (1.0)	6.2(1.0)	5.4 (1.1)	2.6
	4–7	4–8	4–7	
Verbal ability	98.3 (10.7)	99.4 (7.9)	103.3 (7.8)	1.6
	76–116	86–111	89–115	
CAST	24.0 (6.2)	24.1(5.4)	6.3 (3.2)	72.1**
	15–33	17–33	2–12	
Days between assessments	28.8 (3.3)	28.2(3.8)	27.8(1.4)	0.5
	24–38	22–37	25–31	
				$\chi^2(2)$
Female (%)	25.0	26.7	33.3	0.6

** $p < 0.001$. All other test results are not significant ($p > 0.05$)

scored significantly higher on the CAST, compared to the typical control group ($t[51.9] = 14.7$, $p < 0.001$), but did not differ from each other on this measure ($t[36] = 0.1$, n.s.).

Procedure

For Time 1 testing the participants and their parents were invited to our testing suite in Cambridge. Each child was individually tested and the families were informed that they were participating in an emotion recognition study.

Participants' language ability was tested using the BPVS and they were then given the emotion comprehension task. Next, they were seated in front of an IBM compatible computer with a 17" monitor, which was positioned directly in front of them and adjusted for individual eye-level accordingly. If needed, the parent sat next to the child to put them at ease. The participants were shown the opening sequence of *The Transporters* series, in order to familiarize them with the characters and the setting.

The emotion recognition tasks were then presented in level order, starting with Level 1. For each of the 16 questions at each level, a still shot of the scene was presented, and a scenario description relating to the scene was read aloud to the participant. The three silent animated clips of a character showing different emotional expressions were then played one after another and the child was asked to pick which clip of the three presented best matched the particular scenario (i.e., how would the character be feeling in reaction to the situation?). In order to do this, the child had to point clearly to whichever clip they had chosen.

The emotion recognition tasks were run using a PowerPoint slide show, and answers were recorded manually by the experimenter. Participants were allowed to take breaks at any time during or between the tasks. While the tasks were being administered, the participant's parents were asked to fill in the CAST. At the end of the testing session, the parents of the intervention group were additionally given a DVD copy of *The Transporters* series and told that their child should watch a minimum of three episodes per day during the 4 weeks intervention period. They were asked to support their child's learning, using the activities set in the user guide and to document the number of episodes their child had actually watched each day.

Time 2 testing took place 4 weeks later (or as near to 4 weeks as was possible). The experimental procedure was identical to that described for Time 1, except for the administration of different versions of the three emotion recognition tasks at each level. Parents were also not required to complete a CAST. At the end of Time 2 testing, participants and their parents were debriefed with details about the purpose and future directions of the study and asked generally about their child's enjoyment of the series. As a reward for having taken part in the study, all the children received a free copy of *The Transporters* DVD to take home with them and their parents were given £15 on their behalf. All travel expenses were also reimbursed.

Results

After checking that all measures were normally distributed,[2] we looked at the performance of the three groups on the tasks at Time 1. Using four-one-way analyses of variance and Holm's sequential rejective Bonferroni procedure (Holm 1979) we found significant differences between groups on the emotional vocabulary task ($F[2,53] = 10.73$, $p < 0.001$) and on the three Situation-Expression Matching tasks (Level 1, $F[2,53] = 9.88$, $p < 0.001$; Level 2, $F[2,53] = 8.24$, $p < 0.002$; Level 3, $F[2,53] = 10.29$, $p < 0.001$). Pre-planned comparisons using Bonferroni corrections showed that these differences were due to the significantly higher scores of the typical controls on all tasks compared to the two clinical groups, which did not differ from each other. The groups' means and standard deviations on the different tasks at Time 1 are shown in Table 2.

Next, four Multivariate Analyses of Variance (MANOVAs) with repeated measures were conducted for the emotional vocabulary measures and for the three Situation-Expression matching tasks, with Group (Intervention ASC, control ASC, Typical control) as the between participants effect and Time (Time 2 vs. Time 1) as the within participant, repeated measures effect. The groups' task means and standard deviations are shown in Table 2 and the results of the analyses are shown in Table 3.

As Table 3 shows, both Group and Time main effects were significant in all four analyses. However, the more relevant effects to our hypotheses were the interaction effects. Using Holm's sequential rejective Bonferroni procedure, significant Time by Group interactions were found for all four analyses.

Simple main effect analysis for all four tasks (with Bonferroni corrections for multiple comparisons) revealed that the ASC intervention group improved significantly from Time 1 to Time 2 on the four tasks (Emotional Vocabulary task, $t[19] = 7.45$; Situation-Expression Matching tasks: Level 1, $t[19] = 8.37$; Level 2, $t[19] = 7.40$; Level 3, $t[19] = 8.22$; $p < 0.001$ for all tests). This improvement was

[2] To test that the distributions of task scores do not differ from normal, one-sample Kolmogorov–Smirnov tests were conducted with all dependent measures. K–S Z scores were: At Time 1: EmoVoc = 0.9; SEM-Lvl 1 = 1.1; SEM-Lvl 2 = 0.9; SEM-Lvl3 = 0.8; At Time 2: EmoVoc = 1.2; SEM-Lvl1 = 1.1; SEM-Lvl2 = 1.1; SEM-Lvl3 = 1.0. $p > 0.1$ for all the tests.

Table 2 Means (SD's) of the three groups on all task levels at Time 1 and Time 2

	ASC—intervention		ASC control		Typical control	
	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2
EmoVoc (max = 16)	8.25 (2.81)	12.50 (3.09)	9.17 (3.62)	9.11 (3.45)	12.50 (2.26)	13.06 (2.49)
SEM—Level 1 (max = 16)	8.65 (2.54)	13.00 (2.45)	9.67 (2.57)	8.94 (2.34)	11.94 (1.73)	12.39 (2.09)
SEM—Level 2 (max = 16)	9.80 (2.91)	13.45 (2.35)	9.33 (2.91)	9.22 (2.69)	12.72 (2.30)	12.94 (1.59)
SEM—Level 3 (max = 16)	9.85 (2.43)	13.30 (2.27)	9.67 (2.77)	9.61 (2.83)	13.00 (2.28)	12.89 (1.78)

EmoVoc Emotional Vocabulary task; *SEM* Situation-Expression Matching tasks (levels 1–3)

Table 3 Repeated measures MANOVA F scores and effect sizes

	Group		Time		Group × time	
	$F(2,53)$	η_p^2	$F(1,53)$	η_p^2	$F(2,53)$	η_p^2
EmoVoc	7.58*	.22	44.95**	.46	33.55**	.56
SEM—Level 1	8.47*	.24	25.90**	.33	34.14**	.56
SEM—Level 2	10.97**	.29	24.31**	.31	23.13**	.47
SEM—Level 3	10.05**	.28	18.31**	.26	21.97**	.45

Partial eta squared used as effect size measure

* $p < 0.01$; ** $p < 0.001$

greater than any of the other two groups, who showed no significant improvement on any of the tasks. These effects are illustrated in Fig. 2.

Finally, correlations were calculated between age, verbal ability, time between the two assessment meetings, and improvement scores for each task. No correlations were found significant for the entire sample. When calculated separately for each group, positive correlations were found for verbal ability with improvement on the Level 2 Situation-Expression Matching task in the intervention group ($r = .58$, $p < 0.01$) and with improvement on the Emotional Vocabulary task in the typical control group ($r = .57$, $p < 0.02$). No other correlations were significant.

Discussion

This study evaluated a new intervention to enhance the understanding and recognition of emotions by children with ASC. We investigated the effectiveness of individual use of *The Transporters* animated series (with parental support) over a 4 weeks period. Our results show that use of the DVD led children with HFA/AS to improve significantly in their emotion comprehension and recognition skills for the 15 key emotions presented by *The Transporters*: from the same level of ability seen with the ASC control group at Time 1, to a level that was indistinguishable from the typically developing group at Time 2. Furthermore, improvement in the intervention group was seen over all four task levels, which demonstrates generalization of knowledge beyond the material they were trained on. Generalization into social functioning in real life settings was not tested in the current study and requires further investigation.

Results at Time 1 confirmed our hypothesis that children with ASC have marked difficulties in both emotion comprehension and recognition when compared to typically developing controls. This replicates findings from other studies (Baron-Cohen et al. 2001a, b; Golan et al. 2008). Since there were no significant differences between the two clinical groups at Time 1, we can assume that any difference found at Time 2 was due to the intervention.

The improvement of the intervention group was not limited to tasks that required close generalization; participants were able to generalize their knowledge to perform at the level of typical controls on the distant generalization task, which required emotion recognition from naturalistic clips of human characters that were not attached to vehicles. This finding of distant generalization is interesting because other attempts to teach emotion recognition to participants with ASC have shown limits in the amount of generalization they can achieve (Golan and Baron-Cohen 2006; Silver and Oakes 2001; Bölte et al. 2002). Besides the young age of participants in our study, which may have made them more amenable for learning, *The Transporters* may facilitate generalization due to the way in which the intervention was designed. Baron-Cohen (1991) showed that individuals with ASC have particular difficulty understanding emotions caused by belief, which is largely reliant on context. *The Transporters* series was designed so that each emotion and mental state is not only labelled by the narrator, but also explained in terms of its context. Other such interventions, such as the *Mind Reading* software (Baron-Cohen et al. 2004), provide a systematic way for people with ASC to study emotional expression in faces and voices but do not present them in context as *The Transporters* series does.

Another important contributing factor for improved generalization using *The Transporters* may have been the use of entertaining and intrinsically motivating media, such that the children enjoyed watching whilst learning about

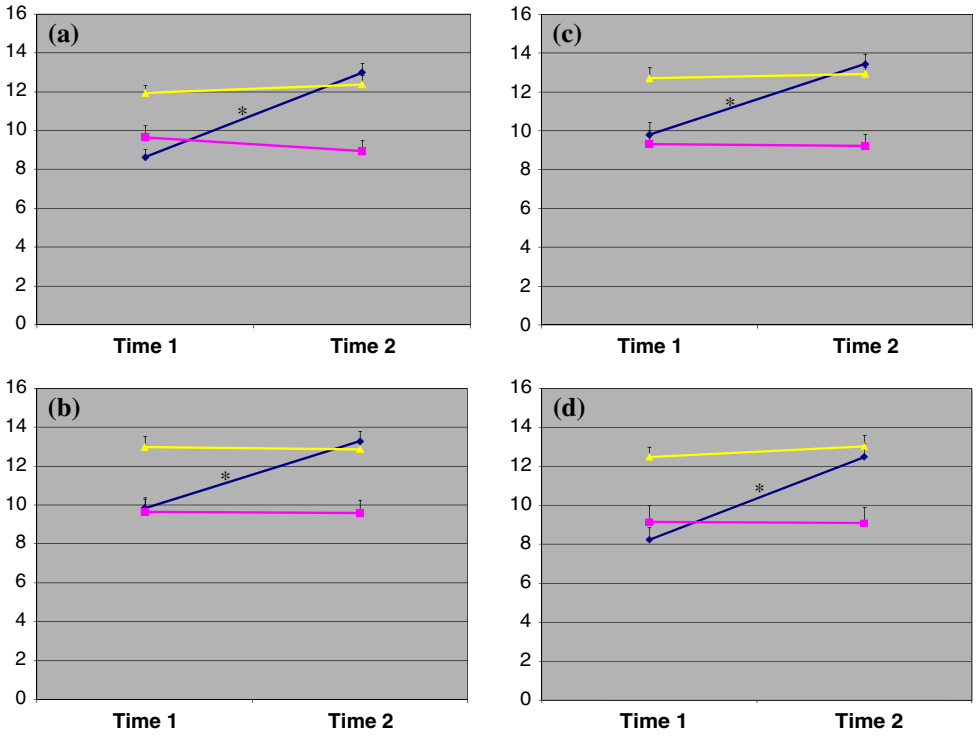

Fig. 2 *Graphs* to show mean scores (with SE *bars*) for each group on the four tasks (* $p < 0.001$). **a** Situation-Expression Matching task—Level 1. **b** Situation-Expression Matching task—Level 2. **c** Situation-Expression Matching task—Level 3. **d** Emotional Vocabulary task

emotions (incidental rather than explicit learning). Thus, *The Transporters* was designed to enhance recognition and understanding of emotions in children with ASC by using characters and an environment that would appeal to their preference for order, systems, and predictability. Grafting real faces onto animated vehicles (an obsession for many children with ASC) appears to have made the characters more appealing to the children, allowing them to learn. Our results show that this approach was successful.

The use of computer-based tasks to evaluate learning in this study obviously has limitations. First, animated vehicles with faces do not represent real life experiences. Thus, the ability to recognize emotions in *The Transporters* and generalize recognition to real people may not translate to a similar improvement in social functioning. However, anecdotal evidence from the parents of the intervention group suggests that their children were more willing to discuss emotions, and were more interested in facial expressions. Parents also noticed a change in their children's behaviour, and in their ability to interact with others. However, further research, using more general, standardized, measures of everyday social functioning, is required to assess if using *The Transporters* leads to improvements in social functioning. Future studies could also look at whether use of *The Transporters* results in any improvement in lower-functioning individuals. Clearly, less verbal methods of testing emotion recognition and comprehension would be needed to assess this group.

It was apparent there was wide variation in the amount of parental involvement (which was not monitored) in helping the child to learn during the intervention period, and in the number of episodes actually watched by the children. Since the intervention group was the only group to receive parental tutoring, it may be hard to distinguish between the effects the series had on its own and the effects of discussion with parents (or other tutors) after watching the episodes. From a clinical perspective, this is not problematic, since the intervention specifically encourages such an integrated approach. However, in order to further explore the unique contribution of series versus parental involvement, future studies could include an ASC control group that would watch another animated series (not specifically designed to teach about emotions) with parental tutoring, and the quantity and nature of parental involvement could be carefully monitored.

The minimum number of episodes the children were requested to watch was 3 per day every weekday (i.e., 15 episodes). However, because of the appeal of the DVD and the obsessive nature of children with ASC, many watched many more than this (from 49 to 382 episodes). This gives us an estimate of motivation, or enjoyment. Correlation analysis conducted between task improvement scores and the total number of episodes watched showed no significant results. However, a closer investigation in future studies of the quantity, regularity, and nature of the episodes watched by the children may teach us more about their learning

styles and may reveal why some children improve more than others. It might also be expected that improvement would be a function not just of the amount but also of the duration of intervention. It is encouraging that even with a relatively brief intervention (4 weeks), significant gains are found. Future studies could investigate if watching the animation series for longer periods of time leads to even greater improvement. Finally, it would be interesting to investigate the integration of *The Transporters* with other, more comprehensive, educational or therapeutic methods for children with ASC, as this may improve its effect even further.

In closing, this study shows that using *The Transporters* significantly improves levels of emotion comprehension and recognition in 4–7 years old children with ASC in as little as 4 weeks. Moreover, this improvement generalizes to faces that were not part of the series. We conclude that the use of systemizing as an intrinsically motivating method for learning about empathy allows affective information that would otherwise be confusing to become more intelligible and appealing to the autistic mind.

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