

Neuroscience in Education

The good, the bad and
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Educational cognitive neuroscience: designing autism-friendly methods to teach emotion recognition

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Overview

Children and adults with autism spectrum conditions (ASC) have difficulties with empathy, but have intact or even above average development of 'systemizing', that is, the drive to analyse or build a system. In this chapter we review the evidence for both the empathy deficits and the systemizing strengths, and present two examples of educational software designed to help people with ASC improve in empathy by playing to their strengths in systemizing. These are the *Mind Reading* and *The Transporters* DVDs, respectively. Treatment trials of both are summarized which confirm that even after relatively short-term intervention with these programmes, improvements in empathy (specifically the cognitive element of emotion recognition) are seen. We conclude that if interventions use the knowledge from cognitive neuroscience to design autism-friendly formats for teaching, then even complex aspects of social cognition can be improved.

18.1 Introduction

It is regrettable that all too often education and cognitive neuroscience barely communicate, since educationalists are entrusted with the most valuable of tasks, to enable a child to fulfil his or her potential, whilst cognitive neuroscientists frequently study children who are not neurologically 'wired' in the typical way, and who therefore process information differently. In this chapter we argue that cognitive neuroscience can assist educators to design teaching materials that are a good 'fit' with the autistic mind; specifically we illustrate how children with ASC may need tailored teaching methods to help them learn aspects of 'empathy', since part of their disability is that they find it difficult to read other people's minds, and make sense of other people's behaviour. We do not wish to suggest that communication between cognitive neuroscience and education is a one-way street however, since in the best-case scenario, educational materials and methods are co-designed by the scientists and practitioners each contributing their expertise (see Chapters 3 and 16, this volume). Before looking at specific methods of teaching empathy to children with ASC, we turn to the question of the nature of empathy.

18.2 What is empathy?

We define empathy as the ability to attribute mental states to others, and to respond with an appropriate emotion to the other person's mental states (Baron-Cohen and Wheelwright, 2004).

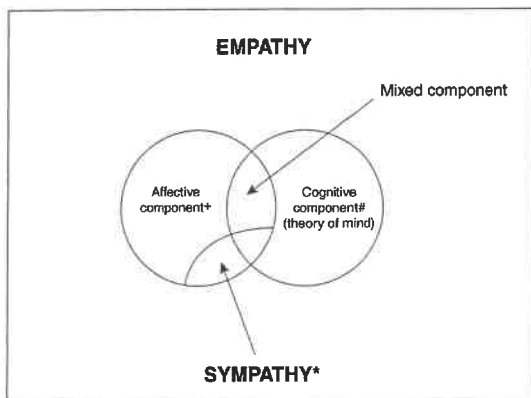


Fig. 18.1 Fractions of empathy. + Feeling an appropriate emotion triggered by seeing/learning of another's emotion. # Understanding and/or predicting what someone else might think, feel, or do. * Feeling an emotion triggered by seeing/learning of someone else's distress which moves you to want to alleviate their suffering. With kind permission from Springer Science+Business Media: *Journal of Autism and Developmental Disorders*, The Empathy Quotient: An investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences, 34 (2), 2004, pp. 163–75, Simon Baron-Cohen.

This definition of empathy suggests the two main 'fractions' of empathy are a 'cognitive' component (the recognition of another person's mental state) Figure 18.1 illustrates this distinction and an 'affective' component (the emotional reaction to another person's mental state). The cognitive component is sometimes also called a 'theory of mind' (Dennett, 1987). Mental states include thoughts and emotions, thoughts being traditionally fractionated into beliefs, desires, intentions, goals and perceptions (Dennett, 1987; Baron-Cohen, 1995). Emotions are traditionally fractionated into six 'basic' emotions (happy, sad, angry, afraid, disgusted and surprised) (Ekman, 1999), and numerous 'complex' emotions that are acquired at different points in childhood (Baron-Cohen, Golan, Wheelwright, Granader & Hill, 2010). Complex emotions involve attributing a cognitive state as well as an emotion, and are more context and culture dependent (Griffiths, 1997). The basic emotions are held to be so because they are universally recognized and expressed in the same way. It may be that more emotions are universally recognized and expressed than these six but have been overlooked because of how expensive, time-consuming and difficult cross-cultural research is (Baron-Cohen et al., 2006). Indeed, research into complex emotions (usually towards developing taxonomies) has been mostly language and culture specific (Ortony, Clore & Foss, 1987; Storm & Storm, 1987). Our own work described the development of the emotional lexicon in the English language (Baron-Cohen et al., 2010), suggesting there are at least 412 distinct emotions and related mental states (each with their own descriptor that is not just a synonym for another emotion) that are recognizable by independent judges within the UK (Baron-Cohen et al., 2010).

18.3 Empathy in autism spectrum conditions

Some individuals in the population may be delayed in the development of empathy, for different reasons. These include people with ASC who for genetic—and ultimately neurological—reasons

have difficulties in putting themselves into someone else's shoes and knowing how to respond to another's feelings, in real time. Since such deficits may have a significant impact on their social functioning, this raises the challenge of whether aspects of empathy can be facilitated or taught to individuals with ASC. We summarize some evidence that the first component of empathy—cognitive empathy—can indeed be taught. This task is made easier through the design of educational resources (including computer-based methods) that tap into systematic areas of interest, characteristic of ASC, that are therefore intrinsically motivating. Whilst we do not rule out that the second component of empathy—*affective empathy*—can be taught, it remains the case that all efforts have so far been focused on the cognitive fraction, so that it is unknown if the second could also be taught.

People with ASC have social-communication difficulties alongside circumscribed interests ('obsessions') and a strong preference for sameness and repetition (APA, 1994). Underlying these characteristics are difficulties understanding the emotional and mental states of others (Baron-Cohen, 1995). Individuals with ASC have difficulties recognizing emotions from facial expressions, vocal intonation, body language, separately (Baron-Cohen et al., 2001; Hobson, 1986a; Hobson, 1986b; Yirmiya et al., 1992), and in context (Golan, Baron-Cohen & Golan, 2008; Klin et al., 2002). Although some individuals with ASC recognize basic emotional expressions (Baron-Cohen, Spitz & Cross, 1993; Grossman et al., 2000), difficulties in identifying more complex emotions persists into adulthood (Baron-Cohen et al., 2001; Baron-Cohen, Wheelwright & Jolliffe, 1997; Golan, Baron-Cohen & Hill, 2006).

The emotion recognition difficulties are in part the result of altered face processing (Langdell, 1978; Dawson et al., 2004; Klin et al., 2002), which in itself may be due to a failure to interpret the mentalistic information conveyed by the eyes (Baron-Cohen, 1995). Others' facial expressions may also be less intrinsically rewarding. Children with ASC show reduced attention to faces and to eyes in particular (Swettenham et al., 1998). The result of this reduced experience with faces is that children with ASC thus do not become 'face experts' (Dawson, Webb & McPartland, 2005). For example, whilst the typically developing brain shows an electrophysiological response to upright faces called the N170 wave form, the autistic brain shows a reduced N170 (Grice et al., 2005).

18.4 Systemizing in autism spectrum conditions

In contrast to their difficulties in emotion recognition, individuals with ASC have intact or even enhanced abilities in 'systemizing' (Baron-Cohen, 2002, 2006). Systemizing is the drive to analyse 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). The 'obsessions' or narrow interests of children with ASC cluster in the domain of systems (Baron-Cohen & Wheelwright, 1999). These include vehicles, spinning objects and computers, all of which are attractive to individuals with ASC. At the heart of systemizing is the ability to detect patterns or rules of the form 'if a, then b'. The systemizing theory of autism relates this affinity to their systematic and predictable nature. In the study summarized in the next section, we illustrate how these special interests can be harnessed when teaching children with ASC, using computer-based or multimedia formats, to keep them intrinsically motivated.

The systemizing theory of ASC has been supported by different studies: children with ASC have been found to outperform matched controls on tests of 'intuitive physics' (Baron-Cohen et al., 2001), and adults with ASC were at least intact on such tests (Lawson, Baron-Cohen & Wheelwright, 2004), as well as on other tests that involve excellent attention to detail (Happé & Frith, 2006; Motttron et al., 2006), a prerequisite for good systemizing (Baron-Cohen, 2008; Jolliffe &

Baron-Cohen, 1997; O'Riordan et al., 2001; Shah & Frith, 1983). In addition, individuals with ASC score above average on the Systemizing Quotient (SQ), a self-report (or parent-report) measure of how strong one's interests are in systems (Baron-Cohen et al., 2003; Wheelwright et al., 2006; Wakabayashi et al., 2007; Auyeung et al., 2009).

18.5 From cognitive neuroscience to intervention

Lego® Therapy

If children with ASC possess intact or enhanced systemizing skills, it may be possible for them to use such skills to facilitate their empathy, particularly in the cognitive component of emotion recognition. Lego® Therapy (Owens et al., 2008) is an example that encourages young children with ASC, to build Lego® models in groups of 3, thereby gaining opportunities for social interaction. Children participating in Lego® Therapy are intrinsically motivated by Lego® because it involves constructional systems that can be assembled in predictable and repeating sequences.

Mind Reading DVD

A method harnessing systematic skills to teach empathy to individuals with ASC is the *Mind Reading* DVD. This comprises educational software that was designed to be an interactive, systematic guide to emotions (Baron-Cohen et al., 2004) (<http://www.jkp.com/mindreading>). It was developed to help people with ASC learn to recognize both basic and complex emotions and mental states from video clips of facial expressions and audio recordings of vocal expressions. It covers 412 distinct emotions and mental states, which are organized developmentally and classified taxonomically to be attractive to a mind that learns through systemizing. The principle behind this was that individuals with ASC may not learn to recognize emotional expressions in real time during live social situations because emotions are fleeting and do not repeat in an exact fashion, which may reduce the number of opportunities to systematically learn from repetition. Putting emotions into a computer-based learning environment enables emotions to be played and replayed over and over again in an identical fashion, such that the learner can have control over their speed and the number of exposures they need in order to analyse and memorize the features of each emotion.

Furthermore, since emotions vary depending on who is expressing them, in the real world it can be difficult to see what defines each specific emotion. *Mindreading* helps its users overcome this problem by having each of the 412 emotions portrayed by six different actors (male and female, old and young, different ethnicities), to facilitate learning to recognize emotions independently of the identity of the person expressing that emotion. In addition, in the real world emotions can appear unlawful (some people smile when they are happy, other people smile when they are pretending to be happy, and yet others are happy when they are not smiling at all) so *Mind Reading* imposes some lawfulness onto emotions by assigning a clear label to each emotional expression, including masked, or insincere emotional expressions (e.g. emotions in the 'sneaky' category). Finally, emotions in the real world can be hard to classify so *Mind Reading* offers the user a pre-designed classification system, to assist in finding patterns among inherently unpatterned emotional information.

Using *Mind Reading* over a 10-week intervention (2 hours usage per week), individuals with ASC improved in their ability to recognize a range of complex emotions and mental states (Golan & Baron-Cohen, 2006). In a follow-up conducted 1 year after the completion of the intervention period, individuals with ASC who used *Mind Reading* reported an improved ability to form friendships and relationships, and increased awareness of the importance of emotions and

emotional expressions in everyday life, improving their understanding of emotions and their corresponding expressions, and affecting their ability to function socially (Golan & Baron-Cohen, 2007). These findings have been replicated with children in the United States, supporting the cross-cultural validity of this intervention (LaCava, Golan, Baron-Cohen & Myles, 2007). These are encouraging results because they suggest that at least one cognitive component of empathy can be taught, and that it may have a long-term effect and affect social functioning. It is not known if such improvement would be seen if the intervention was shorter in duration, or if the users had not just ASC but additional learning difficulties (below average intelligence quotient (IQ)). Finally, it could reasonably be objected that learning to recognize emotions in the simplified context of a computer screen, devoid of the 'noise' of a real social situation like a school playground or a birthday party or an argument, is likely to be both simplified and therefore easier to achieve. This objection is important since it raises the question of whether such learning from 'artificial' contexts generalizes to more natural settings. Guarding against the risk of artificiality, *Mind Reading* used real faces rather than cartoon or schematic faces. However, future work using the *Mind Reading* DVD could assess the benefits of a longer intervention than just 10 weeks. The DVD could also be used with more interactive teaching methods such as social skills groups, or as part of dramatic role-play.

The Transporters DVD

Difficulties with generalization from taught material to everyday life have been found both in computer-based intervention programmes (Bölte et al., 2002; Silver & Oaks, 2001) and in social skills training courses (Barry et al., 2003; Bauminger, 2002). The limited effectiveness of these interventions could be related to a lack of intrinsic motivation, since they utilize explicit rather than implicit teaching methods. The study reviewed next and reported in detail elsewhere (Golan et al., 2010) evaluates the effectiveness of another DVD, this time an animation series created to motivate young children with ASC to learn about emotions and facial expressions by embedding them in a world of mechanical vehicles. Again, this is based on the premise that the reason children with ASC love to watch films about vehicles (according to parental report) may be because they are strong 'systemizers' (Baron-Cohen, 2006, 2008). That is, 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. Kanner's first descriptions of ASC drew attention to their 'need for sameness' and their 'resistance to change' (Kanner, 1943). At the core of ASC 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 ASC over vehicles like planes or cars whose motion could be highly variable, moving at the whim of the human driver operating them. In vision neuroscience this relates to the distinction between physical-causal/mechanical motion (Michotte, 1963) vs. animate/biological motion (Castelli et al., 2000; Premack, 1990). The former requires intuitive physics (Saxe, Carey & Kanwisher, 2004; Wellman & 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, *The Transporters* (<http://www.thetransporters.com>), based around eight characters who are all vehicles that move according to rule-based

motion. Onto these vehicles we grafted real-life faces of actors showing emotions. We tested whether creating an autism-friendly context of predictable mechanical motion could render facial expressions of emotion more learnable and increase the motivation to learn them. The different toy vehicles (two trams, two cable cars, a chain ferry, a coach, a funicular railway and a tractor) had motion that was constrained in a linear manner (all the vehicles moved on tracks or cables).

The Transporters is a high-quality three-dimensional children's animation series and consists of 15 5-minute episodes, each of which focuses on a key emotion or mental state. The 15 key emotions depicted on the vehicles 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 2–7 years of age (Bretherton & Beehly, 1982; Ridgeway, Waters & Kuczaj, 1985).

In the study by Golan et al. (2010), three groups were assessed twice: at Time 1 and then 4 weeks after at Time 2. In each assessment participants were tested at different levels of generalization, one testing participants' emotional vocabulary, and the other three testing their ability to match a socioemotional situation to the appropriate facial expression. Level 1: *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 (listed earlier), in addition to *worried*. Level 2: *familiar close generalization*—participants had to match familiar situations taken from the intervention series to facial expressions of familiar characters from the series. Level 3: *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. Level 4: *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). Examples of items from Levels 1 and 3 are shown in Figure 18.2.

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 were randomly assigned and took part according to the following test conditions: (1) *ASC intervention group*: the parents of 20 participants were given the intervention series and DVD guide to use with their child at home. Children were asked to watch at least 3 episodes per day over a period of 4 weeks. (2) *ASC control group*: 19 participants did not participate in any intervention during the 4-week interval, except for their standard school curriculum. One participant dropped out of the study after the first session. (3) *Typical control group*: 18 participants were recruited for this group. The three groups were matched for sex, age and verbal ability (using the British Picture Vocabulary Scale (BPVS); Dunn, Whetton & Burley, 1997).

At Time 1, there were significant differences between groups on the emotional vocabulary task and on the three situation-expression matching tasks. 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. Analysis of results after Time 2 testing revealed significant time by group interactions, with the ASC intervention group showing significant improvement across all task levels between Time 1 and Time 2. Furthermore, this improvement was comparable to levels of performance found in the typical control group. In contrast, the ASC and typical control groups showed no significant improvement on any of the tasks between test sessions. These effects are illustrated in Figure 18.3.

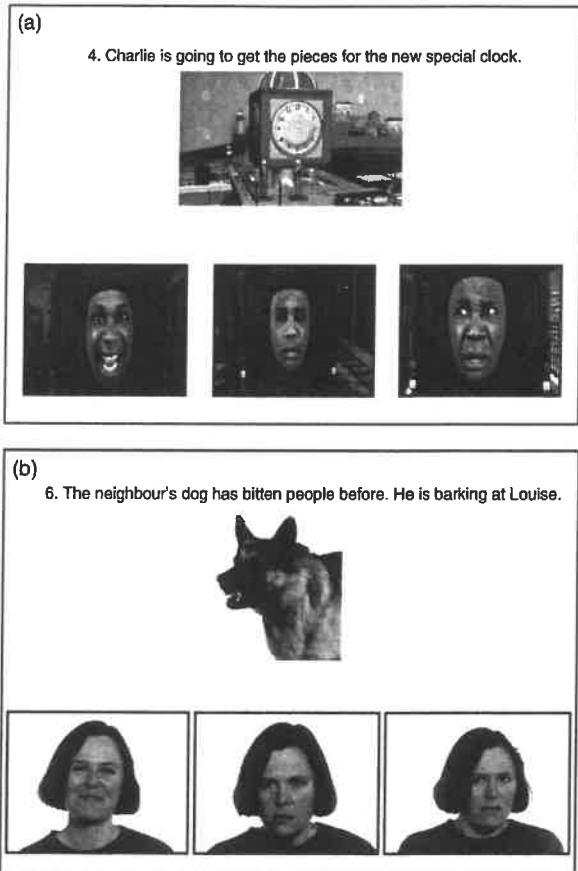


Fig. 18.2 Examples of questions from two of the three emotion recognition task levels. a) Level 1 task: match familiar scenes from the series with familiar faces. b) Level 3 task: match novel scenes and faces using real human faces.

The study we have reviewed (reported in detail in Golan et al., 2010) investigated the effectiveness of individual use of *The Transporters* animated series (with parental support) over a 4-week period. The results show that use of the DVD led children with ASC to improve significantly in their emotion comprehension and recognition skills on tasks including the 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.

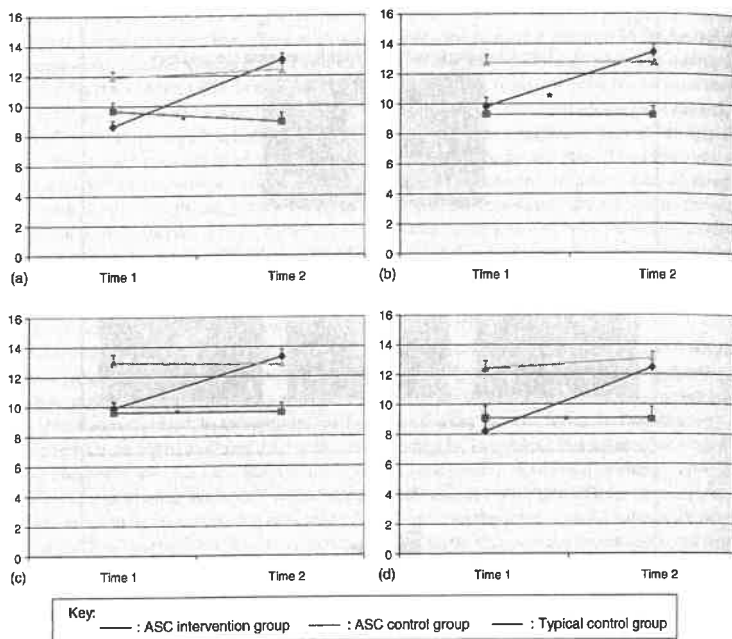


Fig. 18.3 Graphs to show mean scores (with standard error bars) for each group on the four tasks. a) Situation-expression matching task—Level 1. b) Situation-expression matching task—Level 2. c) Situation-expression matching task—Level 3. d) Emotional vocabulary task. * $p < 0.001$.

The improvement of the intervention group was not limited to tasks that required close generalization; these participants were also 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. *The Transporters* may have facilitated generalization because the series was designed using intrinsically motivating media, such that the children enjoyed watching the vehicles whilst learning about emotions from real faces grafted onto them (incidental rather than explicit learning). *The Transporters* used characters and an environment that appealed to a preference for order, systems, and predictability that is characteristic of ASC. Anecdotal evidence from the parents of the intervention group suggests that their children became more willing to discuss emotions, and became more interested in facial expressions. Parents also noticed a change in their children's behaviour, and in their ability to interact with others. Such anecdotal changes need formal evaluation.

We expect the integration of *The Transporters* with other educational or therapeutic methods for children with ASC may improve its effect even further. We conclude that the use of systemizing as an intrinsically motivating method for learning about empathy allows affective information,

which would otherwise be confusing, to become more intelligible and appealing to the autistic mind.

18.6 Future directions

If *The Transporters* is having such a positive effect on the learnability of emotional expressions by children with ASC, might there be other ways to harness the same preference for systemizing in the teaching of emotions to these children? Clearly vehicles are not the only kind of systems that children with ASC enjoy, and others might include robots (Dautenhahn & Werry, 2004), or rules (Hadwin et al., 1996). We see these sorts of interventions as part of an adaptation of the mainstream environment to be more suited to people with ASC, and such environmental adaptations need not be restricted to the teaching of emotions. An example outside the emotional domain might involve sensory perception, where people with ASC may experience hypersensitivity (Baron-Cohen et al., 2009). In this case, as with the use of specifically oriented media for the teaching of emotions, classrooms may need to be specially designed to ensure information, which may otherwise be easily processed by the neurotypical brain, is not over stimulating and therefore aversive to the autistic brain. We cannot expect learning to proceed smoothly or even to occur at all if the information is in a form that causes distress or is even painful. Equally, we need to recognize the limitations of what interventions like *The Transporters* can achieve, since whilst methods like this might improve emotion-recognition we do not yet know whether it would have far-reaching effects into other aspects of social cognition (such as understanding pragmatics of language, or turn-taking in dialogue) or have any impact in non-social areas of the condition, such as the narrow interests and repetitive behaviour. We suspect not, and it is important to have realistic expectations. Nevertheless, having an impact on emotion recognition might still be of considerable value to a child who otherwise might be anxious or confused in the face of other people's changing facial expressions. We conclude that bringing cognitive neuroscience and education together, in partnerships around the design of teaching materials and methods, can facilitate the development of skills that are traditionally viewed as 'impaired', such as empathy in children with ASC.

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