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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Author contributions

ES, DB, ER, ET and PM conceived the study and contributed to data collection. ES and PM analysed the data. ES led the writing of the manuscript. DB contributed to the writing of the manuscript, addressing the educational perspective. PM, ER and ET contributed to revise the manuscript.

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Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterised by impairments in social communication and social cognition. Difficulties in emotion understanding, from emotion recognition to emotion regulation are common features that can affect the inclusion process. One outstanding question is the extent to which age and IQ affect such impairments. The effect of IQ and age on emotion understanding was estimated in 55 children with ASD aged between 5 and 10 and with IQ ranging from 70 to 130. Emotion understanding and non-verbal cognitive ability were assessed, respectively, with the Test of Emotion Comprehension and the Leiter-R scale. The majority of participants scored significantly lower on the TEC compared to the normative sample. Performance compared against norms decreased with age and improved with increasing IQ; children with 'borderline cognitive functioning' performed significantly worse than children with 'normative cognitive functioning'. Emotion understanding skills in children with ASD are affected by cognitive level and age. Implications for educational interventions are discussed.

Keywords: autism, IQ, emotion understanding; normative cognitive functioning; borderline cognitive functioning; Test of Emotion Comprehension

Introduction

Autism Spectrum Disorder (ASD), a neurodevelopmental disorder affecting 1% of the population (Elsabbagh et al. 2012), is characterised by impairments in social communication and social cognition. Consistently, difficulties in emotional competence, an essential skill to communicate socially' (Semrud-Clikeman 2007), have been associated with the clinical phenotype of ASD.

Emotional competence consists of eight related skills (Saarni 1999): awareness of one's own emotions, understanding of others' emotions, ability to use emotional lexicon, empathy, ability to differentiate internal subjective emotions expression from

external emotional expression, emotion regulation, awareness of emotional communication within relationships, and emotional self-efficacy. Emotion understanding is a component of emotional competence, as represented in Figure 1. According to the definition by Harris (1989), it concerns how individuals understand, predict and explain their own and others' emotions. Emotion understanding is associated with several background factors (Pons et al. 2003), and the heterogeneity of clinical profiles in ASD, particularly in cognitive functioning, is likely to play a role in individual differences (Nuske, Vivanti, and Dissanayake 2013). This was recently demonstrated for emotion recognition, a subcomponent of emotion understanding (Figure 1), with a metanalysis showing a substantial impairment in ASD and highlighting the need to explore the role of cognitive skills and chronological age in such difficulties (Uljarevic and Hamilton 2013). Moreover, while some features of emotional competence (such as the ability to share and respond to emotions) are listed in the DSM-5 (American Psychiatric Association 2013), as 'core deficits' in ASD, others (such as the more basic ability to recognize emotional cues) are not considered to be central clinical features, and yet appear to be impaired in many, but not all, individuals with ASD (Uljarevic and Hamilton 2013). Evidence of the universality of a deficit in emotional competence with impairments in all its subcomponents remains therefore unclear decades after this was first questioned (Ozonoff, Pennington, and Rogers 1990), possibly due to both the complex hierarchical structure of the construct and the heterogeneity of tasks used to test it (Uljarevic and Hamilton 2013).

[Figure 1 about here]

The possible effect of age and IQ on emotion understanding in ASD has several potential implications. With respect to age, the older the children, the greater are others' expectations on their social competences: this process may likely enlarge the gap

between the actual abilities of children with ASD and the competences required to face social requests and interactions, as suggested by the negative correlation between adaptive behaviour skills and age in children with ASD (Perry et al. 2009). The basic cognitive processes underpinning emotion understanding are also likely to affect performance on broad emotional competence skills, and in turn, on generalised social communication competences. Despite promising effects of early intervention on reducing social communication deficits (Pickles et al. 2016), universally regarded as core symptoms of ASD (American Psychiatric Association 2013), such difficulties persist across the spectrum of cognitive functioning in real-life adaptive contexts (Chatham et al. 2017). An understanding of factors affecting the development of the building blocks of social communication, such as emotion understanding, is therefore needed to inform personalized intervention and increase participation and inclusion processes.

Specifically, in light of the need to target the preconditions for inclusive practices to overcome barriers to learning in children with ASD (Guldberg 2010) and given that cognitive ability is likely to modulate treatment response (Hedvall et al. 2015), in this study we examine the relationship between emotion understanding ability, age and IQ in school-age children with ASD.

Methods

Participants

Participants were recruited through specialist ASD services and research labs affiliated to University of Turin, Italy, and the University of Applied Sciences and Arts Western Switzerland, Lausanne, Switzerland. The study was approved by the Institutional Review Board of the funder, Swiss National Found (FNS 13DPD3-132427). Written

informed consent was obtained from parents/carers. Diagnostic evaluation was conducted at each recruitment site and all participants met ICD-10 criteria for ASD using a combination of semi-structured observations (ADOS-2, Lord et al. 2012), parent interviews and school reports. The following inclusion criteria were applied: a) age between 5 years, 0 months and 10 years, 0 months and b) non-verbal IQ $\geq$ 70. A total of 55 participants were included in the study: 46 were of Italian nationality, the remaining were French (n=6) and Swiss (n=3).

[Table 1 near here]

Measures

Non-verbal cognitive ability was measured with the Leiter-R Brief IQ (Roid and Miller 2011). Emotion understanding was assessed with the Test of Emotion Comprehension (TEC, Pons and Harris 2000), in its Italian version for the Italian and Italian-speaking Swiss children, and in its French version for the French children and the French-speaking Swiss children. The TEC has been validated on English (Pons, Harris, and de Rosnay 2004) and Italian (Albanese and Molina 2008) samples, and showed good cross-cultural validity in a comparison between German and Italian pre-schoolers (Molina et al. 2014). The TEC provides a 'Total Emotion Comprehension' score, resulting from the evaluation of nine components of emotion understanding: emotion recognition, external causes of emotions, role of desires, beliefs, reminder, emotion regulation, difference between felt and displayed emotion, mixed emotions and moral dimension of emotions. Each component is presented following a prescribed order and is addressed in a single task requiring minimal expressive language skills. The child listens to a short, simple story which is also depicted in illustrations. Then, a panel with four different facial expressions is presented and the child is asked to point to the picture showing the

facial expression of the emotion the character is feeling. The whole administration requires about 15 minutes. Given that 84% of participants were Italian, we used the Total z-transformed scores of the Italian standardization norms (Albanese and Molina 2008) for all participants, as neither Swiss nor French normative data were available. Data on receptive vocabulary (evaluated with the PPVT-R, Stella, Pizzoli, and Tressoldi 2000) were available for 35 children: the correlation between language and IQ was small (r = .25).

Results

Overall, participants' performance on the TEC test fell significantly below the normative expectation by age [one-sample t-test: t (54) = -6.739, p <.001)]. For 20% of children the TEC Total z-score was below -1, i.e. in the 'low average' range, and for a further 41% the score was below -2, i.e. in the 'below average' range.

To estimate the effect of IQ and age on level of emotion understanding (TEC Total z-score) a multiple linear regression was conducted. The regression equation was significant (F(2,52) = 6.652, p = .003), with a R^2 of .204. Age was negatively associated with emotion understanding, while IQ was positively associated with emotion understanding; both effects were small (Table 2). To further explore the effect of IQ on emotion understanding abilities, we examined performance in children with 'borderline intellectual functioning' (as per DSM-5 definition, IQ between 70 and 84, n = 20) and children with 'normative intellectual functioning' (IQ between 85 and 131, n = 35). In the 'normative intellectual functioning' group, 46% scored below a clinically significant level of -2 SD ('below average' range) on the TEC compared to 70% of children in the 'borderline intellectual functioning' group [$\chi^2(1) = 3.32$, p = .034].

[Table 2 near here]

Discussion

Socio-emotional competences are crucial in everyday life: they are associated with successful inclusion, participation in social contexts, and quality of life (Ochs et al. 2001; Jones and Frederickson 2010). Given the heterogeneity of clinical and academic achievement profiles in children with ASD, in order to tailor support for socio-emotional competences there is a need to a) understand the common factors responsible for positive outcomes in educational interventions (Gustavsson, Kittelsaa, and Tøssebro 2017) and b) to identify relevant background factors likely to moderate outcomes (Nuske, Vivanti, and Dissanayake 2013). In this study we examined the role of the key factors of age and IQ on emotion understanding skills, showing independent effects of both age and IQ on emotion understanding skills, with lower standard scores associated with both greater age and lower IQ. The overall effect of the model was small, which could be due to participants' heterogeneity relatively to the sample size or to other variables that were not included in the current study. The negative association of age with TEC standard scores (i.e., the distance between the raw score and the typical population mean) suggests that in children with ASD the gap in emotion understanding competence with typically developing peers tends to widen as children grow. In school-aged typically developing children, both maturation and increased exposure to social contexts (siblings, peers at school) are generally considered to positively contribute to emotion understanding (McAlister and Peterson 2013; Wang and Su 2009; for negative findings see: Molina and Bulgarelli 2012; Das and Babu 2004). However, social skills development in ASD compared to typically developing peers has been found to either worsen with age (Klin et al. 2007) or remain stable (Gillespie-Lynch et al. 2012). Our finding is in line with such evidence, suggesting that difficulties may become more apparent when growing 'social communication demands exceed limited capacities', as

per novel DSM-5 diagnostic criteria (American Psychiatric Association, 2013, 48). Further studies are needed to evaluate individual developmental trajectories of emotion understanding in ASD to contrast them with the typical developmental course (Albanese and Molina 2008; Molina et al. 2014; Pons et al. 2003).

Participants' emotion understanding score increased .03 for each IQ point increase, indicating that, over and above age, cognitive level is associated with emotion understanding. Furthermore, when examining performance by IQ bands, we found that the majority of children with a borderline cognitive functioning were in the low average range on the TEC. This suggests that cognitive ability is more strongly associated with emotion understanding at the lower end of functioning: while the TEC, which does not require a verbal response, can be administered to children as young as 3 years with minimal expressive language skills, in children with ASD these minimum cognitive requirements are not sufficient. This finding could be due to a 'pure effect' of IQ. Alternatively, this could be an indication that other general factors, such as decreased attention and motivation, or other aspects of social cognition that have been found to be associated with lower cognitive skills, such as Theory of Mind, have a significant influence on children's difficulties in emotion understanding (Nuske et al. 2013). Higher IQ was associated with better emotion understanding competence. This is in line with previous evidence of the predictive value of IQ for long-term outcomes (Magiati et al. 2014). However, it should not be excluded that the better performance on the TEC in children with higher IQ may only reflect a 'theoretical' understanding of the task, rather than actual emotion understanding competence in real life, implying that residual deficits may still be present. Previous evidence shows that high-functioning children of ASD are aware of and distressed by negative inclusion practices, such as rejection and derision, exhibited by peers in consequence of their difficulties (Ochs et al. 2001), and

our finding should not be interpreted to mean that children with higher IQ do not merit and may not benefit from access to social communication interventions to help them navigate age-expected social challenges.

The present study shows a number of strengths, including the relatively large sample size and the use of non-verbal measures of emotion understanding and cognitive functioning, which reduces the impact of expressive language on performance. However, the results should be interpreted in the context of several limitations. Language plays an important role in emotion understanding skills evaluated with the TEC both in typically developing children (Pons et al. 2003) and in children with ASD (Wiesendanger et al. 2010). We were not able to collect complete language evaluations for all the participants and therefore we cannot exclude a possible confounding effect of language on the relationship between IQ and emotion understanding. However, this limitation is partly mitigated by the low correlation between receptive language and IQ. In light of the uneven language profile of children with ASD (Hudry et al. 2010), future studies should consider, separately, the possible role of receptive and expressive language skills on the emotion understanding skills. The inclusion of children with intellectual disability in future studies would be useful to take into account the complex relationship between IQ, age and emotional difficulties (Salomone et al. 2014) and gender differences in emotion understanding difficulties should be considered as they may also affect the diagnostic process. Longitudinal studies will be necessary to accurately explore the trend of change by age. Lastly, a structured measure of emotion understanding incurs the risk of focusing on child's limitations rather than capturing alternative or unusual but otherwise appropriate ways of understanding emotions, such as sense of humour (King et al. 2012).

All considered, the TEC showed in our sample to be suitable for testing children with ASD with a range of ages and abilities, and to be a useful tool for research and educational settings. We found that while emotion understanding skills in children with ASD tend to decrease with age, cognitive abilities are positively correlated with emotion understanding skills. As the individuals' unique profile of strengths and difficulties across developmental domains will influence inclusion and participation processes, it is crucial to take these into account for the designing of tailored educational plans. The age-related decline in emotion understanding skills is consistent with well-established findings of a negative correlation between adaptive behaviour skills and age in children with ASD (Perry et al. 2009), which reflects the challenges of the out-of-home environments where all children are incrementally expected to spend time as they grow. One important implication of our findings is the notion that emotion understanding competence should be specifically targeted within educational activities, not only in preschool years, but increasingly as children grow. In fact, while increased exposure to those social contexts at school-age may promote the development of emotion understanding, and more generally of emotion comprehension skills in typical development, the effect of such social challenges, when not addressed within specific psycho-educational interventions, may be detrimental for children with ASD.

In absence of cognitive impairment, children with ASD can partially compensate their socio-emotional impairment thanks to their cognitive abilities (Bauminger 2002; Kasari, Chamberlain, and Bauminger 2001; Sigman et al. 1999): these can be a starting point to build a personalized intervention to support these children ability to emotionally and socially interact with others adequately. For example, children need to be provided with small, structured group learning opportunities when strategies to recognize, understand and interpret emotions are explicitly taught (Stichter et al. 2012).

Moreover, to boost the effectiveness of these educational interventions for those who are most disadvantaged (low-functioning children with ASD, especially as they grow), tailored delivery methods and remediation strategies such as environmental supports (e.g. visual schedules) must be put in place. Adaptations of existing programs to promote emotion understanding, such as reading of short illustrated scenarios or emotional scripts presenting a prototypical everyday situation with emotional connotations, followed by guided group conversations (Ornaghi et al. 2015), would be particularly useful. To cater for all levels of verbal functioning, conversations could be substituted by non-verbal ways of recounting and sharing their own experiences and thoughts in relation to the target emotion, such as drawing or mime. Given its primarily non-verbal nature, the TEC would be an ideal measure to measure progress over time.

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Table 1. Participants characteristics

	Males	*Age in years*		*IQ*	
	n (%)	M (SD)	Min-max	M (SD)	Min-max
Total sample (N=55)	47 (85.5)	7.15 (1.43)	5-10	92.91 (15.95)	70-131
Low IQ (n=20)	16 (80.0)	7.40 (1.60)	5-10	77.85 (4.00)	70-83
High IQ (n=35)	31 (88.6)	7.00 (1.33)	5-9	101.51 (13.62)	85-131

Table 2. Multiple linear regression: emotion understanding on age and non-verbal IQ

	B	SE B	β	p
TEC Total z score				
Age	-.026	.012	-.279	.030
Leiter Brief IQ	.031	.012	.315	.015
R^2 =.20				

Figure 1. Relationships among the constructs of emotional competences, emotion understanding and emotion recognition.