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Impairments in cognitive empathy and alexithymia occur independently of executive functioning in college students with autism

Tim Ziermans^{1,2}, Ymke de Bruijn¹ , Renee Dijkhuis¹,
Wouter Staal^{1,3} and Hanna Swaab¹

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Abstract

Reduced empathy and alexithymic traits are common across the autism spectrum, but it is unknown whether this is also true for intellectually advanced adults with autism spectrum disorder. The aim of this study was to examine whether college students with autism spectrum disorder experience difficulties with empathy and alexithymia, and whether this is associated with their cognitive levels of executive functioning. In total, 53 college students with autism spectrum disorder were compared to a gender-matched group of 29 neurotypical students on cognitive and affective dimensions of empathy and alexithymia. In addition, cognitive performance on executive functioning was measured with computerized and paper-and-pencil tasks. The autism spectrum disorder group scored significantly lower on cognitive empathy and higher on cognitive alexithymia (both $d=0.65$). The difference on cognitive empathy also remained significant after controlling for levels of cognitive alexithymia. There were no group differences on affective empathy and alexithymia. No significant relations between executive functioning and cognitive alexithymia or cognitive empathy were detected. Together, these findings suggest that intellectually advanced individuals with autism spectrum disorder experience serious impairments in the cognitive processing of social–emotional information. However, these impairments cannot be attributed to individual levels of cognitive executive functioning.

Keywords

adults, alexithymia, autism spectrum disorders, college students, empathy, executive functioning, high IQ

While stereotypically a lack of empathy is considered a core feature of autism spectrum disorders (ASDs), the research literature is far more nuanced and does not support this blanket statement. Although there is no universal agreement on its definition, empathy is commonly assumed to include both a cognitive component of recognizing and understanding the emotions of others and an affective component of emotionally reacting to these emotions in an appropriate manner (Davis, 1983; Decety, 2011). The terms cognitive empathy and theory of mind are often used interchangeably and arguably represent more or less similar constructs (Blair, 2005; Leiberger and Anders, 2006; Mathersul et al., 2013; Rogers et al., 2007; Shamay-Tsoory, 2011). Impairments in empathy have been reported in both children and adults with ASD (Auyeung et al., 2009; Sucksmith et al., 2013), as well as for ASD individuals with high levels of intelligence (IQ; Baron-Cohen and Wheelwright, 2004; Lombardo et al., 2007).

Interestingly, the empathy imbalance hypothesis (EIH) of autism (Smith, 2009) suggests that, instead of a global empathy deficit, only cognitive empathy is compromised in individuals with ASD and the capacity for affective empathy is heightened, as indicated by hyperarousal in response to emotional cues by others, such as fearful facial expressions (Lassalle et al., 2017). A specific deficit in cognitive empathy has been supported recurrently by studies in individuals with ASD, with and without high IQ (Bellebaum et al., 2014; Dziobek et al., 2008; Frith, 2001;

¹Leiden University, The Netherlands

²University of Amsterdam, The Netherlands

³Karakter Universitair Centrum, The Netherlands

Corresponding author:

Tim Ziermans, Department of Psychology, University of Amsterdam,
Nieuwe Achtergracht 129-B, 1018 WS Amsterdam, The Netherlands.
Email: t.b.ziermans@uva.nl

Lockwood et al., 2013; Pouw et al., 2013; Rogers et al., 2007). However, regarding affective empathy, the EIH has received fewer direct support so far, with some studies even suggesting a slightly decreased capacity for affective empathy in ASD as well (Mathersul et al., 2013; Rogers et al., 2007; Shamay-Tsoory et al., 2002). Therefore, the most consistent evidence on empathy deficits in ASD to date suggests that it is mostly restricted to reduced cognitive empathy compared to neurotypical individuals.

It has been suggested that empathy deficits in individuals with ASD can partially be explained by the co-occurrence of alexithymia (Bird and Cook, 2013; Bird et al., 2010; Lassalle et al., 2018). This condition is characterized by impairments in experiencing and verbalizing one's own emotions and feelings (Hill et al., 2004; Stephenson, 1996) and differs from empathy in that it is more centered around one's own emotional state instead of emotions in others. Indeed, the prevalence of alexithymia has been reported to be nearly as high as 50% in the ASD population (Hill et al., 2004), while it is only estimated at 13% in the general population (Salminen et al., 1999). Like empathy, alexithymia consists of a cognitive and affective component (Vorst and Bermond, 2001). Cognitive alexithymia involves difficulties in identifying, verbalizing, and analyzing emotions, whereas affective alexithymia involves problems in experiencing emotional arousal and fantasizing (Bermond et al., 2007). Studies that have differentiated between the affective and cognitive domains of alexithymia have shown that elevated levels of alexithymic traits are found in individuals with ASD, predominantly in the cognitive domain (Berthoz and Hill, 2005; Ketelaars et al., 2016). This pattern has also been identified in college students with ASD (Dijkhuis et al., 2017). The comorbidity between ASD and alexithymia is therefore suggested to be specific for the alexithymia II subtype, which is characterized by a deficit in the cognitive domain without impairments in the affective domain (Bermond, 1997).

As follows from the introduction above, the constructs of empathy and alexithymia are theoretically linked since both definitions involve cognitive processes of understanding and reacting to emotions. Accordingly, Bird et al. (2010) found no impairment in empathy in individuals with ASD and high IQ after controlling for alexithymia. In contrast, other studies have found that alexithymia had no effect on empathy in individuals with ASD and high IQ (Fan et al., 2013) and could not explain the reduced levels of cognitive empathy and theory of mind deficits in individuals with ASD traits and high IQ (Gökçen et al., 2016; Lockwood et al., 2013). Therefore, it is currently unclear to what extent reduced (cognitive) empathy can be explained by the presence of alexithymic traits in ASD.

Problems within the cognitive dimension of empathy and alexithymia may partially be explained by cognitive (dys)functions within the executive domain, which regulate relevant thought processes. Executive functions (EF) such

as response inhibition, working memory/updating, mental flexibility/shifting, and planning/organizing are commonly investigated in ASD and often reported to be deficient, although findings are mixed (Demetriou et al., 2018), especially when matched for IQ with a neurotypical group (Wallace et al., 2016). The link between EF and cognitive empathy is largely supported by studies focusing on operationalizations of theory of mind rather than empathy per se. Despite the limited added value of EF deficits for differential diagnostics, many associations between executive dysfunction and poor theory of mind skills have been found in children and adolescents with ASD, as well as non-clinical populations with elevated levels of autism traits (Gökçen et al., 2016; Ozonoff et al., 1991; Pellicano, 2007).

Regarding the compositional nature of EF, reasonable support for relations between theory of mind, on one hand, and inhibition, mental flexibility, and planning, on the other, has been reported for individuals with and without ASD (Ahmed and Miller, 2011; Austin et al., 2014; Carlson and Moses, 2001; Gökçen et al., 2016; Grattan and Eslinger, 1989; Hughes, 1996, 1998; Joseph and Tager-Flusberg, 2004; Müller et al., 2012; Mutter et al., 2006; Pellicano, 2007; Perner et al., 2002; Vetter et al., 2013). These associations tend to show a uniform direction: higher levels of EF are related to better theory of mind abilities. Results on the relation between theory of mind and working memory in individuals with and without ASD are more inconsistent (Austin et al., 2014; Hughes, 1998; Joseph and Tager-Flusberg, 2004; Müller et al., 2012; Mutter et al., 2006; Vetter et al., 2013). There is also some evidence from longitudinal studies in children with and without ASD that EF components can predict abilities in theory of mind, albeit with mixed results for the different components (Austin et al., 2014; Hughes and Ensor, 2007; Müller et al., 2012; Pellicano, 2010). However, these studies are partially restricted by not including multiple EF components simultaneously. Moreover, few direct comparisons have been made between individuals with and without ASD.

In contrast to cognitive empathy/theory of mind, associations between EF and cognitive alexithymia have received little attention. In various clinical samples (traumatic brain injury, HIV), studies have shown inconsistent results (Bogdanova et al., 2010; Henry et al., 2006). However, in non-clinical samples with varying levels of alexithymic traits, relations between (cognitive) alexithymia and impairments in inhibition, working memory, mental flexibility, and planning have been observed (Koven and Thomas, 2010; Xiong-Zhao et al., 2006). Furthermore, Santorelli and Ready (2015) reported that an EF composite score was related to cognitive alexithymia in older adults. Therefore, although there appears to be some support for the notion that EF and cognitive alexithymia are related, it is unclear whether these findings can be extended to the autism spectrum.

The primary aim of this study is to examine cognitive and affective alexithymic traits and empathy in college students with and without ASD. It is hypothesized that compared to typically developing individuals, ASD individuals will display (1) higher levels of cognitive, but not affective, alexithymic traits, and (2) lower levels of cognitive, but not affective empathy. Moreover, we expect that (3) more problems within the cognitive domains are associated with autism symptom severity. We explore whether the difference in cognitive empathy is robust against controlling for cognitive alexithymia, as there is limited and conflicting evidence concerning this matter.

The second objective of this study is to examine relations between executive functioning (EF) (working memory, inhibition, mental flexibility, and planning) and deviations in empathy and alexithymia in ASD. It is expected that (4) better performance on all four executive functioning skills is related to fewer cognitive alexithymic traits and (5) higher levels of cognitive empathy.

Methods

Participants

All participants were post-secondary students enrolled in Dutch university programs or at universities of higher vocational education in the Netherlands. ASD participants were recruited through Stumass, a non-profit organization that provides assisted living facilities to students in higher education with a diagnosis within the autism spectrum. Stumass houses are located in 18 different cities nationwide. In order to be enrolled into Stumass, students are required to have received a formal clinical diagnosis of ASD based on the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) criteria (version dependent on what was customary at the time of referral) and a formal referral for supported living from a mental health specialist. An additional requirement for enrollment in Stumass is that psychiatric comorbidity, if present at entry, is considered either in remission or of minimal impact on global daily functioning of the student. Neurotypical students were recruited through information brochures and an online student recruitment platform at Leiden University. A concerted effort was made to recruit across different faculties to better match the academic profile of Stumass students. Participants in the control group filled out a customized screening questionnaire consisting of a list of yes/no questions to exclude the presence of psychopathology (including ASD). Furthermore, all participants were required to be 18 years or older and fluent in Dutch. This study was part of a larger longitudinal research project on determinants of quality of life in students with ASD. The project was funded by the Stumass foundation and approved by the Medical Ethics Committee of Leiden University Medical Center.

A total of 89 participants (54 ASD, 35 controls) were initially recruited. However, six controls were excluded because they reported being diagnosed with psychopathology (three with ASD, two with attention deficit/hyperactivity disorder, one with depressive disorder). Controls were a priori matched for sex by including approximately one female control student for every three control males. The age of the total participant group ranged from 18.3 to 28.1 years old.

Measures

Intelligence. IQ levels were estimated with the Vocabulary and Block Design subtests of the Dutch version of the Wechsler Adult Intelligence Scale—Fourth Edition (V-BD; Wechsler, 2012). IQ estimation was based on a long-standing method in the short-form literature with the formula $[3 \times (\text{sum of normed scores}) + 40]$ (Tellegen and Briggs, 1967). The V-BD short form correlates highly with the full-scale IQ score of the WAIS-IV and is considered a valid estimation of intelligence, with good reliability and validity in both clinical and non-clinical populations (Girard et al., 2015).

Autism traits. The Dutch self-report version of the Social Responsiveness Scale—Adult version (SRS-A) was used to assess the level of autism traits of all individuals. The SRS-A is a questionnaire consisting of 64 items measuring social responsiveness with a 4-point scale (score 0–3) (Constantino and Todd, 2005). Higher scores indicate more autism traits, and scores range from 0 to 192. The discriminant and concurrent validity of the SRS-A are moderate to good (Bölte, 2012). The Dutch self-report version that is used in this study has excellent psychometric properties with high test–retest reliability ($r=0.88$) and a high internal consistency (Cronbach's $\alpha=0.95$) (Noens et al., 2012).

Empathy. Empathy was measured with the Dutch version of the Interpersonal Reactivity Index (IRI; Davis, 1980). The IRI consists of four 7-item subscales: personal distress (PD), empathic concern (EC), perspective taking (PT), and fantasy (FS). To limit the influence of self-perception bias, informants (mothers) were asked to indicate to what extent the items describe the participants on a 5-point scale, ranging from 0 = “does not describe him or her well” to 4 = “describes him or her very well.” Total scores range from 0 to 112 (max. 28 per scale), with higher scores representing more empathy. Items on the PD and EC scales together form the affective component of empathy. The PT scale represents the cognitive component of empathy, and the FS scale reportedly does not seem to fit the cognitive–affective structure (De Corte et al., 2007). Construct, convergent, and discriminant validity of the Dutch self-report version of the IRI support its psychometric adequacy and the internal reliabilities of the four scales are satisfactory

(De Corte et al., 2007). Informant versions await a similar evaluation. Although psychometric properties are not known for ASD populations, the IRI has been used among individuals with ASD multiple times (Dziobek et al., 2008; Rogers et al., 2007).

Alexithymia. The Dutch Bermond–Vorst Alexithymia Questionnaire (BVAQ; Vorst and Bermond, 2001) was assessed to measure the degree of alexithymic traits. The BVAQ is a self-report questionnaire that consists of five 8-item subscales: emotionalizing, fantasizing, identifying, analyzing, and verbalizing. The answer possibilities range from 1 = “fully applicable” to 5 = “entirely not applicable.” Items are formulated either positively or negatively, and total scores range from 40 to 200, so that higher scores reflect more alexithymic traits. The emotionalizing and fantasizing subscales form the affective component of alexithymia, with scores ranging from 16 to 80. The identifying, analyzing, and verbalizing subscales form the cognitive dimension, with scores ranging from 24 to 120. The psychometric properties of the BVAQ in a Dutch neurotypical population indicate that the divergent and convergent validity are satisfactory and that the reliability parameters are good (Vorst and Bermond, 2001). For ASD, reasonable results regarding the convergent and discriminant validity have been reported as well, and the test–retest reliability of the total BVAQ is considered good (Berthoz and Hill, 2005).

Executive functioning. The measures of EF included two computerized subtests of the *Amsterdamse Neuropsychologische Taken* (ANT; De Sonneville, 2005) and three subtests of the behavioral assessment of the dysexecutive syndrome (BADS; Wilson et al., 1996). Validity coefficients and reliability estimates of the ANT are satisfactory (De Sonneville, 2005, 2014). The ANT has been used in various clinical and non-clinical populations, including ASD individuals with high IQ (e.g. Ziermans et al., 2017). The concurrent and construct validity of the BADS and its subtests are adequate, and the ecological validity is better than the ecological validity of other standard EF tests (Norris and Tate, 2000). Test–retest reliability parameters are considered inappropriate for novel problem-solving tasks such as the BADS subtasks (Chamberlain, 2003). The instrument has been used multiple times in ASD populations (Bramham et al., 2009; Hill and Bird, 2006).

Inhibition and mental flexibility. The Shifting Attentional Set-Visual (SSV) subtest of the ANT measures both inhibition and mental flexibility. Briefly, this task consists of three conditions in which the participant is subsequently asked to follow the movement of a green square (condition 1: compatible response), a red square (condition 2–inhibition: incompatible response) or both (condition 3–shifting: compatible/incompatible response) on a horizontal bar

consisting of nine squares. Speed (reaction time) and accuracy (% errors) parameters were calculated to operationalize inhibition and mental flexibility (for a more detailed description, see the work by Ziermans et al. (2017)).

Working memory. The Spatial Temporal Span (STS) subtest of the ANT is designed to measure working memory, using squares in a 3 × 3 visual spatial grid. These squares are pointed out by a hand animation in a specific order, with increasing complexity. The number of correctly identified targets in the right order in the backward condition of the task constitutes the working memory parameter for this study (for a more detailed description, see the work by Ziermans et al. (2017)).

Planning. Three subtests from the BADS were administered to measure the ability to plan and organize: the Key Search task (KS), the Zoo Map task (ZM), and the Modified Six Elements task (SE). For brevity, we referred to Wilson et al. (1996) and Hill and Bird (2006) for a detailed description of the task content. Raw scores on each of the BADS tasks are transformed into profile scores, ranging from 0 to 4 for each task.

Procedure

The assessment of EF was part of a testing protocol that lasted approximately 3 h in total. Informed consent forms were signed before the start of the assessment. The cognitive part (≈90 min), including the BADS, the ANT, and the abbreviated WAIS, was always administered first. The BADS was administered by the experimenter on paper, whereas the ANT was administered on a laptop computer. At the end of the session, participants were debriefed and received a voucher of €20 for their participation in the study. In addition, students were asked to fill out online questionnaires afterwards. Participants received an e-mail with a link to the questionnaires so that they could answer them at home at their own convenience. The SRS-A and the BVAQ were among the included questionnaires. In addition, participants were asked permission to invite their mothers to fill in separate online questionnaires, including the IRI.

Statistical analyses

All analyses were conducted with IBM SPSS software. Data were first checked for outliers and missing values. For group characteristics, extreme outliers ($M \pm 3 SD$; numerical data only) were removed for any further analyses. Extreme outliers on cognitive test or outcome variables were excluded listwise per analysis. Missing values were tested for randomness with Little’s MCAR (Missing Completely At Random) test. Multiple imputation by chained equations (MICE; Azur et al., 2011) was applied for multivariate missing

data with the predictive mean matching approach for non-normally distributed data (Van Ginkel and Kroonenberg, 2014)

Group characteristics were tested for differences with chi-square tests (sex) and independent samples *t* tests (age, IQ). Next, group differences for alexithymia and empathy were tested with independent samples *t* tests. Significant differences were subsequently investigated for correlations with autism symptom severity. Results were based on pooled statistics generated by SPSS (version 24). Cohen's *d* was calculated as an effect size for group differences (Cohen, 1998). Next, the level of cognitive empathy was analyzed as the dependent variable in an analysis of covariance (ANCOVA), with group (ASD and comparison group) as independent variable and cognitive alexithymia as a covariate. Pooled statistics for ANCOVA were generated with syntax provided by Van Ginkel and Kroonenberg (2014).

To test for associations between EF variables and cognitive alexithymia/empathy, pooled Pearson correlation coefficients (or Spearman, in case of non-normality) were generated: first for the total sample and then for the ASD and comparison group individually. To improve reproducibility and reduce the chance of Type I error, a *p* value of <0.005 for new discoveries has recently been recommended (Benjamin et al., 2018). However, in light of the partially confirmatory nature of our research questions, significance level was set at $\alpha = 0.01$.

Results

Group characteristics

One ASD individual was excluded for analysis due to an estimated IQ score of >3SD below the mean (IQ=73). The final sample for analyses therefore consisted of 82 participants: 53 ASD, 29 controls. Table 1 displays the characteristics of both groups. Age differed significantly between groups ($U=366.5$, $p < 0.001$), with participants in the ASD group being on average 2 years older than individuals in the comparison group. The mean difference in estimated IQ was also significant between groups ($t(80)=3.83$, $p < 0.001$), with higher scores for the ASD group than for the comparison group. Furthermore, ASD participants

reported significantly more autistic traits than comparisons ($U=182.0$, $p < 0.001$). Regarding medication use, 19 ASD participants (36%) used at least one type of psychotropic medication (antidepressants, stimulants, or antipsychotics) of whom seven (13%) used two or more. Comparisons did not use psychotropic medication.

Group differences in alexithymia and empathy and correlation with autistic traits

Missing value analysis showed there was a large proportion of missing data for the IRI parent report (52%) due to unresponsiveness and to a lesser extent for BVAQ (7%). The pattern of missing values was random, based on Little's MCAR test, and MICE was used to generate a recommended number of 40 imputed data sets (Graham et al., 2007) for subsequent pooled statistics. Because age and estimated IQ differed between groups, linear associations with dependent variables were checked with correlations to determine whether group comparisons needed to be controlled for these potential confounders. However, no significant correlations were detected.

Alexithymia. The difference in cognitive alexithymia between the ASD group and the control group was significant ($t(8004)=2.82$, $p=0.005$), with higher scores for the ASD group ($M=69.45$, $SD=15.59$) than the control group ($M=59.31$, $SD=15.34$), and a medium effect size ($d=0.65$) according to Cohen's (1998) interpretation. The differences in affective alexithymia ($p=0.08$, $d=0.40$) and total alexithymia ($p=0.14$, $d=0.35$) were not significant.

Explorative analyses of group differences on subscales of the two BVAQ dimensions revealed significantly higher scores in the ASD group for the cognitive subscales verbalizing ($t(3796)=2.63$, $p=0.009$, $d=0.61$) and (at trend level) identifying ($t(5839)=2.52$, $p=0.012$, $d=0.60$), but not for analyzing ($p=0.14$, $d=0.34$). For the affective dimension both subscales, fantasizing ($p=0.08$, $d=0.41$) and emotionalizing ($p=0.50$, $d=0.15$), did not differ between groups. The mean scores and standard deviations of the ASD and control group on all BVAQ variables are

Table 1. Group characteristics in means (\pm SD) and proportions (%).

	ASD ($n=53$)	Controls ($n=29$)	<i>t/U</i>	χ^2	<i>p</i> value
Sex (% male)	72%	69%		0.68	0.795
Age	22.52 \pm 2.44	20.42 \pm 1.46	4.85		<0.001
IQ	118.28 \pm 11.21	108.28 \pm 11.53	366.5		<0.001
Autistic traits ^a	63.69 \pm 10.77	50.28 \pm 11.40	182.0		<0.001
Medication (% yes)	36%	–			
Antidepressant	19%	–			
Stimulant	17%	–			
Antipsychotic	13%	–			

^aSRS-A scores were missing for four ASD and four control individuals.

shown in Table 2. In addition, to investigate potential sex differences within the ASD group, direct comparisons did not suggest that males and females differed significantly on cognitive ($p=0.41$), affective ($p=0.25$), or total alexithymia ($p=0.19$) scores.

Table 2. Means and standard deviations of the BVAQ and IRI.

	ASD		Controls	
	M	SD	M	SD
BVAQ total	108.12	19.13	101.60	19.17
BVAQ cognitive^a	69.45	15.59	59.31	15.34
Verbalizing^a	27.10	7.39	22.46	7.91
Identifying^a	23.47	6.15	20.08	5.06
Analyzing	18.88	5.97	16.78	6.40
BVAQ affective	38.67	8.31	42.29	9.74
Emotionalizing	21.46	5.21	22.35	6.44
Fantasizing	17.21	6.47	19.94	6.97
IRI total	51.09	9.76	52.62	7.82
IRI cognitive^b				
Perspective taking^a	9.88	5.11	13.03	4.43
IRI affective	30.48	5.88	28.63	5.29
Personal distress^a	15.90	3.82	11.77	5.73
Empathic concern^a	14.58	4.94	16.86	4.03
IRI other				
Fantasy	10.73	5.34	10.96	4.10

BVAQ: Bermond–Vorst Alexithymia Questionnaire; IRI: Interpersonal Reactivity Index; ASD: autism spectrum disorder; SD: standard deviation.

^aSignificant group difference; $p < 0.01$.

^bThe cognitive dimension consists of the perspective taking subscale only and therefore statistics are identical for both.

Empathy. The difference in cognitive empathy between the control group and the ASD group was significant ($t(881)=-2.72$, $p < 0.001$), with higher scores for the control group ($M=13.03$, $SD=4.43$) than the ASD group ($M=9.88$, $SD=5.11$) and a medium effect size ($d=0.65$). Furthermore, the group effect on cognitive empathy remained significant ($F(1, 61)=7.20$, $p=0.009$) when cognitive alexithymia was included as a covariate in the ANCOVA analysis (see Table 3). The group differences in affective empathy ($p=0.16$, $d=0.33$) and total empathy ($p=0.47$, $d=0.17$) were not significant.

Exploratively, the subscales of the IRI revealed that in addition to the PT subscale (=cognitive alexithymia), there

Table 3. Pooled ANCOVA with cognitive empathy as dependent variable.

	F	df _{between}	df _{within}	p value
Model	3.70	2	72	0.029
Intercept	19.64	1	59	<0.001
Group	7.20	1	61	0.009
Cognitive alexithymia	0.01	1	59	0.831

ANCOVA: analysis of covariance.

were also significant, bi-directional group differences within the affective dimension. The subscale results indicated higher levels of PD ($t(1129)=-3.89$, $p < 0.001$, $d=0.85$) and lower levels of EC for others ($t(1789.19)=2.10$, $p=0.007$, $d=0.51$) in the ASD group compared to the controls. The group difference on the FS subscale was not significant ($p=0.71$). The mean scores and standard deviations of the ASD and control group on the IRI variables are included in Table 2. Finally, direct comparisons were not suggestive of significant sex differences within the ASD group on cognitive ($p=0.93$), affective ($p=0.36$), or total empathy ($p=0.86$) scores.

Autistic traits. Autistic traits correlated positively with cognitive alexithymia, for the total group ($\rho=0.61$, $p < 0.001$), for ASD alone ($\rho=0.55$, $p < 0.001$) and at trend level for controls ($\rho=0.48$, $p=0.013$). For all associations, autism symptom severity was moderately related to higher levels of cognitive alexithymia. Figure 1 illustrates a scatterplot of the raw data for the total group. At a subscale level, correlations with verbalizing and identifying were examined. Both were significantly correlated with autistic traits for the total group (respectively, $\rho=0.48$, $p < 0.001$ and $\rho=0.58$, $p < 0.001$). However, when the data were split by group, only the ASD group showed significant correlations for verbalizing ($\rho=0.38$, $p < 0.001$) and identifying in particular ($\rho=0.62$, $p < 0.001$). There were no significant correlations of autistic traits with cognitive or (subscales of) affective empathy.

Correlations of EF with cognitive alexithymia and cognitive empathy

Correlation coefficients based on pooled statistics are summarized in Table 4. None of the EF performance measures correlated significantly with cognitive alexithymia or cognitive empathy. Results for the control and ASD group separately also yielded no significant results. Because cognitive performance may have been influenced by medication use, analyses were performed an additional time without medicated ASD individuals, but this did not change the outcome in terms of significant correlations.

Discussion

This study investigated whether problems with empathy and alexithymia are characteristic of intellectually advanced college students with ASD and whether these problems are associated with EF. As expected, college students with ASD exhibited more alexithymic traits in the cognitive domain and lower levels of cognitive empathy compared to neurotypical college students. Moreover, the group difference in cognitive empathy remained significant after controlling for cognitive alexithymia. In addition, more autism

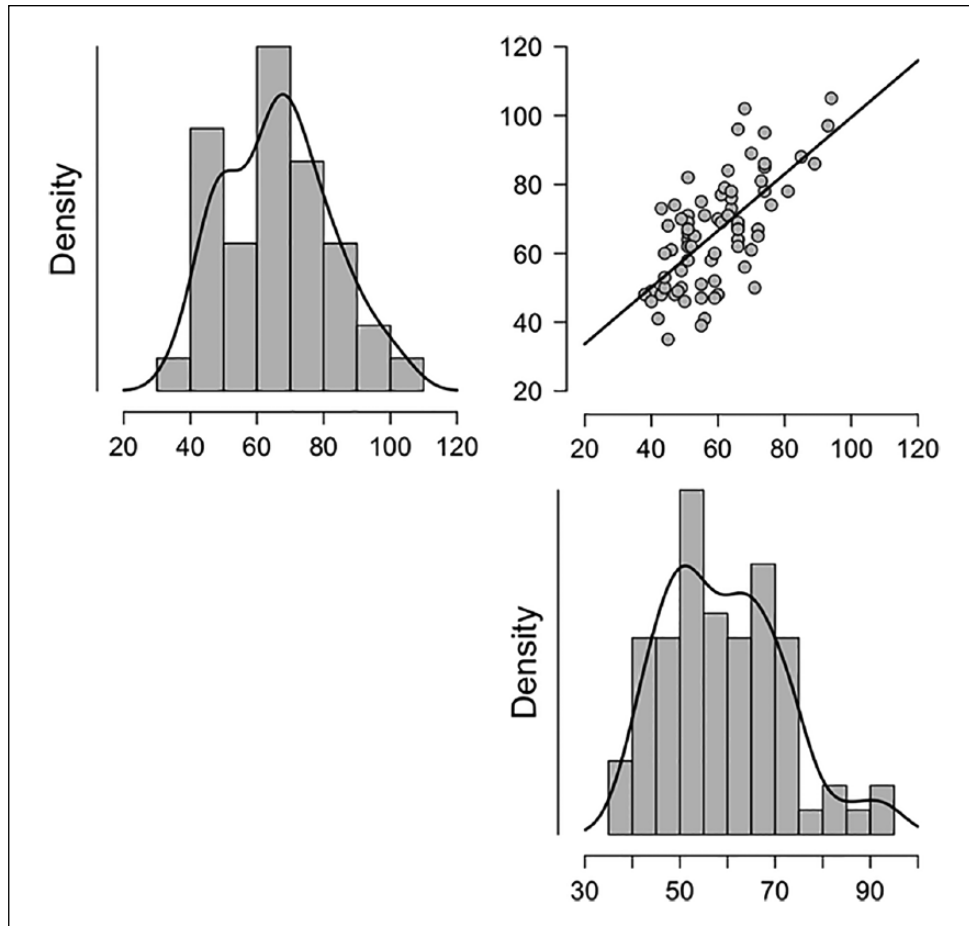


Figure 1. Correlation plot and raw data distributions for autistic traits (SRS-A; X-axis) and cognitive alexithymia (BVAQ; Y-axis) across groups (N=74). The plot shows that more autistic traits are related to higher levels of cognitive alexithymia.

Table 4. Correlations between executive function measures with cognitive empathy and alexithymia.

	Cognitive alexithymia			Cognitive empathy		
	Total	ASD	Controls	Total	ASD	Controls
IH speed (<i>r</i>)	-0.04	-0.16	0.27	0.07	0.17	-0.26
IH accuracy (<i>r</i>)	-0.13	-0.17	0.09	0.09	0.11	-0.13
MF speed (<i>r</i>)	-0.03	-0.01	-0.23	-0.04	0.05	-0.04
MF accuracy (<i>r</i>)	-0.07	0.05	-0.21	-0.05	-0.02	-0.17
WM (ρ)	-0.08	-0.12	-0.06	-0.01	-0.02	0.06
KS (ρ)	-0.10	-0.11	-0.29	-0.08	0.01	-0.11
ZM (ρ)	0.18	0.25	0.04	-0.09	-0.07	-0.08
SE (ρ)	-0.15	-0.02	-0.10	0.16	-0.11	0.11

r: Pearson's correlation; ρ : Spearman correlation; IH: inhibition; MF: mental flexibility; WM: working memory; KS: Key Search task; ZM: Zoo Map task; SE: Modified Six Elements task.

traits were related to more alexithymic traits in the cognitive domain. Contrary to our hypothesis, no significant associations between EF and cognitive alexithymia/empathy were present.

The elevated levels of cognitive alexithymia in the current sample, in the absence of affective alexithymia, provide

strong support for the suggestion that the alexithymic profile in individuals with ASD and high IQ resembles the alexithymia II subtype (Bermond, 1997). This arguably reflects that these individuals with ASD tend to focus more on external events rather than formulating and thinking about their internal emotional experiences (Hill et al., 2004). The

finding is also in agreement with prior studies in adults with ASD (Berthoz and Hill, 2005), women with ASD (Ketelaars et al., 2016), and a highly comparable sample of Dutch college students with ASD (Dijkhuis et al., 2017). In fact, this study replicates these previous findings in an independent cohort on a subscale level, as both studies report the largest effect sizes for the identifying and verbalizing subscales and non-significant results for the others. On a dimensional level, the relation between cognitive alexithymia and the autistic phenotype appears to be independent of diagnosis, as autism symptoms were positively related for the whole group and both groups separately (trend level for controls). However, when zooming in on cognitive subdomains, only individuals with ASD displayed significant positive associations with verbalizing and identifying, suggesting increased diagnostic specificity for these subscales.

Our finding that college students with ASD also showed lower levels of cognitive empathy than neurotypical students is in agreement with the first part of the EIH: Individuals with ASD have a specific impairment in cognitive empathy (Smith, 2009). The second part of the EIH, that is, the notion that individuals with ASD have a heightened capacity for affective empathy, is not unequivocally supported by our findings, as previously also reported for children and adults with ASD and high IQ (Dziobek et al., 2008; Pouw et al., 2013). However, on a subscale level, we observed bi-directional effects for ASD individuals, with elevated scores on the PD subscale and lower levels of EC compared to controls. This is strikingly similar to findings in adults with Asperger syndrome with the IRI by Rogers et al. (2007), which was interpreted by authors as evidence for empathic overarousal and greater empathy in ASD, and therefore in line with the second part of the EIH. Together, both findings suggest that individuals with ASD experience more self-oriented affective responses in a social context (e.g. feeling hopeless or incompetent in reaction to other people's suffering), but less other-oriented affective responses (e.g. a desire to ease the other person's suffering). It should be noted, however, that the current results are based solely on parent report (exclusively mothers). A previous study on self-report and parent report of empathy in youths with ASD and controls showed a clear discrepancy in perception of empathic capacity in ASD dyads which was not present in control dyads (Johnson et al., 2009). ASD youths rated themselves significantly higher on empathic features than their parents did. However, based on this finding, it cannot be determined whether parent reports are perhaps biased in the opposite direction. Including self-report simultaneously would therefore provide a more balanced and detailed picture of the empathic capacities of college students with ASD.

Although the present findings lend support for the EIH, our results oppose the hypothesis posited by Bird et al. (2010) that alexithymia can help explain difficulties with empathy in ASD. Here, cognitive empathy was still

significantly impaired after controlling for the variance in cognitive alexithymia. Methodological differences may account for these seemingly contradictory findings. For example, although Bird et al. (2010) measured cognitive alexithymia with a similar questionnaire (TAS-20), the assessment of empathy consisted of brain responses in reaction to viewing the hand of a familiar other on which an electric shock was applied. It could be argued that these reactions reflect a different, more subconscious level of empathy (i.e. physiological) than the informant reports used in our study. This notion is strengthened by two other ASD studies which applied behavioral theory of mind tasks to measure cognitive empathy and with which our results are more consistent (Gökçen et al., 2016; Lockwood et al., 2013).

Contrary to our expectations, no significant correlations were detected between the performance-based measures of EF and cognitive alexithymia/empathy. The domain-general theory of executive dysfunction has been one of the major cognitive theories that addresses social and non-social behavioral problems in individuals with ASD (Hill, 2004; Rajendran and Mitchell, 2007). Therefore, it was hypothesized that EF performance would be related to the cognitive dimensions of empathy/alexithymia in ASD. The absence of correlations with EF in our comparison group is equally surprising, as it contrasts with previous findings in non-clinical populations (e.g. Carlson et al., 2015; Koven and Thomas, 2010; Perner et al., 2002; Xiong-Zhao et al., 2006) and the assumption that such associations exist regardless of an individual's position within the spectrum. Especially for cognitive empathy, often used synonymously with theory of mind, we have argued that there is compelling evidence for positive associations with different EFs. Despite these previous findings, it is conceivable that our null findings can in part be attributed to the choice of performance-based measures for EF. It is well documented that such measures correlate low with, for example, informant-based ratings of EF (e.g. Dekker et al., 2017; Toplak et al., 2013) and others have previously highlighted the difficulty of interpreting different types of EF measures in ASD (Kenworthy et al., 2008). It is also possible that some or most of these associations do not fully capture the complex nature of the cognitive empathy concept by focusing on theory of mind tasks. For instance, autobiographical memory is also involved in cognitive empathy, as personal earlier experiences are used to interpret and understand situations (Shamay-Tsoory, 2011). Future studies should therefore address to what extent different operationalizations of cognitive empathy and theory of mind can be used to make inferences about both constructs.

Some limitations in this study need to be addressed. First, the present sample consists of a group of ASD individuals with above-average IQ and a moderately sized

control group, both of whom included only a small proportion of female participants, which all narrow the generalizability of the results. Although groups were matched for sex and direct comparisons for alexithymia/empathy in the ASD group did not suggest any sex differences, the sample size was suboptimal to provide conclusive results. Second, it cannot be ruled out that comorbid conditions influenced the outcome. Data on psychiatric comorbidity were unavailable and the use of psychotropic medication by 36% of ASD individuals suggests comorbid problems were still present in this group, despite strict admission policies. Third, the use of questionnaires, such as the BVAQ, always involves a risk of social desirability (Van de Mortel, 2008) and there was a large proportion of missing data for the IRI. However, a sophisticated multiple imputation was used to deal adequately with this limitation (Raghunathan et al., 2003). Finally, a strength of this study is that both the cognitive and affective domains of empathy and alexithymia were included as well as multiple measures of EF.

In conclusion, this study has provided a detailed presentation of explicit problems with cognitive alexithymia and reduced cognitive empathy in intellectually advanced individuals with ASD. Since cognitive alexithymia and empathy are important determinants for adequate social functioning (Baron-Cohen and Wheelwright, 2004; Vanheule et al., 2007), training programs aimed to reduce alexithymia and improve empathy might lessen the social problems college students with ASD experience (Adreon and Durocher, 2007; Welkowitz and Baker, 2005), for example, with establishing peer networks, teamwork, or finding employment. In addition, levels of alexithymia and cognitive empathy have previously been associated with personal well-being in non-ASD populations as well (Honkalampi et al., 2000; Shanafelt et al., 2005), thereby further stressing their importance as viable intervention targets. However, these types of intervention targets are unlikely to benefit from training initiatives primarily aimed at improving EF skills. Instead, trainings aimed at improving emotional intelligence may present an interesting alternative to reduce traits of cognitive alexithymia (Amani et al., 2014), and to improve cognitive empathy (Castillo et al., 2013).

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ORCID iD

Ymke de Brujin  <https://orcid.org/0000-0001-8921-4547>

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