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Impact of cognitive profile on social functioning in prepubescent females with Turner syndrome

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Abstract

Social deficits are prevalent in TS, however, the extent to which these difficulties are secondary to characteristic cognitive impairments is not well known. Here, we sought to establish the relative contribution of executive functions, visuospatial abilities and IQ to social difficulties in young girls with TS. Forty TS girls and 19 typically developing (TD) children were assessed with the Social Responsiveness Scale (SRS), the Motor-Free Visual Spatial test (MVPT-3), the Behavior Rating Inventory of Executive Function (BRIEF) and an IQ test. Hierarchical multiple regression analyses were conducted with the SRS subscales as outcome variables. In a first step, the cognitive factors were entered (verbal IQ, BRIEF global score, MVPT-3 and age), followed by the group variable in a second step. In comparison to TD, TS were significantly impaired on all main measures. All six regression models with the SRS subscales were significant and revealed that global executive functions explained the largest portion of the variance on all subscales and the total score. Even after controlling for cognitive elements, the group factor still explained a significant portion of the variance of the Social Cognition, Social Awareness, and Autistic Mannerisms subscales. In contrast, the group factor was not a significant predictor of Social Motivation and Social Communication scores. These results suggest that executive dysfunction play a role in social impairments encountered in TS, but also that some specific aspects of social behavior are altered beyond what can be attributed to cognitive difficulties in this population.

Keywords

Social cognition; Turner syndrome; Neuropsychology; Executive Functions; Social Responsiveness Scale; Children

Introduction

X-monosomy, or Turner syndrome (TS), is a non-inherited genetic disorder caused by the complete or partial absence of one X-chromosome that affects 1/2000 live female births (Stochholm, Juul, Juel, Naeraa, & Gravholt, 2006). Multiple TS karyotypes exist, the most common being 45,X, where one copy of the sexual chromosome is completely absent (about 50% of the cases). Beyond the physical characteristics associated with the disorder (Gravholt, 2005), individuals with TS show a particular cognitive profile that is reasonably

well characterized and consistent (Ross, Kushner, & Zinn, 1997). Despite having global and verbal IQ within the normal range, individuals with TS often show marked impairments in visuospatial skills and executive functions (Kirk, Mazzocco, & Kover, 2005). The presence of difficulties in the social domain has also been increasingly recognized and studied in TS (Burnett, Rovet, & Wood, 2010), although the source of these difficulties and their relationship to other areas of cognitive impairment remain unclear.

Social cognition in Turner syndrome

Numerous studies have documented the presence of social difficulties in adolescents and women with TS. These individuals have been shown to have difficulties forming and maintaining social relationships (McCauley, Sybert, & Ehrhardt, 1986), have fewer close friends (Lagrou et al., 2006) and are judged as less socially competent than their peers (McCauley, Feuillan, Kushner, & Ross, 2001). Moreover, individuals with TS are also impaired at a number of tasks related to the processing of social stimuli, such as facial recognition (Romans, Stefanatos, Roeltgen, Kushner, & Ross, 1998; Ross, Kushner, & Zinn, 1997), facial matching (Buchanan, Pavlovic, & Reutens, 1998), fear recognition (Lawrence, Kuntsi, Coleman, Campbell, & Skuse, 2003; Mazzola et al., 2006), gaze processing (Elgar, Campbell, & Skuse, 2002; Lawrence et al., 2003) and the interpretation of subtle social cues (McCauley, Kay, Ito, & Treder, 1987). Importantly, social difficulties in TS cannot be solely attributed to family environment (Mazzocco, Baumgardner, Freund, & Reiss, 1998) or physical stigmatization (McCauley et al., 1987), as individuals with TS have more social impairments relative to their sisters or individuals with short stature.

The contribution of core cognitive deficits of TS to these behavioral and sociocognitive difficulties in TS remains unclear. In theory, social deficits may be secondary to cognitive impairments. For example, visuospatial impairments may alter one's ability to correctly interpret non-verbal social cues, while executive dysfunctions could negatively impact social relations because of inappropriate behavior due to impulsivity, lack of mental flexibility and failure to understand other's points of view (Hong, Kent, & Kesler, 2009). Some research results tend to support this view, and suggest that visuospatial impairments characteristic of TS might contribute to impaired facial and emotional processing (Lawrence et al., 2003; Mazzola et al., 2006), thereby impacting social functioning. For example, women with TS have been shown to be less accurate at discriminating halftone images of faces (Lawrence et al., 2003) and to use piecemeal processing style during facial exploration (Mazzola et al., 2006), which could possibly relate to their difficulties in emotion recognition (McCauley et al., 1987) and impact negatively their social interactions. On the other hand, a number of studies show that women and adolescents with TS remain impaired in gaze processing (Elgar et al., 2002), facial recognition (McCauley et al., 1986), affective discrimination (McCauley et al., 1987) and social competency (McCauley et al., 2001), even when covarying for visuospatial abilities and executive function.

Given these mixed results, it is still unclear if the social deficits seen in TS are a consequence of cognitive difficulties or if they are a unique, core feature of the disorder. Moreover, all of the previously mentioned studies were conducted in women or adolescents with TS, and some included participants with mosaicism (McCauley et al., 1986; 1987; 2001), which could obscure potential differences as these individuals represent a more genetically heterogeneous group and may be less affected than their monosomic counterparts (Ross, Stefanatos, Roeltgen, Kushner, & Cutler, 1995). In addition, for the few studies taking into consideration cognitive aspects of TS, the statistical design did not adequately delineate the relative contribution of different cognitive domains to social impairments (Elgar et al., 2002; McCauley et al., 1986, 2001). Understanding how early deficits impact social functioning would be valuable for designing early interventions to improve social abilities of children with TS. Here, we investigated the extent to which

cognitive impairments typical of TS, namely executive function and visuospatial difficulties, could explain the interpersonal, behavioral and communication difficulties seen in a homogenous cohort of prepubescent girls with x-monosomy.

Materials and Methods

Participants

Participants with TS were recruited from national Turner syndrome organizations in the United States and Canada, and by referral from their treating pediatric endocrinologists. Control subjects were recruited through local advertisements or were siblings of TS participants. Written informed consent was obtained from all parents and verbal consent was obtained from children. Study procedures and protocols were approved by the University research compliance office.

Participants with TS were included in the present study if they met the following criteria: 1) aged between 5 and 12; 2) cytogenetic status of non-mosaic 45,X established from a standard karyotype assessment; 3) full scale IQ in the normal range (70-130); and 4) no evidence of a serious mental disorder or chronic condition other than those typically associated with TS (e.g., ADHD). Forty participants with TS met these criteria (35 Caucasians, 2 Hispanics, 1 Asian, 1 mixed Asian, 1 mixed African American; mean age: 8.16 ± 1.92). Hormonal treatment history of all TS subjects was obtained through self-report or medical files. Thirty-four participants were taking growth hormone at the time of testing and no participant reported adhering to an estrogen replacement therapy. Nineteen healthy controls (nine were siblings of participants with TS) in the same age and full scale IQ range were also recruited (18 Caucasians, 1 Asian; mean age: 8.58 ± 2.22). Detailed participant characteristics are presented in Table 1.

Neuropsychology

Neuropsychological assessments were conducted by a research psychologist over two consecutive days as part of a large cognitive assessment battery. Children's full scale IQ (FSIQ), verbal IQ (VIQ), and performance IQ (PIQ) were derived from cognitive assessments appropriate for their age: the Wechsler Preschool and Primary Scale of Intelligence - Third Edition (WPPSI-III) for children up to 5 years-old and the Wechsler Intelligence Scale for Children - Fourth Edition (WISC-IV) for girls between 6 and 12 years-old.

The Motor-Free Visual Perception Test –Third Edition (MVPT-3) was used to assess visuospatial abilities and the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Kenworthy, & Barton, 2002) was used to measure executive functions. The MVPT-3 is a 65-item test designed to assess overall visual-ability without requiring the use of motor response. It provides a single score summing the performance on different tasks of visual-perception (spatial relations, visual discrimination, figure-ground, visual closure, and visual memory) (Colarusso & Hammill, 2003). The BRIEF, a 86-item questionnaire completed by the parent, is comprised of eight clinical scales assessing the multiple components of executive functions: 1) Inhibit (inhibitory control); 2) Shift (flexibility, alternate attention); 3) Emotional Control; 4) Initiate; 5) Working Memory; 6) Organization of Material 7) Plan/Organize; and 8) Monitor (keep track of his/her behavior). These scales can be grouped to give the Behavioral Regulation Index (Inhibit, Shift and Emotional Control), the Metacognition Index (Initiate, Working Memory, Plan/Organize and Monitor) and the Global Executive Composite (all scales). For BRIEF scales, a higher score represents greater impairment and T scores ≥ 65 are considered as having potential clinical relevance.

The Social Responsiveness Scale (SRS) was used as the main outcome measure of social functioning. The SRS is a parental report of 65-items using a four-point Likert scale that taps specific elements of social behavior based on frequency of occurrence. The scale is appropriate for children 4 to 18 years in age, and gives a total score (Total SRS), which sums up the scores obtained on five subscales assessing major areas of interpersonal behavior, communication and stereotypic behavior: 1) Social Awareness; 2) Social Cognition; 3) Social Communication; 4) Social Motivation; and 5) Autistic Mannerisms.

All tests were administered and scored following standard procedures. Results of cognitive/neuropsychological tests were scaled, scored and age-normed, except for the SRS for which no age-norm exists. To address this issue, age was added as a factor in the statistical analyses using SRS as an outcome measure. The analyses were performed using SPSS 19.0 statistical software. Neuropsychological test results are presented in Table 1.

Statistical Analysis

Prior to analysis, data were inspected for outliers and the assumptions required to conduct linear regression were tested. Group differences on all psychometric variables (BRIEF, SRS, MVPT-3, PIQ, VIQ, FSIQ) were assessed using one-way ANOVAs with Bonferroni correction for multiple comparisons (significance level: $p=0.003$). Separate hierarchical multiple regression analyses were conducted with each SRS subscale as an outcome variable. In a first step, cognitive measures were entered (VIQ, BRIEF global score, MVPT3 and age), followed by the group variable in a second step. VIQ was used as a measure of global intellectual abilities in the analysis because using FSIQ would have created redundancy in the analysis by measuring twice visuospatial abilities (and executive functions to some degree); and hence, would have prevented to delineate the contribution of individuals cognitive domains to social functioning. This stepwise statistical design allowed us to control for the main cognitive factors (visuospatial, executive functions, IQ) before considering group status in explaining social functioning.

Results

ANOVA showed that girls with TS scored significantly lower than controls for VIQ ($F_{1,58} = 15.672$), PIQ ($F_{1,58} = 34.631$), FSIQ ($F_{1,58} = 59.753$) and the MVPT-3 ($F_{1,58} = 13.938$) (all p 's $< .001$). Group comparisons also revealed the presence of significant differences on numerous subscales of the BRIEF (Initiate ($F_{1,56} = 10.932$), Working Memory ($F_{1,58} = 13.501$), Monitoring ($F_{1,56} = 14.069$), Behavior Regulation ($F_{1,58} = 18.563$), Metacognition Index ($F_{1,56} = 9.662$), Global Executive Score ($F_{1,58} = 13.006$); all p 's $< .003$), and the SRS (Social Awareness ($F_{1,58} = 17.756$), Social Cognition ($F_{1,58} = 20.801$), Social Communication ($F_{1,58} = 11.860$), Autistic Mannerism ($F_{1,58} = 19.369$), Total Score ($F_{1,58} = 17.778$); all p 's $< .001$), with TS girls showing more problems on all measures, although not reaching significance on the Social Motivation subscale of the SRS (Table 1).

The multiple hierarchical regression models looking at the contribution of cognitive factors (step 1) and group membership (step 2) on social functioning (SRS subscales and total score) were all significant (R^2 range from 0.60 to 0.68; all p 's $< .009$). The BRIEF-GEC was the most significant individual predictor of all social behavioral outcomes (Total SRS ($\beta = 0.886$, $p = .001$), Social Awareness ($\beta = 0.726$, $p = .001$), Social Cognition ($\beta = 0.870$, $p = .001$), Autistic Mannerisms ($\beta = 0.969$, $p = .001$), Social Communication ($\beta = 0.828$, $p = .001$), Social Motivation ($\beta = 0.402$, $p = .003$)), while age, the MVPT-3 and the VIQ factors did not individually contribute in a significant way to any of the models (all p 's $> .255$). The group factor, entered in a second step, explained a significant portion of the remaining variance of the subscales measuring Autistic Mannerisms ($\beta = -7.744$, R^2 change = 0.034, $p = .029$), Social Awareness ($\beta = -6.567$, R^2 change = .035, $p = .044$), Social Cognition ($\beta =$

-6.287, R^2 change = 0.027, $p = .041$), and a trend towards significance was also noted for the Total SRS score model ($\beta = -5.110$, R^2 change = 0.018, $p = .090$). Summaries of the models are shown in Table 2.

Discussion

This study was designed to assess the presence of social difficulties in prepubescent females with TS and evaluate the potential contribution of cognitive factors to these impairments. Our results show the presence of difficulties in several social domains, which are in part explained by particular cognitive weaknesses. However, the magnitude of impairments in specific areas of social functioning seems to exceed what can attributed purely to cognitive limitations.

Individuals with TS in our sample displayed typical neuropsychological characteristics associated with the disorder. This comprises a significant discrepancy between verbal and non-verbal IQ (t-test; $p < .001$) (Shaffer, 1962), as well as significant impairments on visuospatial tasks (Ross et al., 1997) and executive functions (Temple, Carney, & Mullarkey, 1996). Albeit not as often reported as PIQ findings, the presence of discrepancy on the VIQ in comparison to controls has also been previously reported (Hong et al., 2011; Loesch et al., 2005; Kirk et al., 2005).

The quantification of executive functions is particularly challenging in TS given that many neuropsychological tests measuring these abilities rely on complex visuospatial material (e.g. Rey-Ostrich Complex Figure, Matrices, Block Design, Tower of London/Hanoi, etc.), an area of known difficulty in TS (Hong et al., 2009). This overlap makes it difficult to isolate both elements of cognition using standard neuropsychological tests. Here, the BRIEF was used to assess executive functions, allowing us to circumvent this problem. Confirming previous reports of executive difficulties in TS (Romans et al., 1998), we observed that girls with TS were rated as having lower scores than TD controls on all measures of the BRIEF. All subscales and indexes revealed highly significant differences between TS and control groups, with the exception of Emotional Control ($p = .017$), Organization of Material ($p = .064$) and Plan/Organize ($p = .028$) which trended towards significance. It is plausible that these subdomains are less affected in TS, however given previous reports that girls with TS are emotionally less mature and have difficulties with organization and planning (McCauley et al., 2001), we expect that these between-group differences would be significant in a larger sample. While on average, participants with TS were not rated as clinically impaired on any BRIEF domain (all mean t scores < 65); a significant proportion of them (40%; compared to 5% in the TD group) were rated in the clinical range on the GEC. Overall, our results suggest that individuals with TS, as rated by parents, manifest difficulties in practically all areas of executive functions from an early age compared to controls.

Regarding social functioning, the SRS, as rated by parents, showed that young girls with TS manifest notable problems in different elements of the social sphere, with the mean of most subscales being in the clinical range (> 60 ; Constantino & Gruber, 2005). These results are in line with previous studies conducted in individuals with TS, which documented relationship difficulties (McCauley et al., 1986; Lagrou et al., 2006) and decreased social competence (McCauley et al., 2001). While most capacities related to social functioning seem to be affected in TS (Social Cognition, Awareness, Communication) an important aspect that appears to be preserved in young individuals with TS is the motivation to engage in social-interpersonal behavior. This observation is particularly interesting when considering the view of TS having overlapping symptomatology with autism spectrum disorders (ASD) (Mazzola et al., 2006; Skuse, 2005). Indeed, while it is true some characteristic of social behavior seen here correspond to what is observed in ASD, namely autistic mannerisms as

measured by the SRS, TS children differ on at least one important point from individuals with ASD in the sense that they are motivated to engage in social interactions, where as children diagnosed with ASD are not (Hong et al 2011). Plausibly, this drive to engage in social relations, coupled with their decreased ability to perceive, analyze, and communicate social information, contribute negatively to self-esteem of girls with TS (McCauley, Ross, Kushner, & Cutler, 1995), and to their perception of isolation (Amundson, Boman, Barrenäs, Bryman, & Landin-Wilhelmsen, 2010) and diminished social competency (McCauley et al., 2001) in adolescence and adulthood.

The hypothesis that the cognitive limitations of TS may play a role in the occurrence of social deficits has been put forth by some researchers (Hong, Dunkin, & Reiss, 2011; Lawrence et al., 2003; Mazzola et al., 2006), but never formally tested. Here, we provide evidence in favor of this view and show that cognitive impairments contribute to social difficulties of children with TS. Hierarchical regression analyses showed that for all measures of the SRS, the Global Executive Composite of the BRIEF was the most potent individual factor in explaining variance, revealing that overall executive functions impact significantly on every areas of social functioning. In contrast, neither visual-perceptual abilities (MVPT-3) nor intellectual abilities (VIQ) emerged as significant predictors in any model, suggesting a minor contribution, if any, in comparison to executive dysfunctions in explaining social deficits in TS.

This is the first demonstration of a link between executive functions and social behavior in young individuals with TS, but it is reminiscent of findings obtained in children with attention deficit hyperactivity disorder (ADHD; Diamantopoulou, Rydell, Thorell, & Bohlin, 2007) and individuals with subthreshold autistic traits (Christ, Kanne, & Reiersen, 2010), two populations whose symptoms partly overlap with those of TS (Skuse, 2005). Specifically, difficulties with inhibition, mental flexibility and behavioral monitoring have been reported in TS and ADHD (Hong et al., 2009; Miller & Hinshaw, 2010). Similarly, impaired processing of nonverbal cues, such as interpretation of eye gaze, and theory of mind tasks appear to be impaired in children with TS and also ASD (Lawrence et al., 2007; Hong et al., 2010). Importantly, these are essential skills for establishing and maintaining successful interpersonal relationships. In fact, past research has shown that children's growing competence in executive functions facilitates the acquisition of theory of mind (Hughes & Ensor, 2007), an ability crucial for smooth social interactions. Not surprisingly, executive functions during childhood have been shown to predict social functioning during adolescence in girls with ADHD (Miller & Hinshaw, 2010). Current research in TS suggests that social difficulties can increase from childhood to adolescence (Skuse, 2005); whether this change is linked to poor executive functions remains an open question. Here our results provide confirmation that impairments in executive functions contribute to difficulties in adaptive social functioning, while additionally demonstrating the existence of distinct social cognitive deficits beyond what might be expected from impaired executive functions alone.

While cognitive factors explained the largest part of the variance on all SRS measures, they did not solely account for difficulties in certain aspects of social functioning. Namely, after considering the contribution of all cognitive factors, group membership still explained a significant portion of scores on the Social Awareness, Social Cognition and Autistic Mannerisms subscales, implying that difficulties in these three domains are in part independent of the cognitive impairments of children with TS, and in part solely related to having TS itself. This conclusion is further supported by the fact that these subscales of the SRS are significantly correlated with the BRIEF-Global Executive Composite (r value between .722 and .796), which may inflate the prediction's value of the executive functions' measure in the regression. Alternatively, the fact that we still get a significant effect from the second step (*group* factor), supports the view that social difficulties in TS are in part

unrelated to cognitive abilities. This observation echoes previous findings where women and adolescents with TS remained impaired at social tasks even after covarying for PIQ (Elgar et al., 2002; McCauley et al., 1987) and both PIQ and VIQ (McCauley et al., 2001). Furthermore, we found no between-group differences in socioeconomic status between cohorts in our study. This suggests that social cognitive differences are not due to environmental factors, but instead arise from neurobiological features of TS.

Previous genetic and neuroimaging literature also support the hypothesis of a primary social deficit associated with TS. It has been suggested that the cognitive impairments typical of TS result from the absence of genes from specific X chromosome loci (Good et al., 2003). Individuals with TS that have a particular segment missing at Xp11.3 show normal intelligence but are impaired at fear recognition and also demonstrate enlarged amygdala (Good et al., 2003), a region crucial for emotion processing and recognition (Adolph, 2010). Taken together with evidence that integrity of emotional processing circuits broadly correlates with social functioning (Corden et al., 2006), aberrant amygdalar structure in TS provides a further neurobiological basis for primary social cognitive deficits in TS. Furthermore, the Xp11.3 segment of the X chromosome encompasses genes such as monoamine oxidase A and B (Chen et al., 1992), which have been associated with neuropsychiatric disorders characterized by social deficits such as schizophrenia and antisocial personality disorders (Shih & Thompson, 1999). Possibly, haploinsufficiency resulting from the absence of these genes could alter the development, function, or connectivity of brain regions dealing with social stimuli. In this regard, many recent neuroimaging studies of women with TS have shown brain abnormalities in regions other than the amygdala; namely the superior temporal sulcus, the anterior cingulate cortex and the insula (Molko et al., 2004; Good et al., 2003). These alterations provide a plausible substrate for the impairments in social awareness and cognition seen in our sample. However, few studies have established a link between these brain anomalies and behavioral performance in TS (Good et al., 2003; Skuse, Morris, & Dolan, 2005). Considering our present findings, future investigations looking at the neuronal correlates of social abilities in TS should take into consideration cognitive factors such as executive functions in their models.

While we present important data regarding social cognitive and executive functions in TS, our study also has some limitations. This includes the use of a parent-based questionnaire to assess overall social functioning in our sample. While the SRS has been validated for use in ASD and other populations (Aldridge et al., 2011), analyses may be enhanced by including direct observation of social behavior in future studies. Furthermore, our cohorts included a relatively broad age range, and although age was included as a factor in our models, it may be useful to assess the possibility of developmental differences between early and late childhood. Especially given previous findings of worsening social performance in adolescents with TS (Skuse et al., 2005), future studies of social functioning through this critical developmental period would be valuable. Additionally, our results may help inform future directions in treatment of social deficits in TS. For example, cognitive interventions focusing on compensatory strategies with regard to executive problems may be beneficial for social functioning. Optimizing social and environmental factors such as parental scaffolding, which comprises strategic guidance to enable children to achieve levels of problem solving they could not reach on their own, has been shown to influence positively the development of executive functions in young children (Hughes & Ensor, 2009). Presumably, these types of parent-guided cognitive interventions may impact positively on social functioning in TS.

Conclusion

Our findings show the contribution of executive dysfunctions to social difficulties seen in young individuals with TS. These results also suggest that TS present specific alterations in the social sphere that go beyond cognitive impairments, namely in the domains of social cognition, social awareness and mannerisms. Given that some areas of social dysfunctions in TS are not entirely attributable to cognitive difficulties, the use of social skills training tailored for the cognitive capacities and limitations of TS should also be considered.

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Table 1

Subject characteristics and neuropsychological tests results.

	Turner syndrome (N=40)	Controls (N=19)	p value (sign .003)	Cohen's d
<i>Demographics</i>				
Age	8.16 (1.92)	8.58 (2.72)	.494	0.191
Family income	6.75 (2.18)	7.93 (1.58)	.067	0.507
Growth hormone treatment	34	-	-	-
<i>Neuropsychology</i>				
FSIQ	93.28 (11.54)	115.42 (6.8)	<.001	1.517
VIQ	102.40 (11.46)	115.74 (13.37)	<.001	0.986
PIQ	94.35 (13.07)	115.38 (8.23)	<.001	1.377
MVPT-3	86.03 (19.49)	104.95(14.99)	<.001	0.940
BRIEF				
Inhibition	62.20 (12.31)	48.98 (9.32)	<.001	1.021
Shift	60.43 (12.49)	45.66 (9.12)	<.001	1.104
Emotional Control	51.24 (9.37)	44.79 (8.69)	.017	0.660
Initiate	58.39 (9.57)	49.58 (9.31)	.002	0.856
Working memory	63.95 (12.23)	51.45 (12.18)	0.001	0.929
Organization of Material	56.84 (9.52)	51.68 (10.02)	.064	0.521
Plan/Organize	61.85 (12.74)	53.68 (13.59)	.028	0.607
Monitor	62.37 (11.72)	49.74 (12.51)	<.001	0.949
Behavior Regulation Index	58.53 (10.83)	46.05 (9.14)	<.001	1.057
Metacognition Index	62.67 (10.90)	52.68 (12.46)	.003	0.813
Global Executive Composite	61.49 (10.25)	50.74 (11.62)	.001	0.915
SRS				
Total SRS	62.76 (13.84)	47.76 (10.06)	<.001	1.035
Social awareness	61.06 (13.07)	47.13 (8.69)	<.001	1.034
Social cognition	61.91 (13.78)	45.63 (10.42)	<.001	1.098
Social communication	60.08 (13.71)	48.16 (9.00)	.001	0.881
Social motivation	55.45 (11.33)	51.68 (9.83)	.219	0.345
Autistic mannerism	67.66 (15.28)	50.29 (11.40)	<.001	1.069

Demographics and summary of neuropsychological results of all participants for both groups (TS and TD). Means for Full Scale IQ (FSIQ), Verbal IQ (VIQ), Performance IQ (PIQ), Motor-Free Visual Spatial test (MVPT-3), the Behavior Rating Inventory of Executive Function (BRIEF) and Social Responsiveness Scale (SRS) are presented and standard deviation are in parenthesis. Significance level after Bonferroni correction is .003 and effect sizes are reported using Cohen's d (absolute value).

Table 2

Regression models summary

Factors	Total SRS			Social Awareness			Social Cognition			Autistic Mannerism			Social Communication			Social Motivation		
	B	Sig.	95%	B	Sig.	95%	B	Sig.	95%	B	Sig.	95%	B	Sig.	95%	B	Sig.	95%
Constant	13.854	.324	-14.11/41.28	19.697	.193	-10.33/49.75	19.619	.170	-8.71/47.93	8.867	.587	23.76/41.49	7.925	.584	-20.96/36.84	32.256	.051	-17/64.68
BRIEF-GEC	0.886	.001	.66/1.11	0.726	.001	.49/.97	0.870	.001	.64/1.10	0.969	.001	.71/1.23	0.828	.001	.60/1.06	0.402	.003	.14/.66
Age	-0.146	.792	-1.26/.96	-0.163	.784	-1.36/1.03	-0.439	.438	-1.57/.69	-0.041	.948	-1.34/1.26	-0.046	.935	-1.20/1.11	0.584	.367	-.71/1.88
MVPT-3	-0.050	.484	-1.95/.09	-0.010	.896	-.17/.15	-0.036	.622	-.18/.11	-0.017	.838	-.19/.15	-0.051	.493	-.20/.10	-0.096	.254	-.26/.07
VIQ	0.049	.641	-.16/.26	0.053	.641	-.18/.28	0.017	.872	-.20/.23	0.085	.493	-.16/.33	0.090	.415	-.13/.31	-0.002	.986	-.25/.24
Group	-5.109	.090	-11.05/.83	-6.567	.044	-12.94/-.19	-6.287	.041	-12.30/-.28	-7.744	.029	-14.67/-.82	-3.218	.297	-9.36/2.92	2.164	.530	-4.72/9.05
Model's R ²		.672			.561			.678			.645			.559			.223	
Model's p value		< .001			< .001			< .001			< .001			< .001			.009	

Unstandardized Beta coefficients (B), significance level (Sig.) and confidence interval for Beta (95%) for each factor entered in the regression models with measures of the Social Responsiveness Scale as outcome. For each model, cognitive factors were entered in a first step (BRIEF Global Executive Composite (BRIEF-GEC), Age, Motor Free Visual Perceptual Test (MVPT-3), and Verbal IQ (VIQ)), followed by group membership in a second step (TS and Controls). Each model's R² and p values are indicated.