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Relations Between Executive Functions, Social Impairment, and Friendship Quality on Adjustment Among High Functioning Youth with Autism Spectrum Disorder

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Abstract High functioning adolescents with Autism Spectrum Disorder (ASD) often have adjustment difficulties, specifically loneliness and depression. To better understand contributing factors, the current study evaluated associations between several Executive Function (EF) domains, social impairment, and friendship quality on depressive symptoms and loneliness in this population. Participants included 127 high functioning ASD adolescents and a parent/caregiver. Results indicated significant levels of parent-reported EF impairment which were positively correlated with increased levels of loneliness and depressive symptoms. Social impairment was identified as a significant mediator between all studied EF domains and adjustment, while friendship quality only partially mediated the relation between emotional control and loneliness. These results have implications for treatments focusing both on social skills and adjustment in adolescents with ASD.

Keywords Autism spectrum disorder · Executive functions · Social impairment · Friendship quality · Adjustment

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Introduction

Although there is considerable heterogeneity among youth diagnosed with Autism Spectrum Disorder (ASD), research has consistently shown they often have comorbid depressive symptoms (e.g., Ghaziuddin et al. 2002; Volkmar and Klin 2005; Klin et al. 2005; Lopata et al. 2010). Specifically, comorbidity rates between ASD and depressive symptoms are as high as 53–54%, which is much higher than the 4–5% documented in the neuro-typical population (Kim et al. 2000; Mayes et al. 2011; Ghaziuddin et al. 1998; Solomon et al. 2012; Thapar et al. 2012). As higher functioning youth with ASD become aware of their differences in relation to same-aged peers (Volkmar and Klin 2005), they can become frustrated with unsuccessful attempts to initiate and maintain social interactions (Klin et al. 2005), which can lead to higher rates of anxiety and depressive symptoms than typically developing youth (e.g., Kim et al. 2000). Research has also demonstrated youth with ASD exhibit greater levels of loneliness in comparison to neuro-typical peers (e.g., Bauminger and Kasari 2000; Ghaziuddin et al. 2002; Lasgaard et al. 2009). Furthermore, they often reported significantly more feelings of social loneliness (i.e., the feeling that they are being left out of a group of children or peers) in comparison to neuro-typical peers (e.g., Bauminger et al. 2003) suggesting they are not only aware of the concept of loneliness, but recognize it in themselves.

Youth with ASD also have fewer social interactions in comparison to same-aged peers (e.g., Lord and Magill-Evans 1995). ASD-focused research has demonstrated a direct association between social impairment and adjustment difficulties (e.g., Barnhill 2001; Vickerstaff et al. 2007; White and Roberson-Nay 2009), although a recent study did not find a relation between social cognition and

adjustment (Hollocks et al. 2014). Furthermore, although adjustment may be associated with social impairment, it is also possible that the quality of the friendship relates to adjustment. Research has demonstrated that youth with ASD report having fewer friends and spending less time interacting with friends. A review of 235 adults and adolescents with ASD (previously autism) found that only 8.1% reported interacting with same-aged friends on a weekly basis outside of an organized activity and 46.6% of the sample reported having no same-aged friends (Orsmond et al. 2004). Furthermore, Pouw et al. (2013) found that poorer friendship quality was associated with increased self-reported depressive symptoms in boys with ASD.

Although ASD research has documented associations between social impairment, friendship quality, and adjustment, particularly on depressive symptoms and loneliness, less is known about what influences these relations. Difficulty with Executive Functions (EF), likely affects one's ability to successfully interact socially with others (e.g., Joseph 1999; Solomon et al. 2004). EF are a set of cognitive behaviors that allow for higher level planning and organization (Wong et al. 2006). Although EF is a broad construct used in the literature, there are many specific domains of EF that research is increasingly identifying as differentially impacting higher level goal directed behavior (see Gioia et al. 2002 for a review). This can include set-shifting (easily going from one act or aspect of a circumstance to another), emotional control (appropriately regulating emotions), inhibition (resisting impulsive urges, stopping an impulsive act), and working memory (keeping knowledge in one's mind while doing tasks; Gioia et al. 2000). Research has consistently shown that youth with ASD demonstrate EF impairment in comparison to neuro-typical peers (e.g., Russo et al. 2007; Verte et al. 2006; Akshoomoff 2005; Semrud-Clikeman et al. 2014) and those with Attention-Deficit/Hyperactivity Disorder (ADHD; e.g., Semrud-Clikeman et al. 2010; Hughes 2011). This includes impairments in set shifting and cognitive flexibility (Ozonoff and Jensen 1999; Joseph 1999; Russo et al. 2007; Verte et al. 2006; Semrud-Clikeman et al. 2010), working memory (e.g., Russo et al. 2007; Rogers and Bennetto 2000; Verte et al. 2006), emotional control (Konstantareas and Stewart 2006; Semrud-Clikeman et al. 2010) and planning (e.g., Semrud-Clikeman et al. 2010). Results suggesting deficits in inhibition are less conclusive (Rogers and Bennetto 2000; Semrud-Clikeman et al. 2010; Verte et al. 2006; Narzisi et al. 2013). A review of the neuropsychological literature also demonstrates some support for a link between EF impairment and depressive symptoms (Rogers et al. 2004; Austin et al. 2001; Klimkeit et al. 2011) including working memory, planning, verbal fluency, cognitive flexibility, and set-shifting; however, these findings have not been well evaluated in the child and adolescent literature. A review of the mood disorder literature has also found evidence of impaired set-shifting, attention, cognitive flexibility, and verbal fluency; however, there are inconsistent findings related to inhibition (Austin et al. 1999; Rogers et al. 2004; Snyder 2013).

In addition, EF deficits may be associated with adolescents with ASD's ability to develop quality friendships. Carrington et al. (2003) interviewed five youth diagnosed with Asperger's Disorder and found that they demonstrated compromised EF abilities (i.e., cognitive inflexibility) when making decisions about friendships. Therefore, it is important to recognize that friendship quality may not only be associated with levels of loneliness and depressive symptoms in the adolescent ASD population, but may be linked to compromised EF.

Although friendship quality and social impairment may each relate to EF and adjustment, there is evidence suggesting that friendship quality may mediate social impairment in the ASD population, with poorer friendship quality leading to greater adjustment difficulties (e.g., Orsmond et al. 2004). Furthermore, the impact of social impairment may be even further affected by poorer EF, making processing and utilizing social information even more challenging. Jobe and White (2007) found that greater social impairment was related to increased self-reported loneliness. Therefore, it may be that youth with ASD who have more compromised EF abilities have greater social impairment, which is associated with poorer friendship quality and poorer adjustment. Further, because of the previously discussed research supporting a link between social impairment and adjustment (e.g., Barnhill 2001; Vickerstaff et al. 2007; White and Roberson-Nay 2009), it may also be important to take into account this direct relation.

Finally, it is important to recognize the importance of adolescence in terms of its relevance for EF and adjustment. Lerner and Steinberg (2004) note that major depressive disorders are the most common disorder to occur during adolescence, and the prevalence rates of depressive disorders often increase from childhood to adolescence. Loneliness is also a problem during this time, as adolescents transition from being focused on their families to reaching out more to peers for acceptance and social adjustment (Lerner and Steinberg 2004). The development of EF is a process that also continues throughout adolescence as the acquisition of these skills starts in early childhood and is refined throughout adolescence (e.g., Anderson 2002). Recent research suggests that difficulty with EF is linked with this population's ability to successfully interact socially with others (e.g., Joseph 1999; Solomon et al. 2004) and may be manifested as poor quality friendships (e.g., Bauminger et al. 2008). Although adjustment difficulties have been well-documented in youth with ASD, less is known about related factors, including social skills, friendship quality,

and EF, and their links to depressive symptoms and loneliness in this population. The current study proposed several mediation models to examine relations between domains of EF (i.e., cognitive flexibility, shifting, inhibition, emotional control), social impairment, friendship quality and adjustment among an sample of high functioning adolescents with ASD (see Fig. 1). Specifically, this study examined the direct association between EF impairment and adjustment, the extent to which social impairment and friendship quality each mediated relation between EF impairment and adjustment, and the fit of a 2-mediator model examining both direct and indirect pathways between EF impairment, social impairment, friendship quality, and adjustment.

Method

Participants

Participants in this study included 127 adolescents (103 males) previously diagnosed with ASD (per the DSM-IV-TR criteria for Autistic Disorder, Asperger's Disorder, or Pervasive Developmental Disorder Not Otherwise Specified; American Psychiatric Association 2013) and their parents/caregivers. Based on parent-report of DMS-IV-TR

Social Impairment as a Mediator

Friendship Quality as a Mediator

Three-Path Developmental Mediation Model

Four-Path Alternate Developmental Mediation Model

Fig. 1 Proposed mediation models

diagnoses, 24.4% of the youth had a diagnosis of Autistic Disorder, 57.5% had a diagnosis of Asperger's Disorder, and 18.1% had a diagnosis of Pervasive Developmental Disorder Not Otherwise Specified. Participants' current level of education ranged from sixth grade to their first year of college, with the greatest percentage (22.8) in eighth grade. Of the parents completing the questionnaires, 92.1% were biological mothers, 5.5% were biological fathers, 1.6% were grandmothers, and 0.8% were adoptive mothers. The average age of the youth was 13.95 (SD = 1.60) with a range of 12–17. The adolescents were primarily Caucasian (86.6%) followed by Hispanic (4.7%), Biracial (3.9%), African American (3.1%) and Asian (1.6%). Family income ranged from under $10,000 to over $200,000 with the greatest percentage of families reporting $40,000–$69,000 (19.7%). The following inclusion criteria were used to define "high functioning" ASD based on parent report: The youth must: (a) have a current diagnosis of an ASD diagnosed by a qualified professional (e.g., psychiatrist, psychologist, multidisciplinary/developmental team); (b) be between 12 and 17 years of age; (c) be reading at a sixth grade reading level (in order to complete the questionnaires); and (d) be able to verbally communicate on a regular basis with family and peers.

Procedure

Parent and adolescent dyads were recruited through online support groups, advocacy groups, and clinics throughout the United States. The majority of dyads were recruited with the assistance of the Interactive Autism Network (IAN) Research Database at the Kennedy Krieger Institute and Johns Hopkins Medicine—Baltimore, sponsored by the Autism Speaks Foundation. 29.9% completed paper copies of study materials and 70.1% participated online. All dyads who completed and returned both parent and adolescent packets received compensation for their time.

Measures

Social Responsiveness Scale (SRS)

Parents completed the SRS (Constantino and Gruber 2005) to assess severity of social impairment within the last 6 months. The SRS is a 65-item measure designed to assess severity of autism spectrum symptoms. Items are rated on a 4-point Likert scale. Examples of items include "would rather be alone than with others" and "knows when he/she is too close to someone or is invading someone's space." Composite scores were calculated. The current study demonstrated good reliability ($\alpha = 0.80$).
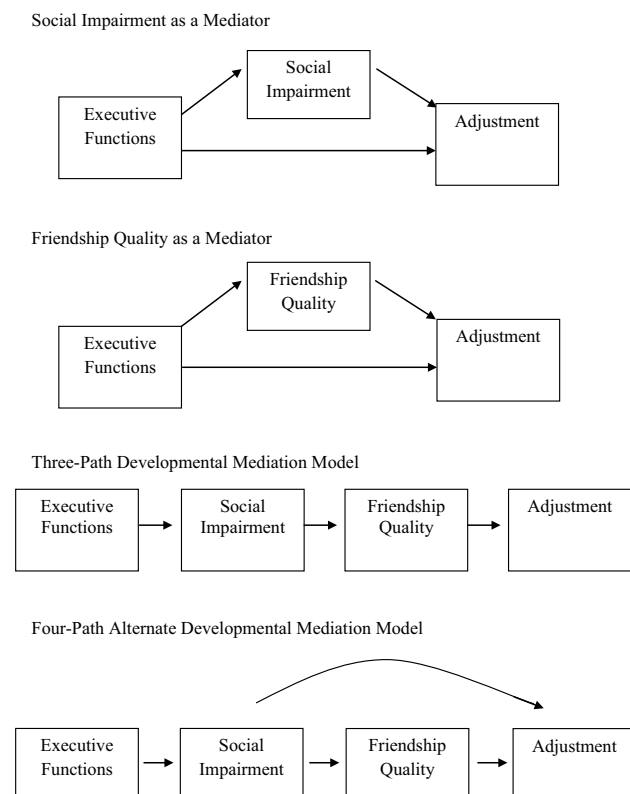
Behavior Rating Inventory of Executive Function, Parent Report, (BRIEF)

Parents completed 41 items included in the shift, working memory, inhibit, and emotional control indices of the BRIEF, an 86-item parent-report rating scale assessing eight domains of EF on a 3-point scale (Gioia et al. 2000). The BRIEF is designed to assess EF in a broad range of children including those with ADHD, developmental disabilities, and adjustment disorders including depression. Examples of BRIEF statements include "becomes upset with new situation" and "interrupts others." Raw score composites were calculated for each domain. This reliability for the current sample ranged from α = 0.83 to 0.92.

The Friendship Quality Questionnaire-Abbreviated Edition (FQQ-A) and Abbreviated Parent Edition (FQQ-AP)

The FQQ-A and FQQ-AP are 21-item measures that assess the quality of a person's best friendship. It is abbreviated based on the 40-item self-reported Friendship Quality Questionnaire (Parker and Asher 1993). The abbreviated version (FQQ-A) was used in the National Institute of Child Health and Human Development (NICHD) study of early child care and youth development and adjusted from the original interview format. The FQQ-AP was created to allow parents to report on their child's friendship quality. Examples of statements on the FQQ-A include "my best friend tells me I'm good at things" and "my best friend makes me feel good about my ideas." The original FQQ has been used in research with both neuro-typical children and children with ASD. The reliability for the current sample was very good for both the FQQ-A and the FQQ-PA (α = 0.91 for each).

Achenbach Child Behavior Checklist—Depression Scale (CBCL-D); Achenbach Youth Self Report—Depression Scale (YSR-D)

Parents completed the CBCL-D, 15 of the 17 items from the original CBCL-D (Clarke et al. 1992; the current study omitted the two questions regarding suicidality) which are a subset of the 118-item CBCL (Achenbach and Rescorla 2001). Adolescents completed the YSR-D, which included the corresponding 15 self-report items from the CBCL-D. Examples of statements include "feels worthless or inferior" and "withdrawn, uninvolved with others." The reliability for the current study was good (α = 0.79 for each).

The Children's Loneliness and Social Dissatisfaction Scale (LS) and the Children's Loneliness Social Dissatisfaction Scale—Parent Report (LS-P)

The LS (Asher et al. 1984) is a 24-item self-report measure that assesses adolescent loneliness in the past few weeks and has been specifically used for youth with ASD. Examples of statements include "I have nobody to talk to" and "I can find a friend when I need to." The LS-P is a 16-item version of the Loneliness Scale, which is appropriate for parents to report on their child's level of loneliness, with the eight filler items from the LS removed. The reliability for the current sample was α = 0. 91 for the LS and α = 0.84 for the LS-P.

Results

Descriptive Statistics and Correlations

Missing data were imputed using PRELIS 2.80 in LIS-REL 8.80. Composites were imputed only if a participant skipped one to three questions within the measure; data was not imputed if a participant left an entire measure blank. Means, standard deviations, and correlations between study variables are listed in Table 1. Although raw scores were used for analyses, T-scores were also calculated for the BRIEF domains to quantify the level of EF impairment in the sample. The mean T-scores of all four domains of EF were in the clinical range (i.e., T-score of 65 or greater), suggesting significant EF impairment. Although adolescents reported higher overall friendship qualities compared to parent reports, parent and adolescent reports were significantly positively correlated for the FQQ-AP and FQQ-A (p < .01).

As shown in Table 1, both loneliness and depressive symptoms were positively correlated with all four EF domains (p < .05 for Inhibit, p < .001 for shift, emotional control, and working memory for loneliness; p < .001 for all EF domains for depressive symptoms). Age was significantly negatively correlated with the BRIEF inhibit (p < .05) and emotional control (p < .01), indicating that older youth demonstrated fewer inhibition and emotional control problems. All four domains of the BRIEF were significantly correlated with each other (p < .01 for all). Positive correlations were also found between the CBCL-D and YSR-D (p < .01), and LS-P and LS (p < .01). Due to the high correlations between parent and adolescent reports, composites were calculated for the Friendship Quality Questionnaires (FQQ-AP, FQQ-A), CBCL-D and YSR-D, and the Loneliness Scales (LS, LS-P), which were used for all mediation analyses.

Table 1 Means, standard deviations, and bivariate correlations between study variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1 Age	–											
2. BRIEF inhibit	−.23*	–										
3. BRIEF shift	−.17	.51**	–									
4. BRIEF EC	−.32**	.63**	.65**	–								
5. BRIEF WM	−.09	.50**	.47**	.45**	–							
6. SRS	−.20*	.55**	.61**	.52**	.50**	–						
7. FQQ-AP	.07	−.23**	−.20*	−.28**	−.17	−.36**	–					
8. FQQ-A	.16	−.04	−.04	−.12	−.08	−.12	.45**	–				
9. CBCL-D	−.08	.36**	.46**	53**	.51**	.43**	−.10	.03	–			
10. YSR-D	−.08	.21*	.34**	.44**	.34**	.32**	−.21*	−.07	.61**	–		
11. LS-P	−.10	.28**	.45**	.49**	.32**	.51**	−.38**	−.07	.48**	.41**	–	
12. LS	−.12	.07	.19*	.32**	.24**	.25**	−.25**	−.43**	.41**	.60**	.50**	–
Mean	13.95	19.85	18.43	21.24	22.54	96.39	64.63	72.01	0.71	0.70	31.63	23.83
SD	1.60	5.42	3.46	5.36	5.31	16.54	16.01	14.53	0.39	0.39	9.14	11.99
Range	12–17	10–30	8–24	10–30	11–30	53–137	35–101	37–97	0-1.62	0-1.69	3–52	0–51

Higher scores on the BRIEF subscales, SRS, CBCL-D, YSR-D, LS-P, and LS indicate greater impairment

*Correlation is significant at the .05 level (2-tailed)

**Correlation is significant at the .01 level (2-tailed)

Comparing all demographic and study variables, there were significant gender differences between parent report of social impairment on the SRS, with parents rating females as having significantly greater social impairment (t = −3.68, p < .01). Furthermore, there were significant differences for mode of participation (online versus paper) for the loneliness and depression composites. Participants completing paper measures were significantly more likely to have increased levels of loneliness (t = −2.14, p < .05) and depressive symptoms (t = −2.65, p < .01). Due to these significant differences and the correlation of age to several study variables, all subsequent analyses were also run controlling for age, gender, and mode of participation, although examination of analyses indicated no differences in results when including control variables.

Mediation Models

LISREL 8.80 was used to test all 16 mediation models using Baron and Kenny's 4-criteria for mediation (Baron and Kenny 1986; Kenny et al. 1998).

Social Impairment

Social impairment emerged as a significant mediator for all eight models (i.e., all four measures of EF for both loneliness and depressive symptoms, see Table 2). All of the eight models met the first mediation criteria (i.e., EF → adjustment; EF → social impairment; social impairment → adjustment). Four of the eight models met the fourth

mediation criteria, (inhibit → loneliness; inhibit → depressive symptoms; shift → loneliness; working memory → loneliness). Furthermore, the Sobel test of indirect effect for each of the other four models was significant, suggesting that the effect of EF abilities on adjustment dropped significantly when social impairment was included in the model.

Friendship Quality

Friendship quality emerged only as a significant mediator of the relation between BRIEF emotional control and loneliness (see Table 3). As discussed previously, each of the eight models met the first of Baron and Kenny's mediation criteria (i.e., EF → adjustment). Two of the eight models met the second mediation criteria (i.e., emotional control → friendship quality). Of those two models, only one met the third mediation criteria (i.e., friendship quality → loneliness). Although, this model did not meet the fourth mediation criteria, the Sobel test was significant, suggesting that the effect of emotional control on loneliness dropped significantly when friendship quality was included in the model. (Sobel = 0.12, p < .05).

2-Mediation Model

LISREL 8.80 was used to test all eight 2-mediation models. For each model, an alternate model, which allowed social impairment to relate directly with the adjustment outcome, was tested along with the original model (see

Model/pathway	B	SE	Sobel test
Table 2 Social impairment as a mediator			
Inhibit → social impairment → loneliness	–	–	0.41***
Inhibit → loneliness	0.31*	0.15	–
Inhibit → social impairment	1.63***	0.23	–
Social impairment → loneliness	0.25***	0.05	–
Inhibit → social impairment → loneliness	−0.10	0.16	–
Inhibit → social impairment → depressive sxs	–	–	0.01***
Inhibit → depressive sxs	0.02***	0.11	–
Inhibit → social impairment	1.63***	0.23	–
Social impairment → depressive sxs	0.01***	0.00	–
Inhibit → social impairment → depressive sxs	0.01	0.01	–
Shift → social impairment → loneliness	–	–	0.54**
Shift → loneliness	0.92***	0.22	–
Shift → social impairment	2.93***	0.34	–
Social impairment →loneliness	0.18***	0.06	–
Shift → social impairment →loneliness	0.38	0.27	–
Shift → social impairment → depressive sxs	–	–	0.12*
Shift → depressive sxs	0.05***	0.01	–
Shift → social impairment	2.93***	0.34	–
Social impairment → depressive sxs	0.01*	0.00	–
Shift → social impairment → depressive sxs	0.03**	0.01	–
Emotional control → social impairment →loneliness	–	–	0.22**
Emotional control → loneliness	0.78***	0.14	–
Emotional control → Social Impairment	1.61***	0.24	–
Social impairment →loneliness	0.14**	0.05	–
Emotional control → social impairment →loneliness	0.55***	0.16	–
Emotional control → social impairment → depressive sxs	–	–	0.01*
Emotional control → depressive sxs	0.04***	0.01	–
Emotional control → social impairment	1.61***	0.24	–
Social impairment → depressive sxs	0.00*	0.00	–
Emotional control → social impairment → depressive sxs	0.03***	0.01	–
Working memory → social impairment → loneliness	–	–	0.30***
Working memory →loneliness	0.55***	0.15	–
Working memory → Social Impairment	1.56***	0.24	–
Social impairment →loneliness	0.19***	0.05	–
Working memory → social impairment →loneliness	0.25	0.16	–
Working memory → social impairment → depressive sxs	–	–	0.01*
Working memory → depressive sxs	0.03***	0.01	–
Working memory → social impairment	1.56***	0.24	–
Social impairment → depressive sxs	0.01**	0.00	–
Working memory → social impairment → depressive sxs	0.02***	0.01	–

*p ≤ .05 (2-tailed), **p ≤ .01 (2-tailed), ***p ≤ .001 (2-tailed)

Fig. 1). Goodness of fit statistics and significance levels were used based on current standards in the literature (see Hu and Bentler 1998). Of the eight models, none of the original models were found to be a good fit; however, four of the alternate models met the criteria for a good fitting model (see Fig. 2). The first of these four models posited that increased inhibition problems would be associated with greater social impairment, leading to poorer friendship quality, and higher levels of loneliness. The original model provided poor absolute fit, χ^2 (3, N = 127) = 16.58, SRMR = 0.10, RMSEA = 0.18 and poor relative fit, CFI = 0.85, NNFI = 0.70. However, the alternate model which allowed social impairment to correlate with loneliness provided excellent absolute fit, χ^2 (2, N = 127) = 0.426, SRMR = 0.01, RMSEA = 0.0 and excellent relative fit, CFI = 1.0, NNFI = 1.0 (see Fig. 2a).

Table 3 Friendship quality as a mediator

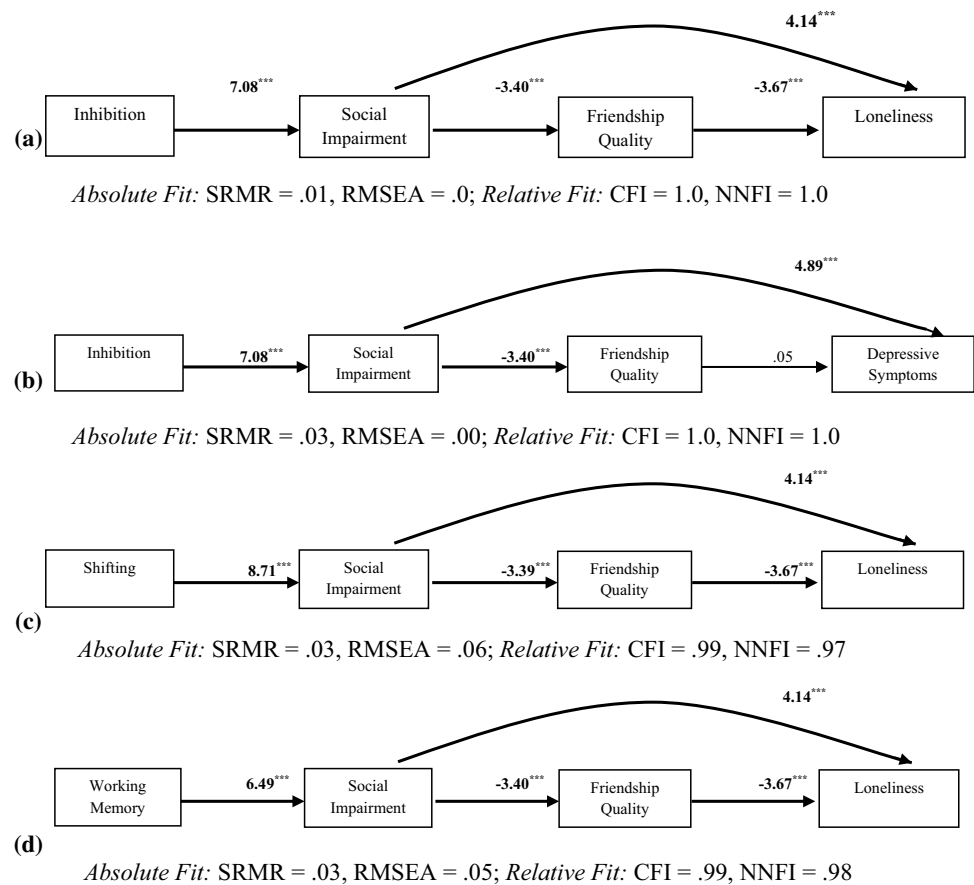| Pathway	B	SE	Sobel test
Inhibit → friendship quality →loneliness	–	–	0.10
Inhibit →loneliness	0.31*	0.15	–
Inhibit → friendship quality	−0.39	0.21	–
Friendship quality →loneliness	−0.26***	0.06	–
Inhibit → friendship quality →loneliness	0.21	0.14	–
Inhibit → friendship quality → depressive sxs	–	–	0.72
Inhibit → depressive sxs	0.02***	0.11	–
Inhibit → friendship quality	−0.39	0.21	–
Friendship quality → depressive sxs	−0.00	0.00	–
Inhibit → friendship quality → depressive sxs	0.02***	0.01	–
Shift → friendship quality →loneliness	–	–	0.13
Shift →loneliness	0.92***	0.22	–
Shift → friendship quality	−0.54	0.33	–
Friendship quality →loneliness	−0.25***	0.06	–
Shift → friendship quality →loneliness	0.79***	0.21	–
Shift → friendship quality → depressive sxs	–	–	0.00
Shift → depressive sxs	0.05***	0.01	–
Shift → friendship quality	−0.54	0.33	–
Friendship quality → depressive sxs	−0.00	0.00	–
Shift → friendship quality → depressive sxs	0.04***	0.01	–
Emotional control → friendship quality →loneliness	–	–	0.12*
Emotional control →loneliness	0.78***	0.14	–
Emotional control → friendship quality	−0.59**	0.21	–
Friendship quality →loneliness	−0.21***	0.06	–
Emotional control → friendship quality →loneliness	0.65***	0.13	–
Emotional control → friendship quality → depressive sxs	–	–	0.00
Emotional control → depressive sxs	0.04***	0.01	–
Emotional control → friendship quality	−0.59**	0.21	–
Friendship quality → depressive sxs	0.00	0.00	–
Emotional control → friendship quality → depressive sxs	0.04***	0.01	–
Working memory → friendship quality →loneliness	–	–	0.09
Working memory →loneliness	0.55***	0.15	–
Working memory → friendship quality	−0.36	0.22	–
Friendship quality →loneliness	−0.25***	0.06	–
Working memory →friendship quality →loneliness	0.46***	0.14	–
Working memory → friendship quality → depressive sxs	–	–	0.00
Working memory → depressive sxs	0.03***	0.01	–
Working memory → friendship quality	−0.36	0.22	–
Friendship quality → depressive sxs	−0.00	0.00	–
Working memory → friendship quality → depressive sxs	0.03***	0.01	–

*p ≤ .05 (2-tailed)

**p ≤ .01 (2-tailed)

***p ≤ .001 (2-tailed)

The second model hypothesized that increased inhibition problems would be associated with greater social impairment, which would be related to poorer friendship quality, and higher levels of depressive symptoms. Again, the original model provided poor absolute fit, χ^2 (3, N = 127) = 24.00, SRMR = 0.15, RMSEA = 0.22 and poor relative fit, CFI = 0.74, NNFI = 0.48. However, the alternate model, allowing social impairment to correlate with depressive symptoms, provided excellent absolute fit, χ^2 (2, N = 127) = 1.95, SRMR = 0.03, RMSEA = 0.0 and excellent relative fit, CFI = 1.0, NNFI = 1.0 (see Fig. 2b). The third model posited that increased shifting

Fig. 2 Structural equation models predicting adjustment by executive function domains, social impairment, and friendship quality. Note that significant paths are in bold type, Z-scores are reported, *p ≤ 0.05 (2-tailed), **p ≤ 0.01 (2-tailed), ***p ≤ 0.001 (2-tailed)

(a)

Absolute Fit: SRMR = .01, RMSEA = .0; *Relative Fit:* CFI = 1.0, NNFI = 1.0

(b)

Absolute Fit: SRMR = .03, RMSEA = .00; *Relative Fit:* CFI = 1.0, NNFI = 1.0

(c)

Absolute Fit: SRMR = .03, RMSEA = .06; *Relative Fit:* CFI = .99, NNFI = .97

(d)

Absolute Fit: SRMR = .03, RMSEA = .05; *Relative Fit:* CFI = .99, NNFI = .98

problems would be associated with greater social impairment, which would be associated with poorer friendship quality, and higher levels of loneliness. As stated previously, the original model provided poor absolute fit, χ^2 (3, N = 127) = 19.15, SRMR = 0.13, RMSEA = 0.20 and poor relative fit, CFI = 0.86, NNFI = 0.71. However, the alternate model which allowed social impairment to correlate with loneliness provided good absolute fit, χ^2 (2, N = 127) = 3.00, SRMR = 0.03, RMSEA = 0.06 and good relative fit, CFI = 0.99, NNFI = 0.97 (see Fig. 2c). The final model predicted that increased working memory problems would be associated with greater social impairment, which would be associated with poorer friendship quality, and higher levels of loneliness. The original model again provided poor absolute fit, χ^2 (3, N = 127) = 18.80, SRMR = 0.13, RMSEA = 0.20 and poor relative fit, CFI = 0.83, NNFI = 0.66. However, the alternate model which allowed social impairment to correlate with loneliness provided good absolute fit, χ^2 (2, N = 127) = 2.64, SRMR = 0.03, RMSEA = 0.05 and good relative fit, CFI = 0.99, NNFI = 0.98 (see Fig. 2d).

Discussion

The goal of this study was to investigate the relations between EF, social impairment, and friendship quality and their associations with adjustment among high functioning adolescents with ASD. The results suggest several interesting insights into adjustment difficulties in this population. Specifically, the current study found both links between specific EF domains and depressive symptoms as well as significant models including EF, social impairment, and depressive symptoms and loneliness respectively. Although the ASD research has focused mainly on identifying specific EF deficits, this research also defines a clear relation between several parent-reports of EF skills and adjustment, even after controlling for age and gender. This is consistent with the literature documenting links between EF and depressive symptoms in neuro-typical populations (e.g., Rogers et al. 2004; Austin et al. 1999). Furthermore, while ASD-focused research has found less support for impairment in certain EF domains such as inhibition, the current study found that inhibition difficulties are related to

adjustment in adolescents with ASD. However, due to the cross-sectional nature of this study, the directionality of this relation cannot be identified. Therefore, it may be that those with poorer adjustment may have more impairment in EF skills.

Additionally, the results of the current study help better understand a potential mechanism by which EF is associated with adjustment. The relations between all EF domains and adjustment were mediated by social impairment. However, this was not the case for friendship quality, which only mediated the relation between emotional control and loneliness. This is surprising since the ASD literature links friendship quality with adjustment (e.g., Bauminger and Kasari 2000), and qualititative research has demonstrated that cognitive rigidity is associated with diminished friendship quality (Carrington et al. 2003). Until this point, our understanding of adjustment in this population has been somewhat limited by the models that have been identified, leading to interventions and treatments that only have a partial understanding of how depression and loneliness are manifested. These results identify both intrinsic (i.e., EF) and extrinsic factors (i.e., social skills impairment) that are important to consider when designing treatments for depression and loneliness in this population. For example, current findings suggest that EF deficits are associated with impaired social abilities, which is linked to adjustment difficulties. Therefore, having a better understanding of and addressing a person's EF as well as their social skills may be important components of successful interventions for adolescents with ASD. In fact, Solomon et al. (2004) found that a social adjustment enhancement intervention for high functioning youth with ASD which included a real-world EF teaching component led to increases in problem solving and emotional awareness compared to a waiting list control group.

In addition to the direct mediation findings discussed above, results identified four 2-mediation models with good fit, three of which included loneliness as the outcome variable. There are several reasons why loneliness may have been a more relevant adjustment outcome. First, it may be that loneliness is a more salient measure of adjustment for this population. As discussed previously, this population is aware of their differences and can recognize and identify both the concept of loneliness and how it feels to them (Bauminger et al. 2003). Loneliness may also be more directly related to friendship quality as compared with depressive symptoms. Those with few friends or poor quality friendships may find the direct consequence is feeling lonely, while depressive symptoms may be the result of the loneliness or perhaps are more closely linked to another social factor, such as bullying or negative peer feedback. Interestingly, the only 2-mediation model of loneliness which did not fit well (emotional control →

social impairment → friendship quality → loneliness) is an expansion of the only model for which friendship quality significantly mediated the relation between EF and adjustment (emotional control → friendship quality → loneliness). This suggests that, although friendship quality independently mediates the relation between emotional control and loneliness, social impairment plays less of a role for this specific relation. Difficulty with emotional control may be something that peers or friends are more able to overlook in the context of a conversation or friendship. Additionally, although the relation between EF and adjustment was more often mediated by social impairment than friendship quality, the significant 2-mediation models demonstrate that it is important to factor in the contribution of friendship quality on adjustment as well. These results are consistent with research focused on friendship quality mediating the relation between social impairment and adjustment in ASD youth (e.g., Orsmond et al. 2004).

The current findings suggest that EF abilities indirectly influence the relation between friendship quality and adjustment through social impairment. Once explanation is that friendship quality may not be as influenced by EF skills. For example, while successful social interactions may involve shifting attention between verbal and visual information during a conversation or inhibiting comments not relevant to the discussion, a good quality friendship is about supporting each other and spending time together. However, it may also be that the Friendship Quality Questionnaires did not adequately assess ASD youths' friendship quality. The measure asks participants to think about a good or best friend when answering the questions and many of these participants may not have had a friend to think of. In fact, several participants either noted "do not have a best friend" or did not fill in the name of the best friend that they were referencing in the measure when asked. Therefore, it may be that a more sensitive and ASD-focused measure would better assess actual friendship quality in this population.

Furthermore, with the four good fitting models, three of the four measures of EF (inhibition, shifting, working memory) were represented. All three of these domains appear to be relevant for successful social interactions. For example, in order to have a conversation with a peer about one of her favorite books, is may be necessary to shift back and forth between listening and talking about the book or between why she liked the book and what other books the author has written (i.e., shifting), take in and process both what she is saying about the book and the nonverbal cues that she is giving to show she enjoys talking about the book (i.e., working memory), and finally try not to interrupt her or grab the book out of her hands (i.e., inhibition). Without these abilities, a successful conversation with this peer may prove to be difficult. Therefore, these domains are relevant

to social interactions and their presence may enhance a person's friendship quality and reduce adjustment difficulties. Interestingly, emotional control did not emerge as a significant predictor within any of the 2-mediation models. This is surprising, as emotional control was found to be directly related to both depressive symptoms and loneliness in the current study. This suggests that emotional control is not as salient a skill as the other domains in the context of adjustment and may not be a necessary component for ensuring better success of social interactions and better friendship quality. As discussed previously, perhaps the other areas of behavioral regulation (i.e., shifting, inhibition) are more necessary or relevant to social interactions, while difficulty with emotional control may be something that peers or friends are more able to overlook in the context of a friendship. However, poorer emotional control was significantly related to lower friendship quality. This suggests that, while emotional control was not associated with the broader expressions of adjustment, it is noteworthy. Again, due to the cross-sectional nature of this data, it is difficult to determine the direction of this relation and furthermore, it's potential contributory impact on the larger model. It is possible that there is a bidirectional relation between emotional control, social impairment, and friendship quality on adjustment. For example, those with poorer emotional control may struggle with both their social skills and their friendship quality, which could simultaneously impact each other, and subsequently, their adjustment.

Although this study makes important contributions to our current knowledge, the limitations of the current study are also noteworthy. First, the high percentage of Caucasians in the study makes results less generalizable to other ethnic groups. Additionally, the sample was predominantly male. Although the gender breakdown was similar to gender differences seen in ASD, results have limited generalizability to females. This may be particularly pertinent given that research has demonstrated gender differences in social experiences including friendship quality and social motivation for youth both with and without ASD (e.g., Sedgewick et al. 2016). Furthermore, the current study only evaluated adolescents with ASD and was not able to compare the results to a neuro-typical population or to genetic (e.g., down syndrome) or other developmental disorders (e.g., ADHD). Therefore, it is important for future research to address whether this model is unique to the ASD population or a consistent pattern among neuro-typical youth. Another limitation of the study was the inability to confirm ASD diagnoses. Although a majority of the participants were recruited through the Interactive Autism Network which screens for an ASD diagnosis, the nature of the study did not allow for researchers to independently screen all youth to confirm a diagnosis. In addition, the cross-sectional design of the study limits conclusions about the

directionality of these findings. Therefore, future research should utilize a longitudinal design which can assess the change and development of EF, social impairment, friendship quality, and adjustment. Furthermore, two of the main predictor variables in the study (EF, social impairment) were based on parent report. Although parents may be equally, if not more accurate reporters of their children's everyday abilities, future research may wish to include laboratory measures of EF and social impairment to get an objective measure of participants' skills. Additionally, laboratory measures could assess other important areas of functioning including IQ, which could not be assessed in the current sample. Furthermore, there was a large age range of adolescents participating in the current study. Given the many changes that occur during adolescence, future work with a larger sample should consider whether these findings replicate across adolescence. It is also important to recognize that there may be other domains of EF (e.g., planning and organizing, initiation) that also influence social impairment, friendship quality, and adjustment. In fact, although the current results identified several good fitting models, there may be other equally good fitting models that exist. Future research should address whether adjustment may also be well explained by other factors including additional EF domains. Finally, this data was gathered prior to the adoption of the DSM-5, which significantly changed the diagnostic criteria for ASD, including shifting from three separate diagnostic categories to one diagnosis of ASD. Although the current study focused on youth who were considered high functioning and collapsed all three DSM-IV-TR diagnoses together, future research needs to verify whether the current results continue to hold true for high functioning adolescents diagnosed with ASD based on DMS-5 criteria. Furthermore, it may be interesting to compare those with ASD to the new DMS-5 diagnosis of social communication disorder both with and without comorbid diagnoses. ASD can now co-occur with diagnoses such as ADHD which was previously an exclusionary criterion in the DSM-IV-TR. Given the many changes to the ASD diagnostic criteria including collapsing all autism spectrum diagnoses into one diagnosis, allowing more comorbid diagnoses, and the creation of a separate social communication disorder, this may affect the presentation of developmental constructs such as those in the current study (social impairment, EF, etc.) depending on the group being evaluation. Comparing these models across different severity levels (i.e., DMS-5 "levels of support") or evaluating whether these models change as a child's severity level changes may also be important future areas of research.

Despite these limitations, the current study is one of the first to investigate both intrinsic and extrinsic factors impacting adjustment in high functioning youth with ASD. These results will help inform treatments that focus

on the promotion of better adjustment. As research continues to identify which factors influence adjustment and how they influence each other, more comprehensive treatments can be adopted to target the development of specific areas and skills that will lead to fewer feelings of depression and loneliness. Furthermore, this understanding of how better adjustment can be achieved can lead to the development of programs aimed at preventing significant adjustment difficulties for high functioning youth with ASD. This study is an important step toward achieving this goal of positive youth development and promotion of better mental health in this population.

Author Contributions RL conceived of the study, participated in its design and coordination, performed the measurement, performed the statistical analysis and interpretation of the data, and drafted the manuscript; AB conceived of the study, participated in its design and coordination, participated in the interpretation of the data, and drafted the manuscript. All authors read and approved the final manuscript.

Compliance with Ethical Standards

Conflict of interest Drs. Lieb and Bohnert declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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