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Executive and Social Functioning in Fetal Alcohol Spectrum Disorders: Comparison to Autism

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Abstract:	Executive function is an area of challenge for both children with fetal alcohol spectrum disorders (FASD) and children with autism spectrum disorder (ASD). Parent ratings of everyday executive function relate to a range of outcomes, including social functioning in ASD. Comparisons between FASD and ASD have revealed both overlapping and distinct skills, but have not addressed executive function or its relation to social function. Utilizing parent report, the current study addressed relative strengths and weaknesses across scales of everyday executive function, as well as group differences between FASD and ASD. The association between executive function and social function was also evaluated. Participants with FASD (n = 23) and ASD (n = 18) were preschool and school-age children whose caregivers completed the Behavior Rating Inventory of Executive Function (BRIEF, BRIEF-2, or BRIEF-P) and the Social Responsiveness Scale, Second Edition. For both groups and all examined executive function scales, scores exceeded the normative mean, indicating challenges. The groups differed significantly on only one executive function scale: working memory. In both groups, executive function was positively correlated with social functioning, even when controlling for nonverbal IQ. The current findings highlight an overlapping association between executive function and social function in FASD and ASD.

Abstract

Executive function is an area of challenge for both children with fetal alcohol spectrum disorders (FASD) and children with autism spectrum disorder (ASD). Parent ratings of everyday executive function relate to a range of outcomes, including social functioning in ASD. Comparisons between FASD and ASD have revealed both overlapping and distinct skills, but have not addressed executive function or its relation to social function. Utilizing parent report, the current study addressed relative strengths and weaknesses across scales of everyday executive function, as well as group differences between FASD and ASD. The association between executive function and social function was also evaluated. Participants with FASD (*n* = 23) and ASD (*n* = 18) were preschool and school-age children whose caregivers completed the Behavior Rating Inventory of Executive Function (BRIEF, BRIEF-2, or BRIEF-P) and the Social Responsiveness Scale, Second Edition. For both groups and all examined executive function scales, scores exceeded the normative mean, indicating challenges. The groups differed significantly on only one executive function scale: working memory. In both groups, executive function was positively correlated with social functioning, even when controlling for nonverbal IQ. The current findings highlight an overlapping association between executive function and social function in FASD and ASD.

Executive and Social Functioning in Fetal Alcohol Spectrum Disorders: Comparison to Autism

Fetal alcohol spectrum disorders (FASD) and autism spectrum disorder (ASD) have distinct developmental trajectories with some overlapping features (Bishop et al., 2007; Stevens et al., 2013). While not a diagnostic term, the FASD umbrella refers to the range of neurodevelopmental outcomes associated with prenatal alcohol exposure. This can include physical and developmental characteristics such as decreased growth, distinct facial features, and difficulties in learning and behavior (Astley & Schwindt, 2011). Defined by behavior, ASD is characterized by differences in social communication, repetitive behaviors, and intense interests. On the group level, both individuals with FASD and ASD are likely to have weaknesses in social interaction and executive function compared to neurotypical development (NT; Freeman et al., 2017; Rasmussen et al., 2007, 2011). Although nonverbal cognitive skills vary widely among individuals, most children with FASD or ASD have nonverbal IQ scores above the range of intellectual disability (Christensen, 2016; Mattson et al., 2019). Despite these overlapping developmental features, little is known about similarities or differences in how executive function and social interaction skills relate in children with FASD or ASD. Commonalities in developmental patterns or relationships among domains of development could yield insights into how to provide supports.

Perspectives, Approach, and Terms in Relation to Disability

The framing of research related to disabilities determines the interpretation and impact of the work (Kover & Abbeduto, 2023). In this study, we use person-first language for consistency between groups, with deep respect for the varying and dynamic preferences across individuals and communities (Bottema-Beutel et al., 2020; Rutman, 2016). Person-first “children with NT” will refer to children not diagnosed with FASD, ASD, or other neurodevelopmental disabilities (Bottema-Beutel et al., 2020).

Additionally, we make a distinction between impairment and disability. An impairment is an illness, injury, or condition that results in loss or differences in functioning, whether physical or cognitive (Oliver, 2017). Disability, on the other hand, is commonly defined in two ways: the social model of disability and the medical model of disability. The social model refers to negative societal consequences, such as loss of education or career development, that are a result of one’s impairment (Berger, 2013; Oliver, 2017). For example, a child may be disabled by a classroom setting that does not provide adequate time to change between activities if executive functioning skills, like adapting to new plans, or social functioning skills, like communicating preferences, are a challenge. The social model of disability pushes back against the medical model which places the person’s limitations on the individual (i.e., the person with a disability should be “fixed”; Berger, 2013). In the previous example, under the medical model, the lack of classroom inclusion would be attributed to the child because they lack flexibility. We frame characteristics that may be associated with FASD or ASD using a social model of disability. Our intention is to support the identity and needs of individuals with FASD and ASD, leading to future work that serves them with strengths-based assessments and person-centered accommodation (Buntinx & Schalock, 2010).

Finally, the current study is limited in understanding executive function and social behavior through a single lens: informant report. Parents are important sources of information, as they know their children unlike any other adults, and parent-report measures quantify behavior in ecologically valid ways

(Kenworthy et al., 2008; Udhnani et al., 2020); nonetheless, they are not expected to generalize to all contexts (e.g., school, where specialists might view behavior differently; Reetzke et al., 2021). This study utilizes a single informant; conclusions do not imply invariable traits or failings of the child.

Executive Function in Children with FASD or ASD

Executive function relates to one's ability to control and regulate behavior, which includes, but is not limited to, flexible thinking, working memory, and self-control (Geurts et al., 2004). Its development is relevant to many childhood outcomes, from academics to peer interactions (Kenworthy et al., 2008; Rosenthal et al., 2013). Although associated with nonverbal IQ, the relationship between executive function and intellectual ability is complex (Friedman et al., 2006). Prior research suggests that executive function develops most rapidly in children with NT from ages three to five years, but continues during adolescence and early adulthood (Best & Miller, 2010). Children with FASD or ASD develop executive function skills during this period, but often more slowly (Fuglestad et al., 2015; Yerys et al., 2007) and differences in skills can remain throughout the lifespan (Green et al., 2009; Rosenthal et al., 2013).

Prior research has largely utilized performance-based assessments or neuropsychological tests of executive function to evaluate various domains in a laboratory environment. Indeed, the literature on which domains of executive function are impacted in FASD (Kingdon et al., 2016; Mattson et al., 1999; Schonfeld et al., 2001) and ASD (Barton & Mcintyre, 2021; Kenworthy et al., 2008; Udhnani et al., 2020) is still burgeoning. Kenworthy et al. (2008) suggest several reasons for the lack of consistently identified weaknesses in directly assessed executive domains, including age-specific differences, laboratory settings not requiring the same executive control as other environments, and different definitions.

One common indicator of executive function, the Behavioral Rating of Executive Function (BRIEF; also, BRIEF-2, BRIEF-Preschool; Gioia et al., 2000, 2015, 2003) is based on parent report. Higher BRIEF scores indicate impairment. Although the degree of correlation with performance-based measures is still under consideration, the BRIEF may provide a valuable understanding of daily living, including for children with developmental disabilities, because parents rate their child based on their everyday actions (Kenworthy et al., 2008; Mcauley et al., 2010).

FASD. Executive function in children with FASD has been studied through neuropsychological tests and caregiver reports to understand the impact of prenatal alcohol exposure on neurocognitive development. Executive function plays a major role in distinguishing between groups of school-age children with and without FASD (Kodituwakku, 2009; Mattson et al., 2019). School-age children with FASD may experience differences in most areas of executive function, including inhibition (Mattson et al., 1999), flexibility (Mattson et al., 1999), set-shifting (Kingdon et al., 2016), with particular challenges in planning (Green et al., 2009; Kingdon et al., 2016) and working memory (Green et al., 2009). Preschool-age children with FASD may also have differences in executive function, but less research has addressed this age group (Mclachlan et al., 2015). Nonetheless, Fuglestad et al. (2015), using a performance-based assessment, found that preschool-age children with FASD had widespread executive function challenges across domains, which is similar to the pattern found in school-age children (Kingdon et al., 2016; Schonfeld et al., 2001). Studies on preschool- and school-age children with FASD have focused on children without intellectual disability or have failed to address nonverbal cognition (Green et al., 2009; Kingdon et al., 2016; Mattson et al., 1999, Mclachlan et al., 2015). Overall, it appears that both preschool and school-age children with FASD would be expected to have higher BRIEF scores indicating greater impairment across scales – especially working memory and planning (Mattson et al., 2020; Mohamed et al., 2019; Rai et al., 2017; Rasmussen et al., 2007). The current study seeks to build on this evidence by examining everyday executive functioning, in comparison to other children, and in relation to reciprocal social behavior.

ASD. When using performance-based measures, there is reasonable evidence that school-age children with ASD have executive function differences relative to children with NT development in areas including mental flexibility, planning, inhibition, and working memory (Canitano et al., 2019; Geurts et al., 2004; Pellicano, 2007). Preschool-age children with ASD have overlapping executive function differences in planning, inhibition, cognitive shifting, and working memory (Gong et al., 2023; Kimhi et al., 2014). In contrast, some studies have found limited executive function differences in preschool or school-age children with ASD compared to children with NT (Dawson et al., 2002; Edgin & Pennington, 2005). One reason for the discrepant findings could be a focus on certain subsets of children (e.g., with or without intellectual disability; different ages). For example, in older participants without intellectual disability, Kenny et al. (2022) found that 11- to 19-year-olds with ASD had global executive function difficulties compared to nonverbal IQ-matched participants without ASD, but with a variable pattern of performance across specific executive function tasks (i.e., group differences on some, but not all). Addressing intellectual disability, Tsermentseli et al. (2018) reported that 6- to 16-year-old children with ASD and intellectual disability had across-the-board executive function difficulties. Further, Terroux et al. (2024) found that executive function challenges were associated with lower intellectual functioning in preschool-age children with ASD. Overall, executive function challenges have been noted in people with ASD across ages and intellectual abilities, with potential for nuances in executive differences related to individual characteristics (e.g., more executive impairment with intellectual disability) or measurement of executive function (e.g., subdomain of ability).

Research using the BRIEF has also pointed to executive function challenges in children with ASD (Tsermentseli et al., 2018): preschool-age children with ASD have greater challenges overall compared to children with NT development, particularly in flexibility and shifting (Smithson et al., 2013), and school-age children with ASD have elevated executive function difficulties overall in comparison to children with NT development, particularly shifting (Blijd-Hoogewys et al., 2014; Gardiner & Iarocci, 2018; Rosenthal et al., 2013). Taken together, the BRIEF is a useful tool for analyzing executive function in children with ASD because it captures aspects of a child’s daily experience, as well as subdomains of skills (Kenworthy et al., 2008). In the current study, we considered BRIEF scores in preschool and school-age children, with an emphasis on overlapping indices between preschool and school-age BRIEF versions.

Social Functioning in Children with FASD or ASD

Many children with FASD and, by definition, all children with ASD have social functioning challenges (Kully-Martens et al., 2012; Rasmussen et al., 2011). Social functioning difficulties are core to ASD diagnostic criteria, but FASD is frequently associated with social problems (Mattson & Riley, 2000; O'Connor et al., 2006; Rasmussen et al., 2011) and difficulty forming relationships (Bishop et al., 2007). There is some debate on the extent of similarity in reciprocal social behavior between FASD and ASD. Bishop et al. (2007) found that children with ASD have considerably different social function than children with FASD, including gestures, sharing enjoyment, and nonverbal communication; whereas, Stevens et al. (2013) concluded that these two groups share many similarities in social function and communication. The overlapping, but not identical, social difficulties in FASD and ASD will serve as a useful comparison for identifying characteristics and correlates of outcomes in these groups.

Although several measures have been used to identify social challenges in FASD or ASD, from the Social Skills Rating System (Rasmussen et al., 2011) to the Autism Diagnostic Interview-Revised (Bishop et al., 2007; Constantino et al., 2003), one of the most commonly used questionnaires is the Social Responsiveness Scale, Second Edition (SRS-2; Constantino, 2012). The SRS-2 is a parent-report measure of social behaviors related to ASD, with an emphasis on reciprocal social interaction and very strong scale reliability relative to other ASD measures (Constantino, 2012; Frazier et al., 2023). The SRS-2 scores are divided into five subscales that assess specific social functioning differences, which combine to form an overall "severity of social deficits" total T-score, as well as a Social Communication and Interaction (SCI) score (Constantino, 2012). A child with ASD is expected to score above SRS-2 Total T-score cut-offs, with elevated scores reflecting social differences compared to NT development.

Very little research has utilized the SRS-2 in children with FASD (Frazier et al., 2023; Tan et al., 2020), despite its well demonstrated potential for characterizing social functioning in other populations. For example, Channell (2020) reported on the rate of elevated SRS-2 scores including ASD-like behaviors in children with Down syndrome. Such work demonstrates the utility of using the SRS-2 with children with different developmental disabilities, including to identify shared behavior patterns.

Relationship Between Executive Function and Social Interaction in FASD or ASD

Executive function appears interrelated with a child's social functioning and social communication (Burroughs et al., 2024; Hutchison et al., 2020; Matthews et al., 2018). Among children with FASD, Schonfeld et al. (2006) tested the association between the BRIEF and parent-reported social function, assessed with the Social Skills Rating System. They found that BRIEF scores were indicative of social competence, showing a relationship between executive function and social function. In that study, all participants' IQs exceeded 70 and IQ was inconsistently related to social scales. In ASD, BRIEF scores have been identified as potential correlates of social or adaptive functioning (Fong & Iarocci, 2020; Howard et al., 2023; Hutchison et al., 2020; Leung et al., 2016; Terroux et al., 2024; Torske et al., 2018). Recent studies have specifically tested the association between the BRIEF and the SRS/SRS-2 in children with ASD, finding that BRIEF scores correspond to SRS/SRS-2 social functioning scores (Bednarz et al., 2020; Chouinard et al., 2019; Leung et al., 2016; Torske et al., 2018), a trend not seen in children with NT development (Leung et al., 2016) or children with ASD with intellectual disability (Tsermentseli et al., 2018). Indeed, the inconsistency with which nonverbal cognition is a significant factor in explaining the association between executive function and social interaction across studies of FASD and ASD is striking. Interestingly, in Torske et al. (2018), all participants' IQs exceeded 70 and IQ was not a unique predictor of SRS total scores beyond BRIEF scores, despite broader evidence of an association between nonverbal cognition, executive function, and social function (Joseph & Tager-Flusberg, 2006; Terroux et al., 2024). Direct comparison of nonverbal-IQ matched children with FASD or ASD when assessing everyday executive function and social function simultaneously can address the association between those areas, as well as overlap in those children's characteristics or experiences.

Rationale and Current Research Questions

Executive function is known to be an area of challenge among individuals with many developmental disabilities (Kodituwakku, 2009). Cross-group comparisons of everyday executive function may yield more detailed understanding of the strengths and weaknesses associated with FASD or ASD, with potential clinical and education implications for support services (Khoury & Milligan, 2019; Yon-Hernández et al., 2022). This is especially true because executive function differences in FASD and ASD may be distinct from other developmental trajectories (e.g., ADHD; Geurts et al., 2004; Yon-Hernández et al., 2022) and executive function is correlated with social function in children with ASD (e.g., Howard et al., 2023). Importantly, comparisons between FASD and ASD have revealed both overlapping and distinct skills, but have not addressed everyday executive function or its relation to social function (Bishop et al., 2007; Stevens et al., 2013). The current study reports on age- and nonverbal IQ-matched children with FASD or ASD in the preschool and school-age years to address two unresolved topics in the literature: first, inconsistent findings regarding areas of strength and weakness in executive function in FASD and ASD, including no previous direct comparisons of FASD and ASD in everyday executive function; and second, limited and inconsistent evidence regarding the association between executive and social function, especially for FASD and especially considering nonverbal IQ. Therefore, we asked the following questions in children with FASD or ASD: (1) What aspects of everyday executive function are strengths or weaknesses relative to normative expectations and cut-offs for clinically significant difficulties, and what aspects differ between groups?, and (2) In children with FASD or ASD, are everyday executive function and parent-reported social function associated, over and above nonverbal IQ, and does that association differ between groups?

Method

Participants

Participants were drawn from a larger study on children with and without developmental disabilities. This study was approved by the [masked for review] IRB. Participants with FASD were recruited from the clinical research database and registry of the [masked for review]. Individuals with FASD had been diagnosed using interdisciplinary assessment and had known in-utero exposure to alcohol; none had a clinical ASD diagnosis. These children each had a diagnosis that falls under the FASD umbrella according to the [masked for review] FASD 4-Digit Diagnostic Code: fetal alcohol syndrome/partial fetal alcohol syndrome (FAS/PFAS), static encephalopathy/alcohol exposed (SE/AE), and neurobehavioral disorder/alcohol exposed (ND/AE; Astley 2004; Astley, 2013). These diagnoses vary in growth deficiency, facial anomalies, and central nervous system abnormalities. Classifications of the 23 participants with FASD were: 2 with FAS or PFAS, 5 with SE/AE and 16 with ND/AE (SE/AE and ND/AE are associated with mild to significant CNS function impairments). Participants with ASD were recruited from the region and entered the study with a community diagnosis of ASD. To be eligible for the larger study, participants with ASD or FASD spoke English as the primary language at home, had no uncorrected vision or hearing impairments, and could follow a simple verbal instruction.

Participants included in analyses had the appropriate caregiver-completed BRIEF, BRIEF-2, or BRIEF-P, as well as a caregiver-completed SRS-2 School-Age form. To be included in analyses, participants with ASD additionally needed to score above the SRS-2 T-Score clinical cut-off of 59 in corroboration of the community ASD diagnosis, or meet ASD classification on the ADOS-2, in the case of one participant with a score below the SRS-2 cut-off. Two participants were excluded for not having a BRIEF/BRIEF-2/BRIEF-P; three were excluded for not having an SRS-2; one additional participant was excluded for having neither a BRIEF nor SRS-2; three participants with ASD were excluded for lacking Leiter-3 scores, three participants with ASD were excluded during the group-wise matching process for age and nonverbal IQ; and one participant with ASD was excluded for not having an above-cut-off SRS-2 score without an ADOS-2 to corroborate community diagnosis.

Included in the analyses were participants with FASD (*n* = 23; 13 males) who were 4 to 9 years old (*M* = 6.98 years, *SD* = 1.62) and participants with ASD (*n* = 18; 14 males) who were 5 to 10 years old (*M* = 7.19 years, *SD* = 1.89). The groups did not differ in age, $t(39) = 0.39$, $p = 0.695$, Cohen's $d = 0.12$ (Kover & Atwood, 2013). As seen in Table 1, the majority of participants identified as exclusively white (74% for FASD; 72% for ASD). While all primary caregivers for participants with ASD were biological parents, 91% of primary caregivers for participants with FASD were non-biological parents (e.g., adoptive parents). On average, parent(s) of participants with FASD and ASD completed 16 years of education. Of households in the FASD group, 48% reported annual income above $100,000; 67% of households in the ASD group reported the same.

Measures

Nonverbal cognition. Nonverbal IQ was assessed using the Leiter International Performance Scale-3 (Leiter-3; Roid & Miller, 2013), which is normed for ages three and above. The Leiter-3 is administered using game-like tasks that do not require spoken language. Scores from four subtests create a composite nonverbal IQ: Sequential Order, Figure Ground, Classification & Analogies, and Form Completion. For one participant in each group, NVIQ scores were calculated from the completed subtests (i.e., 2 out of 4 subtests) by multiplying the sum of the two subtests by two and using the corresponding composite IQ score (Kover et al., 2013). Nonverbal IQ scores ranged from 71 to 120 in participants with FASD (*M* = 100.65; *SD* = 11.36) and from 67 to 133 for ASD (*M* = 98.39; *SD* = 16.90; 3 participants scored under 70). The groups did not differ in nonverbal IQ, $t(39) = 0.51$, $p = 0.612$, Cohen's $d = 0.16$.

Everyday Executive Function. Participants' caregivers completed the BRIEF (Gioia et al., 2000), BRIEF-2 (Gioia et al., 2015), or the preschool version (BRIEF-P; Gioia et al., 2003). The BRIEF and BRIEF-2 are for individuals ages five to eighteen years old; the BRIEF-P is for ages two to five years and eleven months. The BRIEF-P (63 items) and BRIEF-2 (63 items) were based on the BRIEF (86 items), with the BRIEF-P adjusted to be developmentally appropriate; no new items were added to the BRIEF-2 scales to allow consistency for research data between versions (Gioia et al., 2003; Gioia et al., 2015). Of the 41 participants, 24 of their caregivers completed the BRIEF, 13 completed the BRIEF-2, and 4 completed the BRIEF-P. For each version, there is high internal consistency, with Cronbach's alpha exceeding .80 for all scales (Gioia et al., 2000; Gioia et al. 2003; Gioia et al., 2015). Test-retest reliability is greater than or equal to .79 for each version. A BRIEF, BRIEF-2 or BRIEF-P T-score of 50 is the normative mean; 60-64 is considered mildly clinically elevated, and 65 or above is considered clinically noteworthy; higher scores indicate greater impairment. In the current study, the five overlapping subscales of these three forms were included in analyses: Inhibit, Shift, Emotional Control, Working Memory, and Plan/Organize, as well as the cumulative index, Global Executive Composite (GEC). See Table 2.

Social function. Participants' parents also completed the SRS-2 (Constantino, 2012), a 65-item parent-report measure of a child's social behaviors that reflects the likelihood that a child has ASD. For internal consistency, Cronbach's alpha coefficients range from 0.77 to 0.95 (Nelson et al., 2016). Interrater reliability between parents is high (r = .91), with convergent validity correlations of .6 and higher (e.g., with ADI-R), per the manual. Parents complete Likert-scale questions about their child's behavior in the past six months. All caregivers completed the Male or Female School-Age form for ages 4 to 18 years. The SRS-2 scores are divided into subscales related to social functioning differences in ASD: Social Awareness, Restricted Interests and Repetitive Behavior, Social Communication, Social Motivation, and Social Cognition. Together, these yield a "severity of social deficits" Total T-score. A composite subscale, Social Communication and Interaction (SCI), comprises all areas except restricted interests and repetitive behavior. In this study, we considered the overall Total T-score and SCI score, given the focus on social functioning. For the overall T-Score, at or below 59 is within normal limits, 60 to 65 reflects mild social deficits, 66 to 75 reflects moderate social deficits, and 76 and above indicates severe social deficits. Higher T-Scores indicate greater levels of impairment in social skills.

Analysis Plan

Data management utilized REDCap (Harris et al. 2009; Harris et al., 2019), a secure, web-based software platform. Preliminary analyses examined associations between key variables and age, gender, and nonverbal IQ. The first research question tested between-group differences in age- and nonverbal IQ-matched children with FASD or ASD using independent samples *t*-tests on BRIEF scales, and within-group relative strengths and weaknesses with one-sample *t*-tests compared to the normative mean and the clinically significant cut-off. A sequentially rejective Holm procedure controlled family-wise error rate (Seaman, Levin, & Serlin, 1991). Cohen's *d* was calculated as the effect size. The second research question tested the group difference in SRS-2 scores, within-group bivariate Pearson correlations between BRIEF and SRS-2 scores and partial correlations controlling for nonverbal IQ (Channell, 2020; Leung et al., 2016; Torske et al., 2018), as well as the group difference in magnitude of the correlation. Pearson's correlations can be interpreted as effect sizes, where $r = .50$ or greater is large (Cohen, 1988).

Results

Preliminary Analyses

Age and nonverbal IQ were not significantly correlated with BRIEF GEC or SRS-2 Total T-Score or SCI in FASD or ASD, *p*s > .09. There were no gender differences in BRIEF GEC, SRS-2 Total T-Score, or SCI scores in either group, *p*s > .6. As such, these were not considered further, except partialing nonverbal IQ for Research Question 2, on the basis of the literature and theoretical importance.

Research Question 1

We first considered strengths and weaknesses across aspects of everyday executive function relative to normative expectations and cut-offs for clinically significant symptoms. On average, T-Scores exceeded the normative mean (50) in all examined domains of the BRIEF for both groups, $p < .001$, Cohen's $d = 1.0$ to 2.3. See Table 3. Relative to the clinically significant cut-off of 65 and using one-tailed tests due to *a priori* hypotheses, participants with FASD had elevated BRIEF, BRIEF-2, or BRIEF-P scores for the GEC index, $t(22) = 3.74$, $p < 0.001$, Cohen's $d = .78$, as well as the subscales of Working Memory, $t(22) = 4.01$, $p < 0.001$, Cohen's $d = .84$, and Plan/Organize, $t(22) = 3.18$, $p = 0.002$, Cohen's $d = .66$. The Inhibit subscale for FASD, $t(22) = 1.88$, $p = 0.037$, Cohen's $d = .39$, failed to reach alpha-corrected significance. Likewise, participants with ASD also had GEC scores significantly greater than 65, $t(17) = 2.13$, $p = 0.024$, Cohen's $d = .50$. Subscale cores for Inhibit, Working Memory, and Plan/Organize were not elevated above the 65 cut-off for ASD, *p*s > 0.28, Cohen's *d*s <.15. Neither group was elevated for Shift (FASD: $p = 0.28$, Cohen's $d = 0.12$; ASD: $p = 0.16$, Cohen's $d = 0.24$) or Emotional Control (FASD: $p = 0.49$, Cohen's $d = 0.003$; ASD: $p = 0.14$, Cohen's $d = 0.26$).

Relative to a GEC score of 65, 19 participants with FASD (83%) and 13 participants with ASD (72%) exceeded this clinical cut-off. The groups did not statistically differ in the number of participants exceeding the GEC cut-off of 65, Fisher's exact test, $p = .471$. The groups did not differ in GEC score, $t(39) = 1.25$, $p = 0.216$, Cohen's $d = 1.01$. Indeed, the groups did not differ on any BRIEF scales or indices, except working memory, $t(39)$, = 2.84, $p = .007$, Cohen's $d = 1.54$. See Figure 1.

Research Question 2

Mean SRS-2 Total T-Scores were 69.57 (*SD* = 12.82; range = 51 - 93) for FASD and 75.11 (*SD* = 8.73; range = 52 - 85) for ASD; SCI scores averaged 69.30 (*SD* = 12.34; range = 52 - 92) for FASD and 74.06 (*SD* = 8.501; range = 53 - 85) for ASD. The groups did not differ in SRS-2 overall T-score, despite the medium effect size reflecting a descriptively higher mean for ASD, $t(39) = 1.57$, $p = 0.124$, Cohen's $d = 0.49$. The same was true for SCI, $t(39) = 1.39$, $p = .171$, Cohen's $d = .44$. In addition, the groups did not differ in the number of participants exceeding SRS-2 Total T-Score cut-offs for social impairment, Fisher's exact test, *p*s > .09; 17 participants with FASD exceeded the mild cut-off and 7 of those were rated severe.

Within each group, BRIEF GEC scores were significantly and positively correlated with SRS-2 Total T-scores, $r(21) = 0.75$, $p < 0.001$ for FASD and $r(16) = 0.57$, $p = 0.007$ for ASD. See Figure 2. The same was true for SRS-2 SCI scores, $r(21) = .72$, $p < .001$ for FASD and $r(16) = .48$, $p = .023$ for ASD. The correlation coefficients did not significantly differ between groups for GEC with Total T-Scores, Fisher r-to-z transformation = 0.95, $p = 0.342$, or SCI, Fisher r-to-z transformation = 0.40, $p = .345$. Controlling for nonverbal IQ, the positive correlation remained between GEC scores and SRS-2 T-Scores within the FASD and ASD groups, $r(20) = 0.75$, $p < 0.001$ and $r(15) = 0.58$, $p = 0.007$, respectively. The same was true for GEC with SCI scores, $r(20) = .72$, $p < .001$ and $r(15) = .48$, $p = .025$.

Discussion

Strengths and Weaknesses in Everyday Executive Function in FASD and ASD

The first research question considered strengths and weaknesses across aspects of everyday executive function, relative to clinically significant thresholds, for age- and nonverbal IQ-matched children with FASD and children with ASD. As expected, at the group level, participants were rated by parents as having challenges in all areas of everyday executive function, compared to the normative mean of 50, and significantly elevated cumulative BRIEF GEC scores compared the clinically significant cut off of 65. At the individual level, over 75% of participants exceeded the GEC clinically significant 65 mark. This indicates that many children with FASD or ASD have difficulties in executive function compared to children with NT development (Mattson et al., 2020; Rasmussen et al., 2007; Rosenthal et al., 2013; Smithson et al., 2013). That not all participants exceeded the clinical threshold serves as a reminder to nonetheless evaluate children individually to determine if executive function is a strength or weakness. These differences start early in a child's life (Fuglestad et al., 2015; Green et al., 2009; Rosenthal et al., 2013); further research is needed to understand their impacts, including in a child's daily life in the family system and in the context of early intervention targeting executive function.

The current findings using the BRIEF, BRIEF-2, and BRIEF-P in children with FASD or ASD generally align with prior research. For school-aged children with FASD, the literature has indicated weaknesses in many, if not nearly all, areas assessed by the BRIEF (e.g., elevated scores above 65 for all subscales, except organization of materials; Mohamed et al., 2019; Rai et al., 2017; Rasmussen et al., 2007). The current study extends these findings by including preschool-age children alongside school-age children with FASD. Further, the current study indicates that the working memory and plan/organize indices may be most elevated in children with FASD (i.e., above the 65-threshold), similar to existing research (e.g., moderate to large impairments in working memory and planning; Green et al., 2009, Kingdon et al., 2016). For preschool- and school-age children with ASD, the literature points to elevated scores in most indices relative to the norm of 50, but not necessarily the clinical cut-off of 65 (Blijd-Hoogewys et al., 2014; Rosenthal et al., 2013; Smithson et al., 2013; Terroux et al., 2024). Several studies report the Shift subscale to be the greatest area of challenge for school-age children with ASD (Blijd-Hoogewys et al., 2014; Gilotty et al. 2002; Rosenthal et al., 2013). In line with this, the current study found that BRIEF subscales for participants with ASD were elevated above the norm of 50, with Shift being the highest descriptively (M = 67.72). No BRIEF subscales were significantly elevated above 65 for the ASD group, although the cumulative GEC index was.

The current study also tested potential group differences in everyday executive function. The only group difference was for working memory, with a large effect size (Cohen's d = 0.89). In line with this, working memory scores in the FASD group significantly exceeded the clinical cut-off of 65, while they did not for ASD. Together, this points to a strength in working memory for children with ASD – at a group level – relative to FASD. The pattern of significant elevation in FASD, but not ASD, also extended to planning, but the two groups did not differ significantly on that scale. In addition, given that the groups were matched on nonverbal IQ and nonverbal IQ was not associated with the omnibus BRIEF score, parent-identified areas of executive challenge are likely not explained by nonverbal cognition, but rather distinct aspects of behavior and development (Rai et al., 2017).

The working memory scale of the BRIEF addresses a child's ability to hold information in mind while completing a task or working toward achieving a goal. For example, a child with strong working memory would be able to hold a teacher's instructions in mind (process, encode, and manipulate a mental representation) as they followed the steps to get ready to transition to a new activity (e.g., finish their artwork, tidy their desk, and then put on a coat for recess). Situations such as these may pose particular challenges for children with FASD (Green et al., 2009; Rai et al., 2017; Rasmussen et al., 2007). Prenatal alcohol exposure is known to cause reduced brain volume in various areas, including those responsible for memory and executive control, such as hippocampus and prefrontal cortex (Lebel, Roussotte, & Sowell, 2011). These neural differences may contribute to the working memory weakness observed in the current study, which is further bolstered by the association between memory performance and neurophysiological function in FASD (Fuglestad et al., 2022). This area of challenge may also speak to the diagnostic process for children with FASD, who often exhibit later learning challenges and are referred for evaluation expressly because of executive function difficulties in home or school settings, such as trouble following through on instructions to achieve task completion (Chasnoff et al., 2015). As such, endorsement of working memory-related BRIEF items may be more prominent in FASD, especially in the late-preschool and early-school-age years of the current sample. More research is needed to evaluate the implications of this difference in working memory on everyday life and the overall vulnerability of executive function to prenatal alcohol exposure in children.

Taking a strengths-based approach, it is worth highlighting that, at the group level, children with FASD did not statistically exceed the clinical cut-off for Shift or Emotional Control, indicating potential areas of strength. While there is considerable individual variation, these strengths align with qualitative research suggesting that emotional contributions (e.g., positive mood, personality, social motivation, persistence) are strengths of children with FASD (Kautz-Turnbull et al., 2022). For children with ASD, their relative strengths may lie in areas such as emotional control, inhibition, and working memory (Edgin & Pennington, 2005). It is possible that caregivers of children with ASD identify relatively little difficulty in everyday settings in certain areas, such as inhibition, due to experiences with scaffolding associated with their child engaging in focused interests. Attention to areas in which individuals with FASD and ASD excel is critical to advancing theoretical understanding and meaningful supports (Happe, 1999; Kover & Abbeduto, 2023). Achieving this will require embracing qualitative methodologies and participatory approaches to understand children's and families' multifaceted experiences in context.

Overall, the BRIEF can be useful for assessing specific areas of challenges and strengths for children with developmental disabilities. This study identified a group difference for the BRIEF executive function subscale of working memory. Compared to other executive function measures, the BRIEF may be a more ecological measure, as it is designed to measure everyday executive function over the past six months whereas other measures may be influenced by laboratory conditions (i.e., demanding tasks, yet quiet environments) or within-task variations (Bernes et al., 2021; Mattson et al., 2020). More research should examine how to best support individuals with executive function differences, including transdiagnostic approaches (Kerns et al., 2017), and how domains of executive function interact with one another. Regardless, executive function should be considered an important aspect of a child's development in the context of FASD and ASD.

Everyday Executive Function and Reciprocal Social Behavior

The second research question asked whether executive function and social function are correlated in children with FASD or ASD, over and above nonverbal IQ, and whether that association differed between groups. We found that the hypothesized relationship was apparent regardless of whether social interaction was quantified with SRS-2 Total T-score or SCI score. For children with FASD and ASD, everyday executive function was strongly correlated with reciprocal social behavior according to parent report: those with executive function difficulties were rated as having more social impairment in both groups, extending previous findings to children with FASD. The strength of the correlation was similar to that reported by Torske et al., (2018) for ASD and did not differ between groups. Notably, SRS-2 T-Scores also did not differ between groups. In sum, this indicates that children with FASD or ASD may have commonalities in how aspects of behavior and development in the domains of social interaction and executive cognitive control are related to each other. Among children with developmental disabilities, everyday executive function on the BRIEF-2 is associated with many aspects of adaptive behavior, linking parent-reported executive function to everyday living and functional applications (Barton & Mcintyre, 2021, Fong & Iarocci, 2020).

Even when controlling nonverbal IQ, everyday executive function remained correlated with social function for both groups. This is interesting considering children with NT development have not been found to have a relationship between executive function and social function (Bednarz et al., 2020; Leung et al., 2016; Torske et al., 2018). This could be due to restricted ranges of skills in children with NT, cascading impacts of developmental differences in children with disabilities that do not come into play in NT development (Karmiloff-Smith, 2009), or the complex relationships among social interaction, executive function, and other aspects of cognition (Friedman et al., 2006; Joseph & Tager-Flusberg, 2004). Overall, executive function should be considered in relation to social functioning when investigating potential supports for children with FASD or ASD.

Potential Implications

The current study highlights overlapping patterns of executive function and social function, as well as findings specific to FASD or ASD. Preschool- and school-age children with FASD or ASD showed generalized challenges in executive function, but determining fine-grained associations between executive function and social function may lead to better support services (Canitano et al., 2019). Consideration of the individual skill sets of children with FASD or ASD may support tailored interventions for their cognitive and social strengths (Torske et al., 2018). For example, the current study showed that children with FASD have difficulty in planning, so children with challenges in this area might benefit from opportunities to practice beginning activities or achieving goals. A key difference observed here between groups was in everyday working memory ability, such that participants with

FASD had elevated scores relative to those with ASD. This suggests that rehearsal strategies or other metacognitive training might differentially benefit children with FASD (Green et al., 2009). Although dependent on the child and context, such strategies might include repeating instructions, using external visual aids or reminders to guide actions, or self-monitoring to determine when additional cues are needed (e.g., to ask "What comes next after finishing my artwork?"). Overall, intervention techniques may be successful in improving certain aspects of executive function for children with FASD (Nash et al., 2015) or ASD (Cavalli et al., 2021), underlining the importance of targeting specific areas of weakness. The association between executive and social function indicates that bolstering executive skills may further improve a child's social functioning, and vice versa, although this was not directly tested in the current study (Torske et al., 2018). If this is the case, targeted interventions may also have associated benefits for social communication and wellbeing. Future research is needed to address this possibility.

Further, documenting the cognitive and behavioral strengths and weaknesses of children with FASD or ASD has potential for supporting diagnosis, which ultimately facilitates access to resources and the opportunity for increased quality of life (Mattson et al., 2013; Torske et al., 2018). Due to executive or social difficulties, children with FASD or ASD may experience rejection from peers that contributes to internalized ableism and other challenges (Bishop et al., 2007; Gardiner & Iarocci, 2018). FASD and ASD have historically been underdiagnosed (Chasnoff et al., 2015; Lange, 2019), which is influenced by geography, gender, and race (Ferri, 2018; NCBDDD, 2020). With diagnostic information, families might more readily find resources to counteract challenges (Cavalli et al., 2021; Nash et al., 2015).

Finally, this study used a social model of disability framing, with the intention of using these findings to support strengths-based assessments and person-centered accommodations. Our findings highlight different strengths and weaknesses of disability groups, which has the potential to inform both intervention techniques and diagnosis. It is important to note that many, including within the autistic community, believe that it is society's responsibility to meet individuals' needs (Baron-Cohen, 2017;

DeThorne & Searsmith, 2020). Given this perspective, the social model of disability, and other person-centered frameworks (Buntinx & Schalock, 2010), the results of this study are useful in understanding the foundation of everyday behaviors and social interactions, which may support families and educators in understanding their children and students. At the same time, it is equally important to actively promote social changes that will lead to inclusion and acceptance of neurodivergent individuals.

Limitations and Future Directions

This study simultaneously examined executive function and social function in children with FASD or ASD, demonstrating a rarely utilized but potentially productive comparison. Given the relatively small sample sizes, power could have contributed to some nonsignificant findings, although effect sizes were calculated to contextualize the magnitude of observations. Given that participants with FASD and ASD did not differ on SRS-2 scores, further comparing social interaction via direct assessment would be of future interest, for example, using ADOS-2 item scores (Bishop et al., 2007). Participants were primarily white, and analyses did not address other aspects of identity or culture (Bölte et al., 2008), limiting generalizability. Prior research indicates there may be gender differences in executive or social function in children with ASD and other children (Burroughs et al., 2024; Chouinard et al., 2019; Ferri et al., 2018) and although not statistically different, the percentage of males in the current ASD sample (77.8%) relative to the FASD sample (56.5%) should be noted. In addition, intellectual disability in FASD or ASD may impact a child’s executive function, social function, and/or the association between them (Tsermentseli et al., 2018). Children with FASD or ASD and intellectual disability should be purposefully included in future studies to evaluate these questions in groups with and without intellectual disability. Broadly, there may be IQ-, gender-, or age-specific strengths, weaknesses, or correlations between executive function and specific aspects of social function not identified in the current study that would further inform understanding of FASD and ASD (Burroughs et al., 2024; Hutchison et al., 2020). This may also be true for individuals with aggressive or uncontrollable behaviors or coping mechanisms that could not access participation in the current study. Further, diagnosed disability (applicable to both groups) and biological vs. adoptive relationship to the parent (imbalanced across groups in the current study) could influence caregivers' ratings of child behavior (Dinnebeil et al., 2013; Segal et al., 2015). Future research should consider how age, gender, ethnicity, IQ, caregiver characteristics, and other factors impact executive and social abilities.

Finally, the current study utilized parent-report measures of executive and social function; however, other informants, such as teachers and speech-language pathologists, may provide distinct insight based on their training and environmental factors (Reetzke et al., 2021). Real differences in child behaviors at home compared to school settings would inform why parents and teachers report differences for children with ASD or NT development (Levinson et al., 2020). Similarly, for children with FASD or ASD, prior research has shown that direct assessment of executive function has the potential to diverge from parent-report (Bernes et al., 2021; Kenworthy et al., 2008; Mohamed et al., 2019). Therefore, more research should incorporate both direct assessments and informant reports in understanding behavioral profiles and associations, with special consideration of intersectionality of diverse identities and supports that would contribute to wellbeing in these children.

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Table 1. Participant Demographics

	FASD (*n* = 23)	ASD (*n* = *18*)
Mean Age in Years (SD)	6.98 (1.62)	7.91 (1.89)
Male	13	14
Hispanic or Latino	4	1
Race		
American Indian or Alaskan Native	3	1
Asian	0	5
African American or Black	2	2
White	21	18
Native Hawaiian or Other Pacific Islander	1	0
First Parent/Guardian Education		
Some College or Technical School or Lower	8	3
Graduated College or Technical School or Higher	15	15
Second Parent/Guardian Education		
Some College or Technical School or Lower	7	2
Graduated College or Technical School or Higher	13	14
N/A or Prefer not to Answer	3	2

Note. The caregiver of 3 participants with FASD and 5 participants with ASD selected two races for the participant. Ethnicity was not reported by 3 participants with FASD.

Table 2. BRIEF, BRIEF-2, and BRIEF-P (Gioia et al., 2003; Gioia et al, 2000) Scale and Index Comparison

	BRIEF	BRIEF-2	BRIEF-P
Scales			
Inhibit	X	X	X
Shift	X	X	X
Emotional Control	X	X	X
Working Memory	X	X	X
Plan/Organize	X	X	X
Initiate	X	X	
Organization of Materials	X	X	
Monitor	X		
Task-Monitoring		X	
Self-Monitor		X	
Indices			
Global Executive Component (GEC)	X	X	X
Behavioral Regulation Index (BRI)	X	X	
Metacognition Index (MI)	X		
Emotional Regulation Index (ERI)		X	
Cognitive Regulation Index (CRI)		X	
Inhibitory Self-Control (ISC)			X
Flexibility Index (FI)			X
Emergent Metacognition (EM)			X

Note. Shaded cells represent shared scales and indices included in the current analyses.

Table 3. Everyday Executive Function as Estimated by BRIEF T-Scores

	FASD (*n* = 23)			ASD (*n* = 18)			
	M	*SD*	Range	*M*	*SD*	Range	Cohen's *d* Between Groups
GEC Index	73.61*	11.04	50 - 96	69.56*	9.08	50 – 81	.39
Subscale T-Scores							
Inhibit	69.83	12.29	47 - 90	66.00	10.78	48 - 83	.33
Shift	66.39	11.40	43 - 87	67.72	11.27	43 - 88	.12
Emotional Control	65.04	14.66	35 - 86	62.94	7.78	46 - 76	.17
Working Memory†	73.87*	10.61	53 - 94	65.28	8.16	52 - 81	.89
Plan/Organize	71.47*	9.78	54 - 90	66.33	9.66	48 - 80	.53

Note. The values shown are T-Scores combined across versions of the BREIF (BRIEF, BRIEF-P, and BRIEF-2) and thus are limited to their overlapping subscales. GEC = Global Executive Composite cumulative index.

*Indicates the group mean statistically exceeded the cut-off for clinical significance of 65.

†Indicates that the two groups differed statistically for that subscale.

Figure 1

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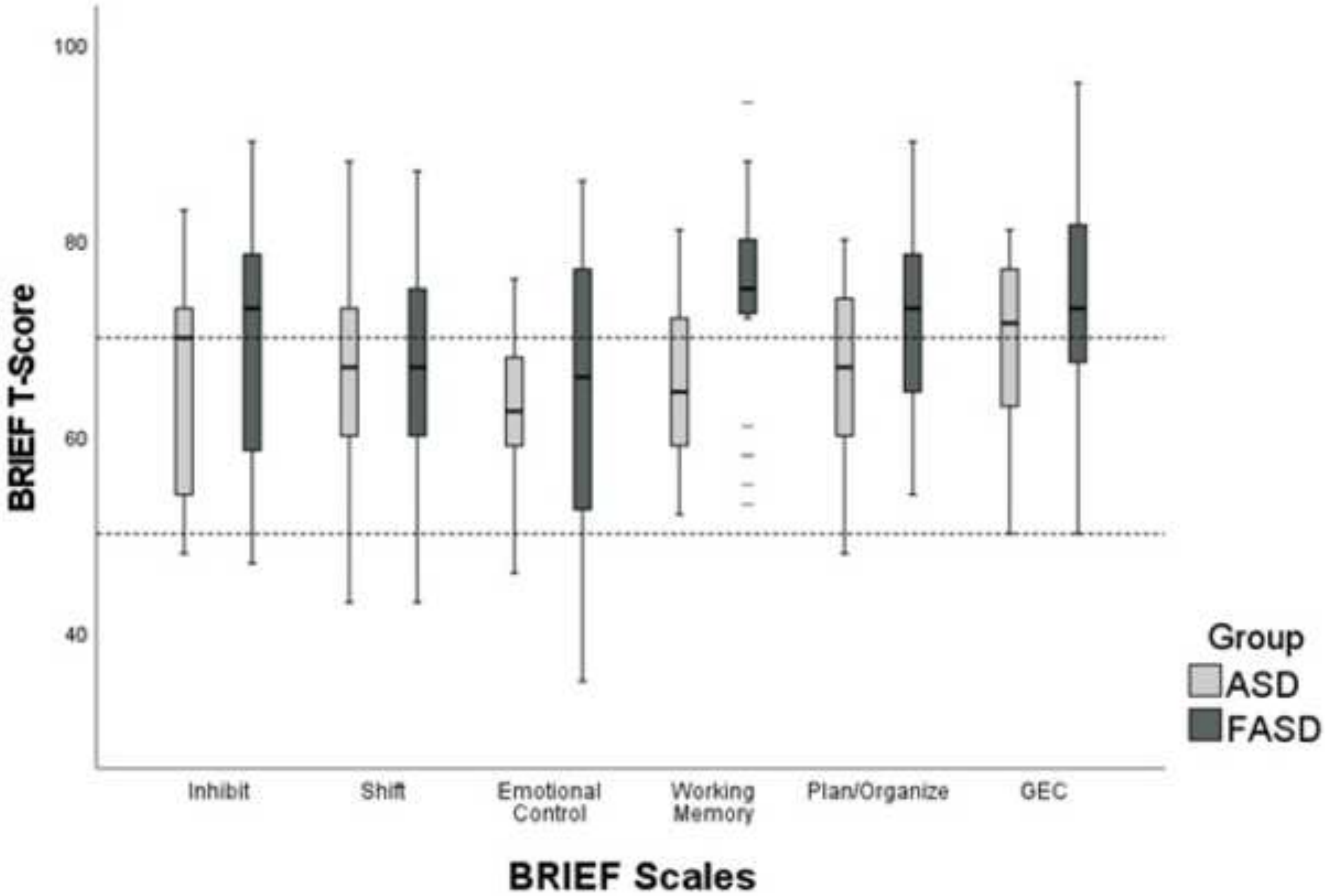

Figure 1. BRIEF Scales and GEC for participants with BRIEF, BRIEF-2, and BRIEF-P. Reference lines show T-scores of 50 and 65, which are the normative mean and clinically significant cut-off, respectively.

Figure 2

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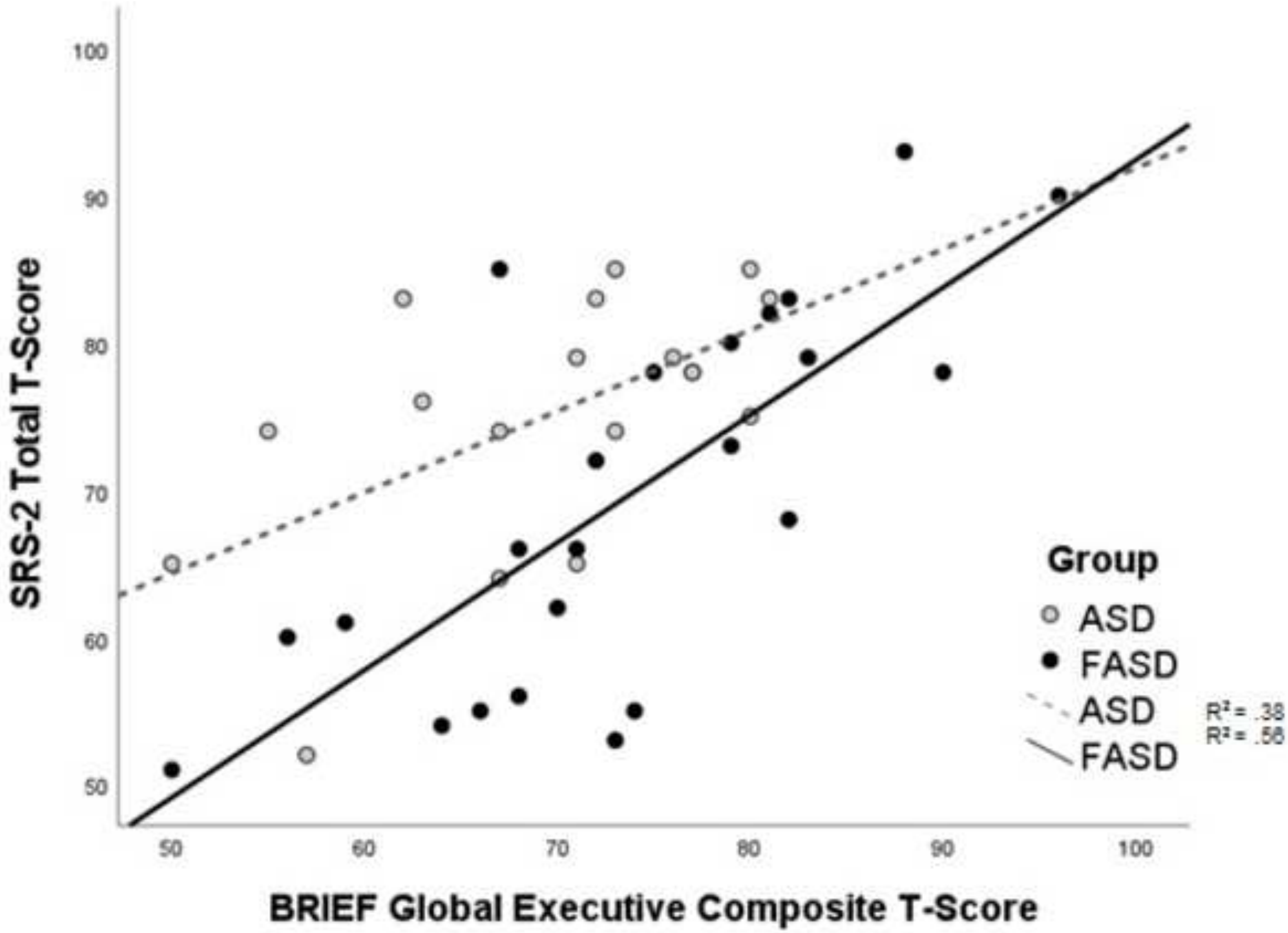

Figure 2. Scatterplot of BRIEF Composite based on BRIEF, BRIEF-2, or BRIEF-P with SRS-2 Total T-Score