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RESEARCH PAPER

EFFECTS OF DIFFICULTIES IN EXECUTIVE FUNCTIONS ON BEHAVIORAL AND ADAPTIVE PROBLEMS IN ITALIAN AUTISTIC PRESCHOOLERS

Roberta Igliozzi, Romina Cagiano, Marta Berni, Chiara Pecini, Valentina Viglione, Gabriele Masi, Filippo Muratori, Sara Calderoni, Raffaella Tancredi

Abstract

Objective: To describe the relationship between executive functions (EF) and symptom's severity, behavioral problems, and adaptive functioning in autistic preschoolers.

Method: Seventy-six autistic preschoolers (age-range: 37-72 months; SD: 8.67 months) without intellectual disability were assessed. Executive functions were measured by both performance-based (Battery for Assessment of Executive Functions -BAFE-) and indirect measures (Behaviour Rating Inventory of Executive Function – Preschool Version -BRIEF-P); adaptive skills were assessed using the Vineland Adaptive Behavior Scales Second Edition (VABS-II); ASD severity was evaluated through the ADOS-2 and the SCQ; the Child Behavior Checklist (CBCL ½-5) questionnaire was used to describe the emotional/behavioral profile.

Results: A considerable rate of autistic preschoolers showed weaknesses in one or more measures of EF, in particular in inhibition and working memory at both performance-based and parent report measures. EF measures explained a significant proportion of variance in the emotional/behavioral profile, and in the adaptive skills, particularly in the socialization domain. Specifically, the most relevant EF predictors are Inhibition, Emotional Control and Cognitive Flexibility subscales of the BRIEF-P.

Conclusions: Assessment of EF in autistic preschoolers may identify those children at higher risk for emotional/behavioral problems and adaptive difficulties. EF are a crucial target for early intervention in preschoolers with autism with the potential to improve child outcomes.

Key words: executive functions, autism spectrum disorder, adaptive behavior, ASD symptoms, behavioral and emotional profile, preschoolers

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Autism Spectrum Disorders (ASD) are complex, heterogeneous neurodevelopmental conditions characterized by persistent difficulties in social communication skills and repetitive and stereotyped patterns of behavior (RRB) that cause clinically significant impairment in social, occupational or other important areas of functioning (American Psychiatric Association, 2013).

The most recent data on the prevalence of ASD in the United States record a national rate of 1 in 44 children with ASD in 8-year-olds, with a prevalence 4.2 times higher among boys than girls (Maenner et al., 2023). Specifically, in Italy, the prevalence of ASD in the 7- to 9-year-old age group is 1 in 87, with a male-to-female ratio of 5.2:1 (Narzisi et al., 2018).

As ASD prevalence is increasing over time (Zeidan et al., 2022), clinical research emphasized the priority of focusing on evidence-based interventions that can

have real and immediate effects on the current needs of autistic individuals and their families (Lord et al., 2022), including positive quality of life and good adaptive outcomes (Pugliese et al., 2014, 2016; Tomaszewski et al., 2020). In particular, among individuals with ASD having a full intellectual quotient (IQ) on average, there is a great variability in the developmental trajectories and outcomes.

In particular, Pickles et al. (2020) have highlighted that IQ may have a protective role against the poorest outcome, but it does not guarantee a good outcome for ASD adolescent and adult functioning since outcome heterogeneity could be explained by other variables related to child and family characteristics. In this framework, understanding the sources of variability in the outcomes could be essential to better identify the target of the treatment and to improve the quality of the results (Kenny et al., 2019; Pugliese et al., 2014).

Recent research suggests that among the individual variables executive functioning (EF) may have greater impact on the development of adaptive behavior skills than other factors such as IQ, sex, and ASD symptoms (Pugliese et al., 2014).

EF are a set of higher and goal-directed cognitive skills, aimed at solving problems and coordinating social behaviour (Best & Miller, 2010). Specifically, EF enable individuals to formulate, plan, and organise ideas, manage challenges and new situations, resisting temptations, and maintaining focus (Diamond, 2013). Prior work has demonstrated that EF play a significant role in different aspects of children development, predicting later outcomes such as academic achievement, adaptive skills, socio-emotional development and more in general the mental and physical health in both typical and atypical circumstances (Kroll et al., 2017; Laporta-Hoyos et al., 2017; Moffitt et al., 2011).

In 2000, Miyake et al. proposed a model that fractionated Executive Function (EF) into three partially independent, though interrelated components, namely inhibition to predominant responses, updating of information in working memory, and cognitive flexibility. With respect to inhibition, Miyake et al. (2000) focused mainly on the voluntary suppression of responses that have become automatic, dominant, and preponderant. The second process identified by Miyake et al. (2000) in the EF domain is the updating and monitoring of representations contained in working memory. The third and final component identified is called 'cognitive flexibility' or 'shifting'. This term refers to the ability to flexibly shift between multiple and different cognitive or behavioral trials, operations, and mental arrangements.

Executive functions are traditionally assessed through standardized psychometric tests that provide performance-based measures at highly structured tasks requiring specific EF processes (Pennington & Ozonoff, 1996). However, it has been suggested that real-life impairments are often not detected in performance-based assessments, as they neglect how a child performs in 'real' or everyday contexts (Toplak et al., 2013). For this reason, the importance of integrating performance-based assessment with information regarding the use of EF in driving child everyday behavior is currently emphasized (Gardiner & Iarocci, 2017; Souissi et al., 2022).

Executive behavior is usually assessed by surveys that can be self-reported or filled by adults belonging to the child's proximal context, such as parents and teachers (Gioia et al., 2000). As studies suggest that the measures derived from two assessment methods frequently do not correlate with each other (Biederman et al., 2008; Conklin et al., 2008; Nordvall et al., 2016), their combined use is strongly recommended in order to provide a comprehensive picture of the executive functioning. This aspect is particularly relevant for the clinical assessment of children with atypical development, in order to supply information of executive functioning and related behaviors from a multidimensional perspective (Chaytor et al., 2006).

Several impairments in EF are frequently recorded in ASD (Demetriou et al., 2019), but there is significant unclear information surrounding EF skills in the preschool age.

Crucially, the limited existing data suggest that also this population experiences EF difficulties (Garon et al., 2018; Pellicano et al., 2017).

Extensive variability exists in the literature: some studies showed that EF difficulties are in the clinical range on a parent-report measure (BRIEF-P) in a substantial rate of preschoolers with ASD (ranging from 43% to 67%) (McLean et al., 2014; Williams et al., 2014), and they are associated with lower daily-life competence like social and adaptive behaviors, academic skills and co-occurring mental health symptoms (Hill, 2004; Kenworthy et al., 2008; White et al., 2020). Conversely, a recent investigation demonstrated that early preschoolers in the ASD group had the fewest number of clinically significant index and scale scores on BRIEF-P compared to children with intellectual disability (ID) or autism/ID (McClain et al., 2022). Despite discrepant results, Kenny et al. (2019) suggest to extend EF interventions in ASD children into the preschool period because it may have the greatest chance of influencing a range of skills, among which play (Faja et al., 2016), school readiness (Pellicano et al., 2017), theory of mind (Pellicano, 2010), later behavior (Berger et al., 2003; Sparrow, 1984; Szatmari et al., 1989) and psychopathological aspects (Gardiner & Iarocci, 2017; Wallace et al., 2016). In line with previous studies, Terroux et al. (2024) highlighted that increasing difficulties in everyday EF, assessed through the BRIEF-P, were associated with lower levels of adaptive behavior skills and higher levels of symptomatology in preschool ASD children.

Several studies show that EF difficulties in individuals with ASD become more apparent in the everyday life situations compared to the structured clinical-laboratory setting (Blijd-Hoogewys et al., 2014; Chan et al., 2009; Granader et al., 2014; Rosenthal et al., 2013; Smithson et al., 2013). This finding may be partly ascribed to the difficulties of ASD children in facing the real-world expectations, which imply social interactions and context-dependent rules as compared to performance-based tasks that indeed tend to have socially neutral instructions and are performed individually (Kenworthy et al., 2008; van den Bergh et al., 2014). Accordingly, some investigations suggest that EF weakness in ASD are closely related to impairments in everyday social competence (Pellicano, 2010; Rosenthal et al., 2013; Vogan et al., 2018) and adaptive functioning (Pugliese et al., 2016). Although in typically developing populations and in several neurodevelopmental disorders, adaptive abilities are generally positively correlated with cognitive abilities (Sparrow, 1984), in ASD population adaptive abilities are reported to be significantly lower than cognitive abilities (McQuaid et al., 2021).

Furthermore, the discrepancy between cognitive ability and adaptive functioning is lower in ASD children with ID than in those without ID (Alvares et al., 2019; McQuaid et al., 2021), and persists from early childhood (Bradshaw et al., 2018) throughout development into adulthood, where ASD individuals

without ID demonstrate levels of independent living, employment and social connectedness well below what would be expected on the basis of their intellectual functioning (Hofvander et al., 2009).

Further studies of adaptive functioning in individuals with ASD without intellectual disabilities (ID) becomes critical because in recent years there has been a significant increase of this subgroup, which corresponds to about two- thirds of the population with ASD (Shenouda et al., 2023). Well-developed adaptive behavior skills are essential to independent functioning: in fact, they are critical for crucial outcomes in adolescence and adulthood such as employment, social engagement, and independent living (Howlin et al., 2013; Orsmond et al., 2013).

Regarding children and adolescents with ASD, studies in the scientific literature demonstrate the predictive value of executive functioning in relation to emotional/behavioral symptoms (Hollocks et al., 2014; Lawson et al., 2015); this evidence have also been confirmed in adult individuals with ASD (Wallace et al., 2016).

In a longitudinal study examining youth with ASD, Vogan and colleagues (2018) showed that parent-reported poorer ability to inhibit, set shift, and maintain emotional control predicted both internalizing (i.e. worry, anxiety, depression, and social withdrawal) and externalizing (i.e. hyperactivity, impulsivity, aggression, and rule violation) problems two years later; conversely, other EF skills (e.g., planning, organization, initiation, monitoring) were not predictive of later psychiatric symptoms. Underlying mechanisms in the development of internalizing and externalizing symptomatology may also be difficulties in emotional regulation (Mazefsky et al., 2013; Paulus et al., 2021), which is defined as the effort required to control or modify the intensity of the emotional reaction in order to achieve one's goal (Faraone et al., 2018). Of note, emotional regulation is closely related to executive functioning: in fact, in order to choose and implement adaptive emotional regulation strategies, individuals must control the strategy selection process and switch flexibly from one strategy to another. This level of processing involves working memory, cognitive flexibility, and planning (Bailey & Jones, 2019), even in children with ASD (Costescu et al., 2023).

A short-term longitudinal investigation on ASD preschoolers detected that stable impairments across two years in daily executive functioning evaluated through the BRIEF-P questionnaire, were associated with autism symptoms severity, especially in the social affect domain and emotional/behavioral problems (Davico et al., 2022)

Overall, results from the literature support the incremental benefits of EF assessment with the purpose of outlining the target of intervention from early ages in youth with ASD, with the final aim of reducing the risk of psychiatric comorbidities and to promote social competences.

In this contextual framework, this study aims to investigate already in preschool ASD children without intellectual disability the relationship between EF and crucial aspects of functioning (ASD symptomatology, adaptive behaviors, and psychopathological traits).

Based on the above-mentioned background, we hypothesized that: (i) preschoolers with ASD would present a weakness in basic EF measures, including inhibition, working memory and cognitive flexibility; (ii) EF measures would predict some characteristics of ASD symptomatology, adaptive behaviors and psychopathological traits of ASD preschoolers.

Methods

Procedure

This investigation involves children evaluated between February 2017 and December 2022 in a tertiary care University hospital in Italy, and whose aggregated data were analyzed. All participants and their parents or legal guardians gave written informed consent to the conduct of clinical care and data collection for research purposes.

Participants

A sample of 76 Italian preschoolers with ASD (mean age=57.75 months, SD=8.67 months; 63 males and 13 females) were consecutively recruited.

Inclusion criteria were as follows:

(a) age 37-72 months; (b) clinical diagnosis of ASD assigned by a multi-professional team according to the Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-5; American Psychiatric Association, 2013) criteria; (c) Full Scale IQ ≥ 70; verbal QI ≥ 70, measured by the Wechsler Preschool and Primary Scales of Intelligence-Third Edition (WPPSI-III; Wechsler, 2002) or by the Wechsler Preschool and Primary Scales of Intelligence-Fourth Edition (WPPSI-IV; Wechsler, 2012).

Exclusion criteria included:

(a) neurological syndromes or focal neurological signs; (b) significant sensory impairment (e.g., blindness, deafness); (c) comorbidity with ADHD, in order to exclude a frequent condition that might impact on the EF profile of pre-school children with ASD (Leitner, 2014); (d) epilepsy or paroxysmal electroencephalographic abnormalities.

The mean scores at the Block Design and Information subtests in addition to Full-Scale IQ (FSIQ) at the WPPSI-III or WPPSI-IV (Wechsler, 2002, 2012), and the Social Affect (AS), Restricted and Repetitive Behaviors (RRB) domains, and the Calibrated Severity Score (CSS) of the Autism Diagnostic Observation Schedule- Second Edition (ADOS-2; Lord et al., 2012) are reported in **table 1**.

Table 1. *Descriptive statistics of the sample of demographics and clinical characteristics*

Measure	M (SD)	Min	Max
Age (months)	57.75 (8.67)	37	72
WPPSI_Block Design (71)	11.31 (2.74)	5	19
WPPSI_Information (71)	9.31 (2.80)	2	16
WPPSI_Full Scale IQ (70) *	101.91 (14.10)	71	136
ADOS-2_Social Affect CSS (74)	5.19 (1.57)	2	10
ADOS-2_Restricted and Repetitive Behaviors CSS (74)	5.24 (2.03)	1	9
ADOS-2_Total score CSS (74)	5.11 (1.41)	1	10

Abbreviations: WPPSI, Wechsler Preschool and Primary Scale of Intelligence; ADOS-2, Autism Diagnostic Observation Schedule, Second edition.
*Total IQ could not be identified for some children because some subtests pertaining to it were missing.

Measures

The presence of ASD symptomatology was evaluated by a primary caregiver through the Social Communication Questionnaire (SCQ; Rutter et al.,

2003), a 40-item, parent-report screening measure to indicate whether behaviors have been present during the past three months. The SCQ Current form was used in the present study and the corresponding total score was interpreted with reference to a cut off of 15.

Executive function. The neuropsychological assessment of EFs was carried out using both performance-based and indirect measures. Regarding the performance-based EF measures, we used the Battery for Assessment of Executive Functions- BAFE (Valeri et al., 2015), an Italian neuropsychological battery for the EFs assessment of preschool children based on the fractionated construct of EF with partially dissociable Inhibition, Working Memory and Cognitive Flexibility components (Garon et al., 2008).

Specially, we selected Card Sort (Carlson & Moses, 2001; Zelazo et al., 2004) to evaluate Cognitive Flexibility; the Night and Day "Stroop-like day-night task" (Carlson, 2005; Gerstadt et al., 1994) to assess Inhibition and Spin the Pots (Diamond & Taylor, 1996; Hughes, 1998) to evaluate Working Memory.

Scores were transformed in percentiles according to the Italian normative data (CIT). Children who were not able to complete the test were assigned the percentile score of 0. The score obtained on the BAFE subtests was interpreted to be in the borderline area when it was between the 25th and 11th percentile and in the clinical area when it was less or equal than the 10th percentile. The indirect measurement of EF was carried out through the Behaviour Rating Inventory of Executive Function – Preschool Version - BRIEF-P (Gioia, 2003); it is a standardized rating scale designed to measure EFs in children 2–5.11 years old, and it was completed by the parents or caregivers. The BRIEF-P includes a series of 63 items regarding a child's behavior, each of which is rated on a three-point scale (1 = Never, 2 = Sometimes and 3 = Often), to assess how often each type of behavior has been a problem in the previous six months: higher scores indicate more severe problems. These 63 items divided across five clinical scales (Inhibition, Working Memory, Shift, Emotional Control, Plan/Organize), which together give rise to three index scales: Inhibitory Self-Control (ISCI = Inhibit + Emotional Control), Flexibility (FI = Shift + Emotional Control) and Emergent Metacognition (EMI = Working Memory + Plan/Organize). A composite score is obtained as well, called the Global Executive Composite score (GEC). BRIEF-P scores were converted into standardized T-scores (M = 50, SD = 10). T-scores between 60 and 64 are in the borderline range, whereas T-scores ≥ 65 converge in the clinical range. All BRIEF-P scales and global score of BRIEF-P GEC were used.

Adaptive behavior. Vineland Adaptive Behavior Scales Second Edition: Parent/Caregiver Rating Form (Vineland-II; Sparrow et al., 2005) is a standardized, semi-structured interview administered by an examiner with parents/caregivers.

It assesses adaptive ability across four domains: Communication (sub-domains of receptive, expressive, and written), Daily Living Skills (subdomains of personal, domestic and community), Socialization (subdomains of interpersonal relationships, play and leisure time and coping skills) and Motor Skills (gross and fine).

In particular, communication, socialization, and daily living adaptive skills assess each developmental step from 0 to 90 years old and motor adaptive skills from 0 to 7 years old.

Each domain standard score and Adaptive Behavior Composite standard score have a mean of 100 and standard deviation of 15. The VABS has demonstrated strong reliability and validity (Sparrow et al., 2005). The scores obtained on the VABS-II scales were considered in the borderline area (between 70 and 84) and in the clinical range (below 70).

In the present study, we used the scores obtained for all domains of the Italian adaptation of the Vineland-II (Balboni et al., 2016) that has also been used previously in studies of preschoolers with ASD (Balboni et al., 2021).

Emotional and Behavioral Functioning. The Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2000) is an informant report questionnaire that evaluates behavior and emotional symptoms during the past six months for children between 1½ and 5-year-old.

The questionnaire is composed of 100 items resulting in 12 scales: seven Syndrome Scale (Emotionally Reactive, Anxious/Depressed, Somatic Complaints, Withdrawn, Sleep Problems, Attention Problems, Aggressive Behavior) and five DSM-Oriented Scales (Depressive Problems, Anxiety Problems, Pervasive Developmental Disorder Problems, Attention Deficit/Hyperactivity Problems, Oppositional Defiant Problems). Furthermore, internalizing, externalizing and total problem scores can be obtained. Through the analysis of the subscales of the questionnaire, it is also possible to obtain the CBCL AAA Profile that is computed by the sum of the Attention, Aggression and Anxious/Depressed CBCL T-scores (Davico et al., 2022). A condition of Severe Dysregulation is indicated by a clinical cut-off of the sum of these T scores higher than 210, while a condition of Deficient Emotional Self-Regulation (DESR) is indicated by a total score above 180.

Based on the CBCL normative data, for Internalizing, Externalizing and Total scale, a T-score ≤ 59 indicates non-clinical symptoms, a T-score ranging from 60 to 64 suggests that the child is at risk for problem behaviors, and a T-score ≥ 65 indicates clinical symptoms; while for other scales a T-score ≤ 64 indicates non-clinical symptoms; a T-score between 65 and 69 indicates difficulties that are considered significant but not clinic; and a T-score ≥ 70 indicates clinical symptoms.

For the purpose of the present study, given the size of the sample, the scales used were Internalizing, Externalizing, Total, Withdrawn, Pervasive Developmental Disorder Problems (PDP), Emotionally Reactive Attention and CBCL AAA score.

Statistical analysis

All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS version 28.0.1.0).

Preliminary analyses were conducted to examine the distribution of the variables as well as their fit to the normal distribution curve, by calculating skewness and kurtosis.

Descriptive and frequency analyses were conducted on the standardized scores to provide the central tendency values and the percentage of subjects falling within the borderline or clinical range for each dependent variable. Considering the outcome measures, missing data ranged between 2 and 14; missing data have not been interpolated.

Pearson's correlations were also conducted between EF parent rating and EF performance-based measures in order to investigate whether there was a significant correlation between them.

Pearson's correlations analyses were conducted to examine the relationship between EF and adaptive

behavior, emotional and behavioral functioning, and ASD symptoms on the following measures: BRIEF-P scales, BAFE subtests scores (Card sort, Stroop-like day-night task and Spin the Pots), VABS II indices, CBCL 1½-5 scales and SCQ Current form score.

Multiple linear regression analyses were carried out to quantify the proportion of variance explained by performance-based and indirect EF measures (predictors: BRIEF-P GEC T-score, BAFE Card Sort, Stroop-like day night task and Spin the Pots percentile) on the following dependent variables: VABS II indices; CBCL 1½-5 scales and SCQ Current form score.

Multiple linear regression analyses were carried out to quantify the proportion of variance explained by different indirect EF measures (predictors were BRIEF-P subscales: Inhibition, Emotional Control, Flexibility, Working Memory, and Plan/Organize) on the following dependent variables: VABS II indices; CBCL 1½-5 scales and SCQ Current form score.

not reach the borderline or clinical cut-offs, 31.8% of the sample obtained a global score in the clinical or borderline area, with almost an equivalent distribution among the sub-scales.

At the BAFE subtests, the percentage of children falling in the clinical or borderline areas ranged between 35.3% and 56.7%, with the highest rate in the Stroop-like day-night task.

Correlation Analyses

As shown in **table 3**, correlations between parental ratings and performance-based measures of EF show significance only between the Card Sort test of the BAFE and the Working Memory scale, the EMI index, and the GEC score of the BRIEF-P.

Results of the correlational analysis among EF measures (BRIEF-P scales and GEC; BAFE subtests)

Table 2. *Descriptive statistics (Mean, standard deviation, minimum and maximum) and frequency distribution of the scores falling in the borderline or clinical range at the measured variables*

Measure (n)	M (SD)	Min	Max	% clinical range	% borderline area	Median	Interquartile range
SCQ Current form (62)	8.44 (5.45)	0	22	12.9%	-	-	-
VABS_Communication QI (74)	83.42 (15.24)	49	112	14.9%	31.1%	-	-
VABS_ Daily Living Skills QI (73)	89.18 (14.06)	60	130	12.3%	19.1%	-	-
VABS_ Socialization QI (73)	90.03 (15.67)	55	115	13.7%	20.5%	-	-
VABS_ Motor Skills QI (71)	86.31 (14.86)	50	117	15.5%	26.8%	-	-
VABS_ Adaptive Behavior Composite QI (72)	85.06 (13.98)	50	112	18.1%	25.0%	-	-
CBCL_Internalizing (72)	56.65 (10.36)	33	78	16.7%	23.6%	-	-
CBCL_Externalizing (72)	54.44 (10.41)	32	77	12.5%	13.9%	-	-
CBCL_Total (72)	55.40 (10.32)	32	78	12.5%	18%	-	-
CBCL_Emotional Reactivity (72)	57.01 (8.71)	41	87	8.3%	11.1%	-	-
CBCL_Withdrawan (72)	61.35 (8.76)	50	82	15.3%	6.9%	-	-
CBCL_ PDP (72)	63.18 (9.93)	50	84	23.6%	4.2%	-	-
CBCL_AAA (72)	171.90 (17.03)	150	217	1.4%	25.0%	-	-
BRIEF-P_Inhibition (69)	59.16 (13.29)	39	94	23.2%	13.1%	-	-
BRIEF-P_Flexibility (69)	54.88 (14.19)	39	95	20.3%	2.9%	-	-
BRIEF-P_Emotional Control (69)	53.94 (11.53)	38	82	14.5%	13.1%	-	-
BRIEF-P_Working Memory (69)	57.10 (8.53)	41	78	14.5%	17.4%	-	-
BRIEF_Plan/Organize (69)	53.99 (9.58)	36	77	10.1%	4.3%	-	-
BRIEF-P_GEC (69)	57.86 (11.13)	40	86	24.6%	7.2%	-	-
BAFE_Card Sort (68)	-	0	99	30.9%	4.4%	99	89.5
BAFE_ Stroop-like day night task (67)	-	0	99	50.7%	6.0%	10	99
BAFE_ Spin the Pots (68)	-	0	88	16.2%	30.9%	31	29.25

Results

Descriptive Analyses

All variables were normally distributed (skewness < 2; kurtosis < 2).

As shown in **table 2**, a high percentage of children (between: 31.4% and 46.0%) fell in the clinical or borderline range across the VABS indexes, although with higher values in the border than in the clinical range.

At the CBCL scales, the percentage of children falling in the clinical or borderline scores ranged between 19.4% and 40.3%.

For what regards the EF measures, at the BRIEF-P, although the mean values obtained by the sample did

and VABS II indices, SCQ score and CBCL 1½-5 scales were reported in **table 4**.

BAFE Card Sort was significantly related to VABS II domains of Communication, Socialization, Motor Skills and Adaptive Behavior Composite QI.

BAFE Spin the Pots was significantly related to VABS II domains of Communication.

BRIEF-P Inhibition was significantly related to SCQ, VABS II Socialization, and all scales of CBCL considered included CBCL AAA score.

BRIEF-P Shift was significantly related to SCQ, VABS II Socialization, VABS II Adaptive Behavior Composite QI, and all scales of CBCL considered included CBCL AAA score.

BRIEF-P Emotion Control was significantly related to SCQ, VABS II Socialization, and all scales of CBCL

Table 3. *Results of the correlation analysis between parental ratings and performance-based measures of EF*

Measure	BRIEF-P Inhibition	BRIEF-P Flexibility	BRIEF-P Emotional Control	BRIEF-P Working Memory	BRIEF-P Plan/ Organize	BRIEF-P ISCI	BRIEF-P FI	BRIEF-P EMI	BRIEF-P GEC
BAFE_Card Sort	-0,196	0,035	-0,106	-0,274*	-0,203	-0,167	-0,062	-0,264*	-0,214*
BAFE_ Stroop-like day night task	-0,101	-0,054	-0,092	-0,127	0,124	-0,094	-0,100	-0,031	-0,081
BAFE_ Spin the Pots	-0,113	0,036	-0,026	-0,065	-0,167	-0,087	-0,029	-0,108	-0,076

Legend: * p < 0.05.

Table 4. *Results of the correlation analysis between EF and the other variables*

Measure	BRIEF-P Inhibition	BRIEF-P Shift	BRIEF-P Emotional Control	BRIEF-P Working Memory	BRIEF-P Plan/Organize	BRIEF-P GEC	BAFE Card Sort	BAFE Stroop-like day night task	BAFE Spin the Pots
SCQ Current form	0.437**	0.467**	0.271*	0.326**	0.329**	0.521**	-0.183	-0.190	-0.003
VABS-II_Communication IQ	-0.088	-0.087	-0.128	-0.291**	-0.124	-0.201*	0.275*	0.162	0.243*
VABS-II_Daily Living Skills IQ	-0.161	-0.159	-0.156	-0.282*	-0.232*	-0.234*	-0.045	0.059	0.045
VABS-II_Socialization IQ	-0.344**	-0.390**	-0.260*	-0.366**	-0.293**	-0.437**	0.220*	0.166	0.133
VABS-II_ Motor Skills IQ	-0.110	-0.061	-0.085	-0.340**	-0.103	-0.196	0.275*	0.187	0.147
VABS-II_ Adaptive Behavior Composite IQ	-0.186	-0.215*	-0.182	-0.356**	-0.174	-0.293**	0.226*	0.137	0.177
CBCL_Internalizing	0.524**	0.677**	0.639**	0.365**	0.290**	0.666**	-0.116	-0.192	0.003
CBCL_Externalizing	0.713**	0.475**	0.577**	0.338**	0.288*	0.653**	-0.179	-0.085	0.031
CBCL_Total	0.644**	0.604**	0.648**	0.430**	0.348**	0.718**	-0.192	-0.180	-0.017
CBCL_Emotional Reactivity	0.413**	0.509**	0.581**	0.252*	0.261*	0.535**	-0.167	-0.059	-0.008
CBCL_Withdrawan	0.434**	0.633**	0.327**	0.423**	0.355**	0.575**	-0.062	-0.090	-0.082
CBCL_ PDP	0.534**	0.698**	0.453**	0.442**	0.387**	0.669**	-0.142	-0.128	-0.067
CBCL_AAA	0.644**	0.524**	0.616**	0.305**	0.352**	0-650**	-0.149	-0.068	0.092

Notes: * p < 0.05; ** p < 0.01.

considered included CBCL AAA score.

BRIEF-P Working Memory was significantly related to SCQ, all domains of VABS II, and all CBCL scales considered included CBCL AAA score.

BRIEF-P Plan/Organize was significantly related to SCQ, VABS II domains of Daily Living Skills, Socialization and all scales of CBCL considered included CBCL AAA score.

BRIEF-P GEC was significantly related to SCQ, VABS II domains of Communication, Daily Living Skills, Socialization, VABS II Adaptive Behavior Composite QI and all CBCL scales considered included CBCL AAA score.

Regression Analyses

The multiple regression analysis on the ASD symptoms measures shows that 31% of variance of SCQ was significantly explained by EF measures (BRIEF-P GEC, BAFE Card Sort, Stroop-like day night task and Spin the Pots) and the significant predictor was BRIEF-P GEC.

The multiple regression analysis on adaptive behavior skills shows that 19,3% of variance of VABS II Socialization was significantly explained by EF measures (BRIEF-P GEC, BAFE Card Sort, Stroop-like day night task and Spin the Pots) and the significant

Figure 1. *Regression model with EF measures as predictors and ASD symptoms measure as outcome measure*

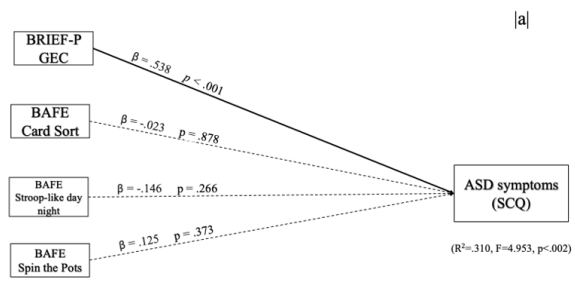
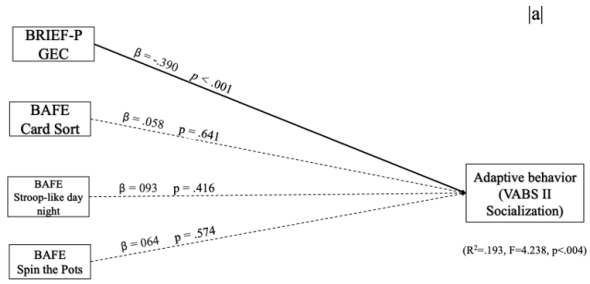


Figure 2. *Regression model with EF measures as predictors and adaptive behavior measure as outcome measure*



predictor was BRIEF-P GEC.

The multiple regression analysis on emotional and behavioral functioning with EF (BRIEF-P GEC, BAFE Card Sort, Stroop-like day night task and Spin the Pots) as predictors and CBCL scales as outcome variables shows that:

- 39.6% of variance of CBCL Total score was significantly explained and the significant predictor was BRIEF-P GEC;
- 33.3% of variance of CBCL Internalizing score was significantly explained and the significant predictor was BRIEF-P GEC;
- 32.4% of variance of CBCL Externalizing score was significantly explained and the significant predictor was BRIEF-P GEC;
- 25.5% of variance of CBCL Withdrawn score was significantly explained and the significant predictor was BRIEF-P GEC;
- 44.5% of variance of CBCL Pervasive Developmental Problems score was significantly explained and the significant predictor was BRIEF-P GEC;
- 28.5% of variance of CBCL Emotional Reactivity score was significantly explained and the significant predictor was BRIEF-P GEC.
- 46.4% of variance of CBCL AAA index was significantly explained and the significant predictor was BRIEF-P GEC.

Additional multiple regressions were conducted on precedent dependent variables and the various scales of the BRIEF-P (inhibition, emotional control, flexibility, working memory, and plan/organize).

The multiple regression analysis on the ASD symptoms measures at SCQ shows that the significant predictor was BRIEF-P flexibility.

The multiple regression analysis on emotional and behavioral functioning measure shows that:

- at CBCL Total score the significant predictor was BRIEF-P emotional control;
- at CBCL Internalizing score the significant predictors were BRIEF-P flexibility and BRIEF-P emotional control;
- at CBCL Externalizing the significant predictor was BRIEF-P inhibition;
- at CBCL Withdrawn the significant predictor was BRIEF-P flexibility;
- at CBCL Pervasive Developmental Problems the significant predictor was BRIEF-P flexibility ;
- at CBCL Emotional Reactivity the significant predictor was BRIEF-P emotional control.
- at CBCL AAA the significant predictor was BRIEF-P inhibition.

Discussion

The present study conducted on 76 Italian preschool children with ASD aimed to investigate the presence of weaknesses in basic EF measures, including inhibition, working memory and cognitive flexibility, in ASD preschoolers and the relationship between the assessment of EF with performance-based (i.e. clinician-administered tests) or indirect measures (i.e. parent-report) and the presence of psychopathological and adaptive difficulties at this age.

Regarding the first aim, descriptive analyses do not detect marked impairments in global EF, partially in agreement to recent research (McClain et al., 2022) in which ASD preschoolers without ID showed the smaller number of clinically significant scale scores on BRIEF-P as compared to peers both with ID and with ASD plus ID. However, descriptive analysis indicated that our sample exhibited significant variability: indeed, some weaknesses in EF were demonstrated in both performance-based and indirect measures.

Importantly, there is a considerable rate of children who showed vulnerabilities in executive functioning falling into the borderline area, or even difficulties falling into the clinical range, and this variability is in line with the considerable heterogeneity in the presentation of EF skills within this diagnostic group (Dajani et al., 2016). Thus, addressing heterogeneity is especially important since EF alterations in ASD children can vary from marked deficits to mild alterations that can still have an impact on daily functioning. For this reason, in both research and clinical practice it is important to quantify any EF difficulties in ASD children by combining direct and indirect measures to gain a more nuanced understanding (Teivaanmäki et al., 2020).

In line with the second aim of the current study, to better understand how executive functioning impacts on different clinical characteristics of preschool ASD children, the current study examined whether performance-based and indirect measures of EF were related to measures of symptomatic, adaptive, and emotional-behavioral aspects.

The results indicated that the ecological evaluation of EF through the BRIEF-P was positively correlated with both communication skills/social functioning assessed through the SCQ questionnaire, and emotional-behavioral characteristics -including emotional regulation- evaluated using the CBCL.

As for adaptive abilities evaluated by the VABS II, the strongest positive correlations with EF emerged with the domain of socialization, in line to a previous study (Pugliese et al., 2014, 2016), while in the other domains (communication, daily living skills and motor skills) the correlations were not very strong, which is the reason why subsequently in linear regression

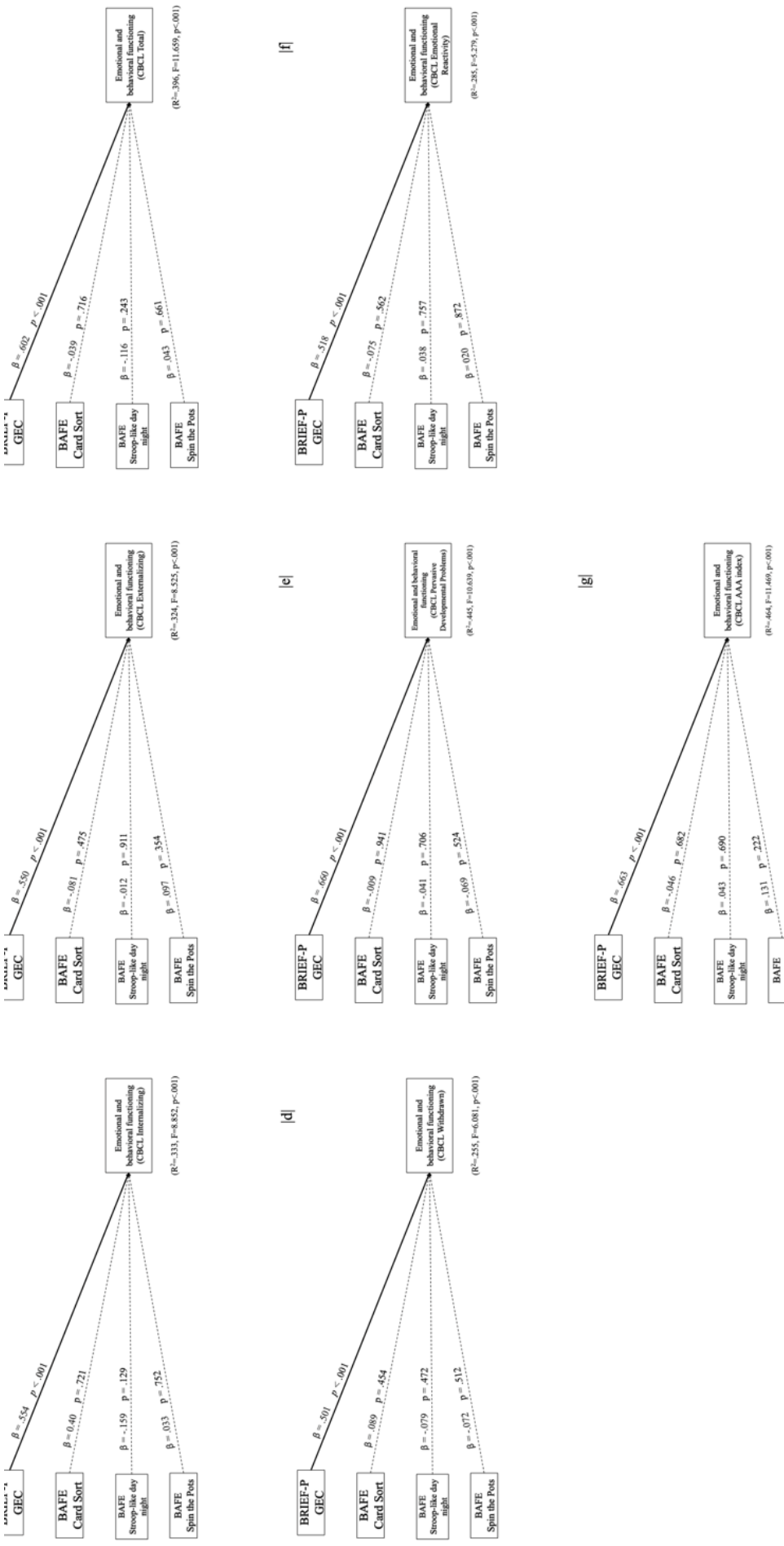
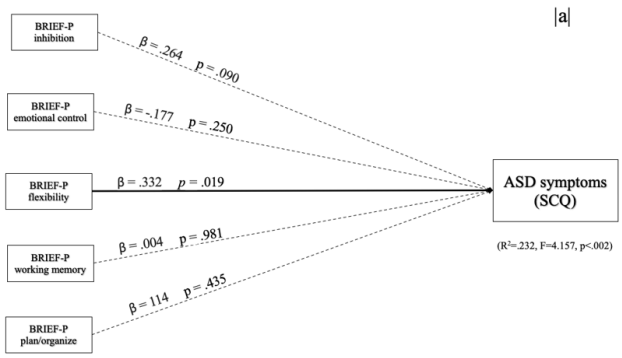


Figure 3. *Regressions model with EF measures as predictors and emotional and behavioral functioning as outcome measure*

Figure 4. *Regressions model with various scales of the BRIEF-P as predictors and ASD symptoms measure as outcome measure*



analyses they did not result in a significant model.

Based on these preliminary findings, our investigation deepens the analysis of the relationship between EF and various aspects of functioning through linear regression models: it emerges that parent-reported EF, assessed by the BRIEF-P questionnaire, explain a significant amount of variance. Of note, executive functioning was predictive of several abilities, including communication, social and interpersonal skills (SCQ's dimensions), the socialization domain of adaptive functioning, and emotional-behavioral characteristics, according to Gardiner and Iarocci (2017). In addition, it is important to point out that in our sample executive functioning explains also a large percentage of variance in emotional regulation as assessed by the CBCL AAA score, even though the mean score of the sample was not clearly in the clinical range, in line with recent findings (Davico et al., 2022).

Finally, a closer examination of the regressions between the various EF domains assessed by the BRIEF-P and different outcomes revealed that the significant predictors were the 'Shift', 'Inhibition' and 'Emotional Control' scales.

Specifically, Shift Scale predicted the score obtained on the SCQ questionnaire and Pervasive Developmental Problems, Internalizing and Withdrawal symptoms evaluated by the CBCL in preschool children with ASD. The BRIEF-P Shift scale explores indeed the ability to deal with new situations or activities, to adapt to change, to solve problems and to move from one topic to another, all skills needed to establish and maintain an interaction with others. For this reason, individuals with ASD are perceived as rigid and inflexible, and these characteristics affect their ability to socialize with others, preventing them from making new friends, participating in socializing activities. These results can be linked to a previous study (Kenworthy, Anthony et al., 2013), which underlines that social skills and adaptive behaviors in the classroom improves when interventions are focused on EF rather than on social skills.

Our results confirm previous studies (Gardiner & Iarocci, 2017; Vogan et al., 2018), in which everyday EF were predictive of several aspects of outcome in ASD, including social functioning, emotional (i.e, depression/ anxiety symptoms) and behavioral (i.e, oppositional and aggressive behavior) characteristics.

Secondly, in the current sample, 'inhibition' predicted externalizing symptoms: this finding agrees with previous studies on this topic (Buss et al., 2013; Kahle et al., 2017). Indeed, according to the meta-analysis of Schoemaker et al. (2013), out of all the aspects of executive function, inhibitory control was the one most closely linked to externalizing issues in preschoolers. In fact, externalizing problems are often considered to stem from extensive difficulties in self-regulation and inhibitory control (Eisenberg et al., 2001). Despite this, it has been unclear whether weak inhibitory control precedes or follows elevated externalizing problems in childhood, because very few studies showed an inverse relationship between inhibitory control and externalizing problems in preschool age (Hughes & Ensor, 2008; Olson et al., 2011; Utendale & Hastings, 2011). Also, the BRIEF-P Inhibition scale was found to be a significant predictor of the CBCL AAA score, confirming that children with inhibitory control difficulties may also be impaired in flexibly responding to the surrounding context and implementing adaptive emotional regulation responses, thus experiencing high emotional dysregulation (Mazefsky et al., 2013).

Finally, the emotional regulation scale predicted the total score obtained at the CBCL, internalizing problems, and emotional reactivity. This is in line with previous studies which showed that ASD children often have difficulties with emotional regulation that are associated with internalizing symptoms, such as anxiety and depression (Li et al., 2019; Rieffe et al., 2011, 2014)

Overall, these findings were consistent with previous research that suggested EF difficulties in everyday contexts reported by parents of children with ASD, demonstrating that these impairments (i.e, inhibition, shifting, emotional control) contribute to adaptive weaknesses in preschool and school-age children as well as to development of ASD comorbidity later in life (All et al., 2024).

Our results were also consistent with previous literature confirming a low correlation between EF assessed by rating scales and performance-based tests (Conklin et al., 2008; Toplak et al., 2013). Apparently, it might therefore seem psychometrically inappropriate to reify uncorrelated tests as measures of the same basic construct, but it is currently concluded that different types of measures capture different information: performance-based tests represent performance efficiency in an optimal context, while behavioral rating scales represent frequency of goal attainment in ecological context, such as at home and at school (Toplak et al., 2013). Additionally, since performance-based measures of EFs occur in highly structured contexts, they are most closely correlated to measures of academic achievement such as reading and

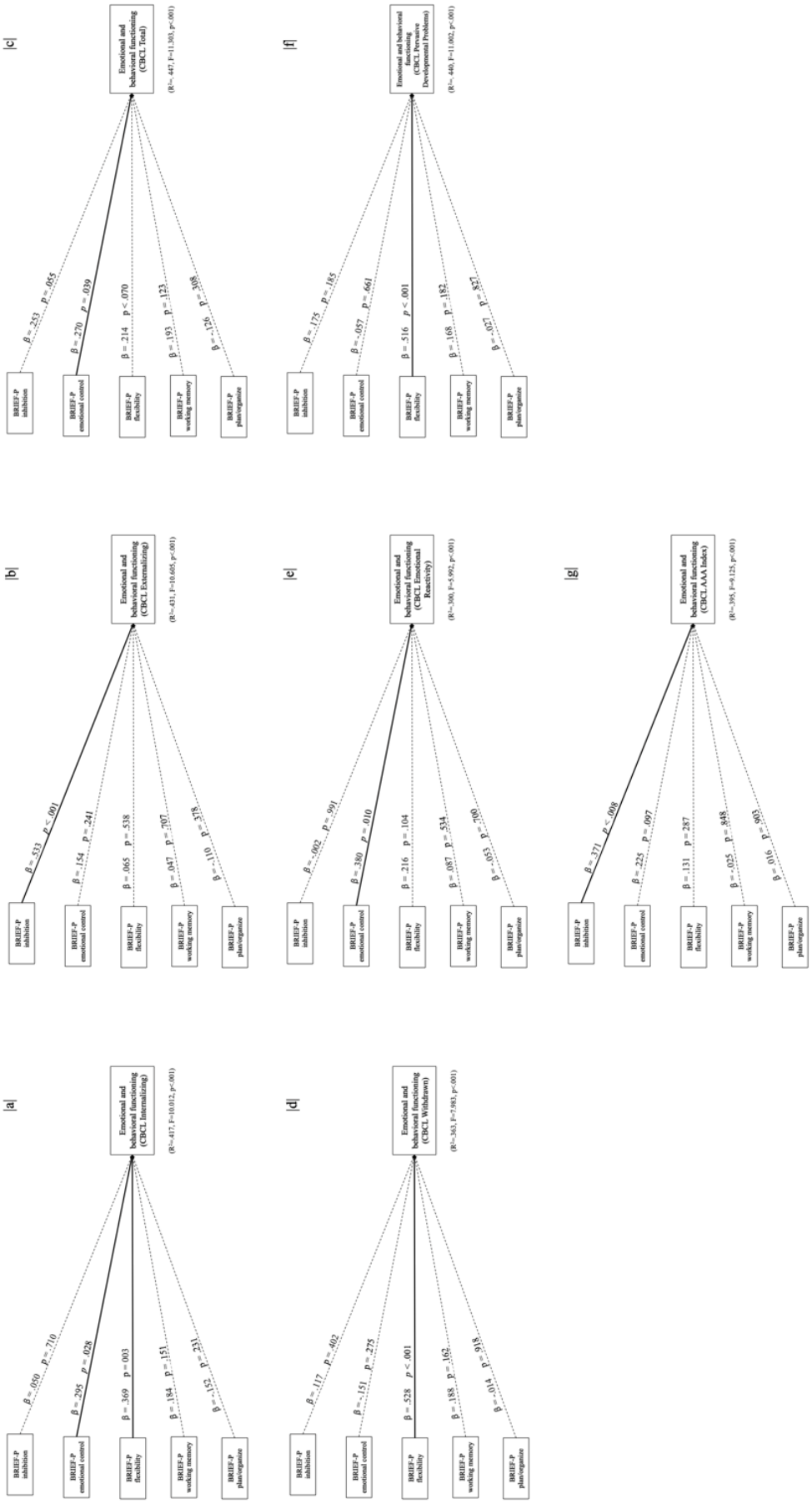


Figure 5. *Regressions model with various scales of the BRIEF-P as predictors and emotional and behavioral functioning measure as outcome measure*

mathematics (Ten Eycke & Dewey, 2015).

Given the significance that measures reported by parents take on, future research into executive dysfunction in preschoolers with ASD should consider a multi-method approach including not only parent but also teacher ratings as well as performance on neuropsychological tasks targeting EF skills (Powell et al., 2022).

Early and global definition of EF vulnerabilities or difficulties allows to initiate intervention and consequently to improve prognosis and to reduce long-term negative effects, such as greater EF deficits (Rosenthal et al., 2013), emotional and behavioral problems (Sikora et al., 2012), and the stalling of adaptive skills (Bal et al., 2015).

Limitations and future directions

This investigation has certain limitations and related suggestions for future research. First, the relatively small sample size, the lack of power analysis, and the retrospective nature of this single-center study make the results prone to bias: the findings obtained here must therefore be validated on a larger sample of ASD children. In particular, we used existing data that have been collected for clinical purposes at a tertiary care university hospital in Italy. For this reason, it was not possible to obtain further information (e.g. socio-demographic data), and we cannot assume that the children involved are representative of the general population. Second, the sample was composed of ASD participants without ID: this issue impacts on the generalizability of the results to preschoolers with both ASD and ID. Third, in line with the well-known male-skewed prevalence in ASD (Zeidan et al., 2022), particularly in ASD individuals without ID (Loomes et al., 2017), ASD females are poorly represented in our sample: this aspect did not allow us to conduct separate analyses for sex, and to investigate whether sex differences in EF exist, as previously detected in a sample of ASD individuals aged 5–19 years (Torske et al., 2023). Fourth, the lack of participants with other, partially overlapping neurodevelopmental disorders (e.g. ADHD, ID, Language Disorders, Specific Learning Disorders) did not enable us to evaluate the specificity of EF impairments in ASD children, as well as to delineate EF features shared with other NDDs.

Furthermore, although the multifactorial approach we used is strongly recommended, many studies in the literature have shown a poor correlation between performance-based and parent-report measures of executive functioning (for a meta-analysis, see Toplak et al., 2013). Therefore, given the multifaceted roles executive functioning skills play in various contexts of ASD daily lives, it would be useful for future studies to include proxy-report assessments of the child's executive functioning not only filled in by parents but also by teachers, as well as to implement innovative evaluation tools administered by clinicians. Moreover, since the sample analyzed is cross-sectional, it will be highly desirable that a longitudinal study can be planned to examine the relationship between EFs and social/adaptive functioning, psychopathological comorbidity, and academic achievements in subsequent stages of development. Finally, given the prevalence and impact of EF in autism, a research priority will be to conduct further rigorous trials (for a recent systematic review, see Pasqualotto et al., 2021) during the preschool years to test the effect of targeted EF interventions on core and associated ASD features as well as on global quality of life for ASD individuals and their families.

Conclusion

In conclusion, our study found that impairments in inhibition and working memory are frequently observed in youth with ASD, both through clinician-based and parent-report evaluations. Specifically, findings show that EF difficulties in Inhibition, Emotional Control and Cognitive Flexibility reported by parents are critical for emotional and behavioral functioning, as well as for the socialization competencies of the adaptive skills.

In addition to supporting the importance of EF assessment in ASD preschoolers, these results suggest that EF could be a potential intervention target, with the aim of preventing and mitigating comorbid psychopathology, and promoting social skills in children with ASD.

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