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ORIGINAL

Executive Functions Profiles in Preschool Children with Autism Spectrum Disorder

Perfiles de funciones ejecutivas en niños preescolares con trastorno del espectro autista

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Abstract

Objective: Executive functions (EFs) play a crucial role in overall human functioning. Children with Autism Spectrum Disorder (ASD) often have EFs deficits. The aim of this study was to examine EFs in preschool children with ASD.

Methods: The sample for this study comprised 32 children (27 boys, mean age 65.3 months, SD- 4.0 months) with ASD. The control group consisted of 32 children with neurotypical development (16 boys, mean age 64.3 months, SD- 5.1 months). EFs were assessed with *Behavior Rating Inventory of Executive Function- Preschool version*.

Results: The results of this study indicated that children with ASD have more heterogeneous EFs profiles than children with typical development. Children with ASD had substantially lower EFs than children with neurotypical development.

Conclusion: Identifying EFs deficits in children with ASD at an early age may help create programs to ameliorate these deficits. Psychologists and educators have many evidence-based interventions at their disposal to improve EFs in children with ASD.

Key words: Executive functions, Developmental domains, Autism Spectrum Disorder, Preschool children.

Resumen

Objetivo: Las funciones ejecutivas (FE) desempeñan un papel crucial en el funcionamiento humano general. Los niños con Trastorno del Espectro Autista (TEA) a menudo presentan déficits de FE. El objetivo de este estudio fue examinar las FE en niños preescolares con TEA.

Métodos: La muestra de este estudio estaba formada por 32 niños (27 varones, con una edad media de 65,3 meses, SD- 4,0 meses) con TEA. El grupo de control estaba formado por 32 niños con desarrollo neurotípico (16 niños, edad media de 64,3 meses, SD- 5,1 meses). Las FE se evaluaron con el Inventario de Calificación de la Conducta de la Función Ejecutiva - versión preescolar.

Resultados: Los resultados de este estudio indicaron que los niños con TEA tienen perfiles de FE más heterogéneos que los niños con desarrollo típico. Los niños con TEA tenían unas FE sustancialmente más bajas que los niños con desarrollo neurotípico.

Conclusión: Identificar los déficits de EFs en niños con TEA a una edad temprana puede ayudar a crear programas para mejorar estos déficits. Los psicólogos y educadores tienen muchas intervenciones basadas en la evidencia a su disposición para mejorar las FE en los niños con TEA.

Palabras clave: Funciones ejecutivas, Dominios del desarrollo, Trastorno del espectro autista, Niños en edad preescolar.

Introduction

Executive functions (EFs) refer to a set of higher-order cognitive processes involved in goal-directed behavior[1]. They are crucial for everyday functioning and are described as a "cognitive toolkit of success"[2]. Defining EFs is a difficult task given the different theoretical standpoints of the researchers and different taxonomies[3]. One of the definitions is that EFs are self-regulatory behaviors necessary for selecting and sustaining actions and guiding behaviors in the context of rules[4]. EFs are required for novel tasks and situations, problem solving, conscious choices, and overriding a strong internal or external pull[5].

EFs develop rapidly in early childhood and evidence clearly shows their importance for school readiness and academic success[6]. The development of EFs during childhood is of great importance for many later life outcomes, such as health and wealth[7]. However, despite being widely researched, there are still many questions related to EFs. One of the questions is related to the dimensionality of EFs, that is are EFs unidimensional or multidimensional construct, especially at a younger age[8]. Recent research suggests that EFs are multifaceted and that different EFs are correlated but separable[9]. Most researchers agree that EFs consist of a wide range of skills, including inhibition, mental flexibility, self-control, shifting of attention, initiation, impulsivity, working memory, and planning[10-12]. It is also important to note that some researchers view EFs as a unitary concept at preschool age[13] and that differentiation into separate skills begins at school age. Some authors have proposed that at preschool age it is possible to differentiate two EFs, namely working memory and inhibition, while the shifting, as the third EF, appears later, around 8 years of age[14].

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by deficits in the social-communication domain and a pattern of repetitive sensory-motor behaviors[15,16]. As the name implies, ASD is a highly heterogeneous disorder with symptoms ranging from mild to severe[17]. According to the 5th Edition of Diagnostic and Statistical Manual of Mental Disorders, ASD is categorized into three severity levels: Level 1 "Requiring support", Level 2 "Requiring substantial support" and Level 3 "Requiring very substantial support"[16]. ASD is a common neurodevelopmental disorder with a current prevalence rate of 2.79% in children aged 3 to 17 years[18]. Given the high prevalence rate, it is particularly important to identify ASD at an early age which, in turn, will lead to provisions of timely interventions and possibly improve the developmental trajectory of the disorder.

EFs have been widely studied in neurodiverse populations, including traumatic brain injury[19], schizophrenia[20], and depression[21]. In addition to this, EFs deficits were widely examined in developmental disorders, including Attention Deficit Hyperactivity Disorder, Autism Spectrum Disorder, and Intellectual Disability[22-24]. Much scientific attention has been directed to EFs development in individuals with ASD. It is widely recognized that children with ASD have deficits in EFs, which, consequentially, affect their adjustment and social skills[25]. Children with better EFs have more prosocial behavior according to their peer's rating[26]. EFs play a significant role in the adaptive behavior of children with ASD, thus affecting their overall outcomes[27]. More specifically, the research has shown that EFs affect three domains of adaptive behavior: socialization, communication and daily living[28]. Given the role EFs play in everyday functioning, a rationale for the increasing research in this area stems from the notion that EFs may improve everyday functioning. Many studies have found a relationship between social communication deficits and EFs in children with ASD[29,30]. However, the exact nature of this relationship is not clear. More specifically, it is unclear whether EFs deficits contribute to social and communication deficits or vice versa. Although there is strong evidence of EFs deficits present in individuals with ASD, findings for the preschool age have been inconsistent[31] and require further scientific investigation. Thus, given the wide implications of EFs deficits in ASD, we wanted to further examine the EFs profiles in this group of children. We also wanted to examine how EFs in children with ASD compare with the profiles of typical, age-matched, preschool children. The research questions we set to answer in this study are:

1. Do children with ASD have more heterogeneous scores across EFs domains than typically developing children?
2. Are there differences in EFs of children with ASD and typically developing children?
3. Is ASD severity level related to EFs?

Methods

Participants

The sample for this study consisted of 32 children with ASD (27 boys, mean age 65.3 months, SD- 4.0 months). Children with ASD were conveniently recruited from the Center for Early Intervention in Sarajevo that provides services to families and children with ASD. Children were referred to the Center after a formal diagnosis of ASD was made by a neuropediatrician at the local clinic. The inclusion criterion was that children had a formal diagnosis of ASD and were younger than 7 years. The control group consisted of 32 typically developing children (16 boys, mean age 64.3 months, SD- 5.1 months) who, according to their parent's statements, did not have developmental disability. Children with typical development were conveniently recruited from two local kindergartens. The inclusion criterion was that children did not have a diagnosis of developmental disability and were younger than 7 years. The mean age of children in the ASD group was not different from the mean age in the control group ($t(62)=0.93$; $p=.36$). However, the groups were not matched in relation to gender ($\chi^2 = 8.4$; $p < .01$), as there were significantly more boys than girls in ASD group, a ratio which corresponds to the actual population rates of ASD in relation to gender[32].

Procedure

Parents of children with ASD who attended the Center for Early Intervention were asked to participate in the study. Parents provided basic demographic information for their children and granted permission to early special educators to complete the Behavior Rating Inventory of Executive Functions- Preschool Edition (BRIEF-P; Gioia et al., 2003), and the Gilliam Autism Rating Scale (GARS; Gilliam, 2014) for this research. Total of 32 written consent forms were obtained and professionals (early childhood special educators) who have a wide experience working with children with ASD (ranging from 8-20 years) and have worked with these children for at least two months completed the scales. Parents of typically developing children attending two local kindergartens were asked to participate in the study. After the written parental consent forms were received, early childhood educators completed BRIEF-P for 32 children with neurotypical development. The approval for this study was granted by the Faculty of Educational Sciences, University of Sarajevo.

Instruments

The *Behavior Rating Inventory of Executive Function – Preschool Version* (BRIEF-P;[33]) is an ecologically valid measure of executive functions intended for children aged 2-5.11 years. BRIEF-P consists of five clinical scales: Inhibit, Shift, Emotional Control, Working Memory, and Plan/Organize. These five clinical scales yield three indexes: Inhibitory Self-Control Index, Flexibility index, and Emergent Metacognition Index. The overall composite index is the Global Executive Index. For this study, we only used the clinical scales of the BRIEF-P, which are continuous variables. According to the BRIEF manual Cronbach's alphas for the BRIEF-P clinical scales ranges from $r = .80$ to .90 for parent version and from .90 to .97 for the teacher version.

The BRIEF-P takes 10-15 minutes to complete. Raw scores were used in the analysis and lower score means better executive function. We used Bosnian translation of the BRIEF-P[34].

The *Gilliam Autism Rating Scale - Third Edition* (GARS-3,[35]) was developed to screen for ASD in individuals aged between 3 and 22 years. The GARS-3 consists of six clinical subscales: Restrictive/Repetitive Behaviors, Social Interaction, Social Communication, Emotional Responses, Cognitive Style, and Maladaptive Speech. These six clinical subscales are converted to Autism Index Composite score, a measure that was used in this study and indicates the severity of autism. Interclass correlation coefficients of the subscales are within the acceptable range ($r=.71$ - .85). Internal consistency, Cronbach's alpha is high and is above .90.

Statistical analysis

For the first research question, we we calculated Pearson's correlation coefficients between EFs (as measured by the BRIEF-P) for children with ASD and children with neurotypical development. These correlations helped us determine whether the EFs profiles of children with ASD are uneven. We next separately standardized the scores of BRIEF-P for each group of children and presented their distribution to examine whether children with ASD have more heterogeneous score distribution within the EFs domains than children with neurotypical development. For the second research question, we performed independent t-tests and presented Cohen's d effect size of mean differences in EFs between children with ASD and children with neurotypical development. For the third research question, we calculated the Pearson correlation coefficients between autism severity (as measured by the GARS) and EFs. We also regressed scores of EFs clinical scales to predict ASD severity. An alpha level of .05 was used as a benchmark for statistical significance. The statistical analysis was performed with the computer program SPSS v.27[36].

Results

Heterogeneity of EFs profiles

The first research question was to examine the heterogeneity in EFs domains in children with ASD and children with neurotypical development. We first present correlations between EFs domains in **table I**.

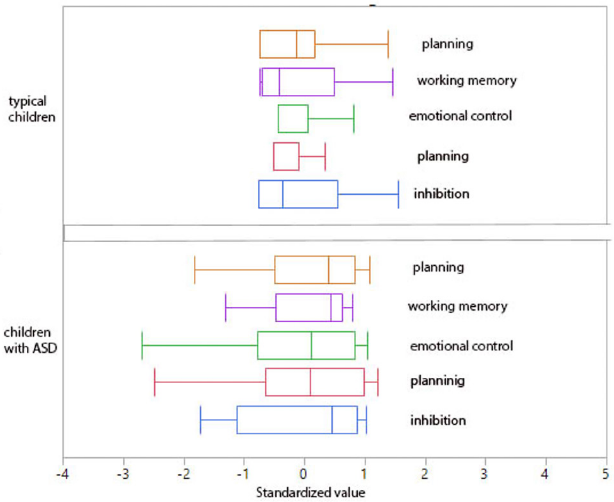
Table I: Correlations between EFs domains in children with ASD and children with neurotypical development.

Executive	Variables	1	2	3	4	5
functions	Inhibit	---	**.38**	**.76**	**.46**	.29
	Shift	**.58**	---	**.66**	**.48**	**.38**
	Emotional Control	**.67**	**.70**	---	.34	.12
	Working memory	**.36**	.13	.10	---	**.78**
	Planning	**.78**	**.48**	**.40**	**.59**	---

Note. Correlations below diagonal line are for children with ASD, and above the line are for neurotypically developing children. Correlations in bold font are statistically significant at $p<.05$ level.

As for the correlations within the domain of EF for children with ASD, only two of the correlations were not statistically significant, the one between working memory and shifting, and the one between *working memory* and *emotional control*. In typically developing children, three correlations within the domain of EF were not statistically significant, the correlation between *emotional control* and *working memory*, the correlation between *emotional control* and *planning*, and the correlation between *inhibition* and *planning*. We next inspected standardized values within EFs domains in children with ASD and children with neurotypical development to examine the spread of results. We first converted EFs scores into standardized z-scores values separately for children with ASD and separately for children with neurotypical development. In **figure 1**, we presented the interquartile range of these scores.

Figure 1: Interquartile range of standardized values of EF domains in children with ASD and typically developing children.



As can be seen from **figure 1**, EFs profiles seem to be more heterogeneous in children with ASD, especially in the domains of emotional control and planning.

Differences in EFs between children with ASD and children with typical development

The second research question was to examine the differences in the mean scores in EFs between children with ASD and children with neurotypical development. These results are shown in **table II**.

Table II: Group differences for EF domains and Developmental domains between children with ASD and typically developing children.

	Variable	Children with ASD		Typical children		t (62)*	Cohen'
		M	SD	M	SD		d
EF domains	Inhibit	41.7	6.2	19.9	5.2	15.3	3.8
	Shift	23.4	5.4	11.2	2.4	11.7	2.9
	Emotional Control	25.0	4.8	11.8	4.0	11.9	3.0
	Working memory	46.5	5.7	21.4	5.9	17.3	4.3
	Planning	26.2	4.5	12.4	3.3	14.0	3.5

Note.* all p's are <.001.

There were statistically significant and large differences in favor of children with neurotypical development on all EFs domains mean scores. All effect sizes were large according to criteria set by Cohen[37]. The largest differences in EFs were for the variables working memory and inhibition.

The relation between ASD severity and EFs

The last research question examined the correlation of the autism severity level as measured by the Gilliam Autism Rating Scale and EFs domains.
These results are shown in **table III**.

Table III: The Pearson correlation of the Gilliam Autism Rating Scale and EF domains and Developmental domains.

	Variable	Gilliam Autism Rating Scale	
		r	p
EF domains	Inhibit	.31	.10
	Shift	.35	**.04**
	Emotional Control	.29	.10
	Working memory	.33	.06
	Planning	.42	**.01**

Note. N=32. Values in bold are statistically significant at $p < .05$ level.

The severity of autism symptoms as measured by GARS-3 is significantly related to EFs domains of Shifting and Planning. The correlation between autism severity and working memory narrowly fell short of reaching statistical significance (p=.06). All other correlations were not statistically significant. On the other hand, results of the regression analysis of EFs domain predicting severity of ASD were not statistically significant ($F = 1.7$, $p = .17$) and are shown in **table IV**.

Table IV: Regression analysis of EFs domains predicting ASD severity.

EFs	Estimate	Std Beta	Std Error	t Ratio	p
Inhibition	-0.56	-0.26	0.75	-0.74	0.46
Shifting	0.43	0.18	0.61	0.70	0.49
Emotional control	0.48	0.18	0.77	0.62	0.54
Working memory	0.38	0.16	0.50	0.75	0.46
Planning	1.10	0.38	1.00	1.10	0.28

Note. N=32, $R^2 = .24$; $R^2_{(adjusted)} = .09$.

Discussion

The goal of the present study was to investigate EFs in preschool children with ASD. The first finding of this study was that preschool children with ASD had slightly more heterogeneous EFs profiles than children with neurotypical development. We mentioned earlier some reports that children with ASD have unbalanced EFs profiles, as indicated by strengths and weaknesses in various domains. This study showed that children with ASD had more variable EFs scores than children with neurotypical development on all EFs clinical subscales. Although children with ASD had significant EFs deficits on the group level, given the high variability in their scores, it is evident that some individuals with ASD had smaller or even non-existing EFs differences compared to children with neurotypical development. This again points to the importance of examining differences on the individual level and the group level.

Conversely, correlations of all EFs domain were slightly stronger in children with ASD. These findings contrasted with our expectations, as we hypothesized lower correlations between various EFs domains in children with ASD given the genetic and phenotypical heterogeneity of ASD[38]. However, it might be the case that EFs profiles in children with ASD become more uneven at a later chronological age. This explanation is related to the developmental trajectory of EFs. It might be the case that EFs, after starting as a unitary concept[13], remain more unitary/less specialized in children with ASD and differentiate more slowly in this group of children. This might explain the stronger relationships within EFs domains in preschool children with ASD. Similarly, it has been shown, that EF differentiation in children with intellectual disability begins at a preschool age[8]. Lastly, another explanation for these findings might be due to the assessment instruments that we used. Although ecologically valid, the BRIEF-P was not developed specifically for children with ASD and thus might not have the same measurement properties as in the group of children with neurotypical development. Understanding the individual differences of children with ASD might help practitioners design better treatment protocols[39].

We found large, statistically significant differences between children with ASD and children with neurotypical development in all EFs domains. The most significant differences were for the domain of working memory, followed by inhibition, planning, emotional control, and shifting. However, existing research does not point to the universal profile of weaknesses in EFs that we found in our study. For example, other studies have also found significant EFs differences in preschools with ASD and preschoolers with neurotypical development in the domain of shifting and inhibition but not on visual-spatial working memory tasks[40]. In a study that used the BRIEF-P for the assessment of EFs, significant differences between preschoolers with ASD and children with neurotypical development were found on the subscales: inhibition and shifting but not on the subscale working memory[41]. On the other hand, there are studies that point to working memory as the main EFs impairment in children with ASD[42]. A large meta-analysis of 28 studies involving 819 individuals with ASD has found significant impairments in working memory in this group compared to typically developing individuals[43]. The possible reason individuals with ASD have impairments in working memory might be that they are deficient in the use of verbal mediation strategies that helps to maintain goal-related information in the working memory[44]. As for the differences in the studies regarding the role of working memory deficit in ASD, the potential explanation for these differences might be related to factors such as autism phenotype, intelligence, and autism severity level which differ in participants across studies. The most likely explanation is that working memory is intact in some children with ASD, while in other children with ASD, working memory is much more impaired.

Autism severity was statistically significantly correlated with two executive functions: shifting and planning. The results in our study are in line with earlier studies that found people with autism to have particular deficits in shifting and planning[45]. We have now found these significant deficits to be present in preschool children with ASD as well. We also performed a regression analysis to determine the ASD severity based on EFs measures. The results indicated a non-significant model, which means the EFs domains were not significant predictors of ASD severity. However, this result should be interpreted cautiously as the sample size was rather small for regression models. Future studies should aim to validate or refute these findings with a larger, more diverse sample of preschool children with ASD.

Identification of EFs deficits in children at an early age will help create programs to ameliorate these deficits. Earlier research has shown that it is possible to improve EFs in preschool children[46]. This is especially relevant for children with ASD. Some reports showed that Early Intensive Behavioral Training could significantly improve EFs in children with ASD[38]. Behavioral intervention, through the use of positive reinforcement, has the potential to significantly improve working memory in children with ASD[42]. Programs that aim flexibility, goal-setting, and planning significantly improve EFs in children with ASD and improve social skills[47]. Besides these programs, it is also noteworthy to mention physical activities as an efficient way to improve EFs in children with ASD. Many studies have shown positive effects of martial arts[48] and exergaming[49] on EFs. In addition, physical activity has also been found to positively affect the academic achievements of children with ASD50. Educators have many evidence-based interventions at their disposal to improve EFs in children with ASD. Better understanding of EFs deficits in ASD and individual EFs will lead to better intervention programs at an early age.

The strength of this study is the employment of ecologically valid measure, the BRIEF-P, in the assessment of EFs in a group of preschool children with ASD. In addition, we also assessed the control group of children with neurotypical development, which in turn helped us identify which EFs are particularly vulnerable in children with ASD.

There are several limitations of this study that need to be noted. First of all, we used only one measure of EFs domains (BRIEF-P). It would be useful if we have used parental's reports as well, which would increase the reliability of the results. Second, it would also be useful if we have used some performance-based measures of EFs. Third, the sample size was relatively small, thus reducing the generalizability of the results. Conversely, the mean differences in EFs were exceptionally large, so there was a minimal risk of committing a type I error. Lastly, we did not have IQ scores of children, a measure which could be used as an important covariate in this study.

Conclusions

Children with Autism Spectrum Disorder had more heterogeneous EFs profiles than typically developing children. There is more interindividual variability in EFs a domain scores in children with ASD than in typically developing children. Preschool children with ASD had significantly lower EFs domains scores than children with typical development. Autism severity level had a significant effect on shifting and planning domains of EFs. However, EFs domain scores were not good predictors of ASD severity.

Conflict of interest

None

References

1. Tungate AS, Conners FA. Executive function in Down syndrome: A meta-analysis. *Research in Developmental Disabilities 2021*;108:103802. doi: https://doi.org/10.1016/j.ridd.2020.103802

2. Hendry A, Jones EJH, Charman T. Executive function in the first three years of life: Precursors, predictors and patterns. *Developmental Review* 2016;42:1-33. doi: https://doi.org/10.1016/j.dr.2016.06.005

3. Jurado MB, Rosselli M. The Elusive Nature of Executive Functions: A Review of our Current Understanding. *Neuropsychology Review* 2007;17(3):213-33. doi: 10.1007/s11065-007-9040-z

4. Mahone EM, Cirino PT, Cutting LE, Cerrone PM, Hagelthorn KM, Hiemenzet JR, et al. Validity of the behavior rating inventory of executive function in children with ADHD and/or Tourette syndrome*. *Archives of Clinical Neuropsychology* 2002;17(7):643-62. doi: 10.1093/arclin/17.7.643

5. Diamond A. The Early Development of Executive Functions. Lifespan cognition: Mechanisms of change. New York, NY, US: Oxford University Press 2006:70-95.

6. Blair C. Executive function and early childhood education. *Current Opinion in Behavioral Sciences* 2016;10:102-07. doi: https://doi.org/10.1016/j.cobeha.2016.05.009

7. Thompson A, Steinbeis N. Sensitive periods in executive function development. *Current Opinion in Behavioral Sciences* 2020;36:98-105. doi: https://doi.org/10.1016/j.cobeha.2020.08.001

8. Memisevic H, Malec D, Pasalic A. Factor structure of the BRIEF-P teacher version in a sample of Bosnian preschool children with intellectual disability. *Child Neuropsychology* 2021:1-12. doi: 10.1080/09297049.2021.2008338

9. Friedman NP, Miyake A, Young SE, DeFries JC, Corley RP, Hewitt JK. Individual differences in executive functions are almost entirely genetic in origin. *Journal of Experimental Psychology: General* 2008;137(2):201-25. doi: 10.1037/0096-3445.137.2.201

10. McLean RL, Johnson Harrison A, Zimak E, Joseph RM, Morrow EM. Executive Function in Probands With Autism With Average IQ and Their Unaffected First-Degree Relatives. *Journal of the American Academy of Child & Adolescent Psychiatry* 2014;53(9):1001-09. doi: https://doi.org/10.1016/j.jaac.2014.05.019

11. Garon N, Bryson SE, Smith IM. Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin* 2008;134(1):31-60. doi: 10.1037/0033-2909.134.1.31

12. Gioia GA, Isquith PK, Kenworthy L, Barton RM. Profiles of Everyday Executive Function in Acquired and Developmental Disorders. *Child Neuropsychology* 2002;8(2):121-37. doi: 10.1076/chin.8.2.121.8727

13. Wiebe SA, Sheffield T, Nelson JM, Clark CAC, Chevalier N, Espy KA. The structure of executive function in 3-year-olds. *Journal of Experimental Child Psychology* 2011;108(3):436-52. doi: https://doi.org/10.1016/j.jecp.2010.08.008

14. Lee K, Bull R, Ho RMH. Developmental Changes in Executive Functioning. *Child Development* 2013;84(6):1933-53. doi: https://doi.org/10.1111/cdev.12096

15. Lord C, Elsabbagh M, Baird G, Veenstra-Vanderweele J. Autism spectrum disorder. *The Lancet* 2018;392(10146):508-20. doi: https://doi.org/10.1016/S0140-6736(18)31129-2

16. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 5th ed. Washington, DC: APA, Washington, DC 2013.

17. Kantzer A-K, Fernell E, Gillberg C, Miniscalco C. Autism in community pre-schoolers: Developmental profiles. *Research in Developmental Disabilities* 2013;34(9):2900-08. doi: https://doi.org/10.1016/j.ridd.2013.06.016

18. Xu G, Strathearn L, Liu B, O'Brien M, Kopelman TG, Zhu J. Prevalence and Treatment Patterns of Autism Spectrum Disorder in the United States, 2016. *JAMA Pediatrics* 2019;173(2):153-59. doi: 10.1001/jamapediatrics.2018.4208

19. Slomine BS, Gerring JP, Grados MA, Vasa R, Brady KD, Christensen JR, et al. Performance on measures of 'executive function' following pediatric traumatic brain injury. *Brain Injury* 2002;16(9):759-72. doi: 10.1080/02699050210127286

20. Kluwe-Schiavon B, Sanvicente-Vieira B, Kristensen CH, Grassi-Oliveira R. Executive functions rehabilitation for schizophrenia: A critical systematic review. *Journal of Psychiatric Research* 2013;47(1):91-104. doi: https://doi.org/10.1016/j.jpsychires.2012.10.001

21. Han G, Helm J, Iucha C, Zahn-Waxler C, Hastings PD, Klimes-Dougan B. Are Executive Functioning Deficits Concurrently and Predictively Associated with Depressive and Anxiety Symptoms in Adolescents? *Journal of Clinical Child & Adolescent Psychology* 2016;45(1):44-58. doi: 10.1080/15374416.2015.1041592

22. Barkley RA, Murphy KR. The Nature of Executive Function (EF) Deficits in Daily Life Activities in Adults with ADHD and Their Relationship to Performance on EF Tests. *Journal of Psychopathology and Behavioral Assessment* 2011;33(2):137-58. doi: 10.1007/s10862-011-9217-x

23. Happé F, Booth R, Charlton R, Hughes C. Executive function deficits in autism spectrum disorders and attention-deficit/hyperactivity disorder: Examining profiles across domains and ages. *Brain and Cognition* 2006;61(1):25-39. doi: https://doi.org/10.1016/j.bandc.2006.03.004

24. Memisevic H, Sinanovic O. Executive function in children with intellectual disability – the effects of sex, level and aetiology of intellectual disability. *Journal of Intellectual Disability Research* 2014;58(9):830-37. doi: https://doi.org/10.1111/jir.12098

25. Reed T. Visual Perspective Taking as a Measure of Working Memory in Participants With Autism. *Journal of Developmental and Physical Disabilities* 2002;14(1):63-76. doi: 10.1023/A:1013515829985

26. Zorza JP, Marino J, Acosta Mesas A. Executive Functions as Predictors of School Performance and Social Relationships: Primary and Secondary School Students. *The Spanish Journal of Psychology* 2016;19:E23. doi: 10.1017/sjp.2016.23 [published Online First: 2016/05/12]

27. Pugliese CE, Anthony L, Strang JF, Dudley K, Wallace GL, Kenworthy L. Increasing Adaptive Behavior Skill Deficits From Childhood to Adolescence in Autism Spectrum Disorder: Role of Executive Function. *Journal of Autism and Developmental Disorders* 2015;45(6):1579-87. doi: 10.1007/s10803-014-2309-1

28. Kenny L, Cribb SJ, Pellicano E. Childhood Executive Function Predicts Later Autistic Features and Adaptive Behavior in Young Autistic People: a 12-Year Prospective Study. *Journal of Abnormal Child Psychology* 2019;47(6):1089-99. doi: 10.1007/s10802-018-0493-8

29. McEvoy RE, Rogers SJ, Pennington BF. Executive Function and Social Communication Deficits in Young Autistic Children. *Journal of Child Psychology and Psychiatry* 1993;34(4):563-78. doi: https://doi.org/10.1111/j.1469-7610.1993.tb01036.x

30. Pellicano E. The Development of Executive Function in Autism. *Autism Research and Treatment* 2012;2012:146132. doi: 10.1155/2012/146132

31. Garon N, Smith IM, Bryson SE. Early executive dysfunction in ASD: Simple versus complex skills. *Autism Research* 2018;11(2):318-30. doi: https://doi.org/10.1002/aur.1893

32. Nicholas JS, Charles JM, Carpenter LA, King LB, Jenner W, Spratt EG. Prevalence and Characteristics of Children With Autism-Spectrum Disorders. *Annals of Epidemiology* 2008;18(2):130-36. doi: https://doi.org/10.1016/j.annepidem.2007.10.013

33. Gioia GA, Espy KA, Isquith PK. Behavior Rating Inventory of Executive Function - Preschool Version. Odessa, FL: Psychological Assessment Resources: Odessa, FL: Psychological Assessment Resources 2003.

34. Dzambo I, Sporisevic L, Memisevic H. Executive Functions in Preschool Children Born Preterm in Canton Sarajevo, Bosnia and Herzegovina. *International Journal of Pediatrics* 2018;6(4):7443-50. doi: 10.22038/ijp.2018.29481.2584

35. Gilliam JE. Gilliam Autism Rating Scale. Austin, TX: PRO-ED: Austin, TX: PRO-ED 2014.

36. IBM SPSS Statistics for Windows, Version 27.0 [program]. Armonk, NY: Armonk, NY: IBM corp, 2020.

37. Cohen J. Statistical power analysis for the behavioral sciences: New York: Academic press 2013.

38. Skogli EW, Andersen PN, Isaksen J. An Exploratory Study of Executive Function Development in Children with Autism, after Receiving Early Intensive Behavioral Training. *Developmental Neurorehabilitation* 2020;23(7):439-47. doi: 10.1080/17518423.2020.1756499

39. Geurts H, Sinzig J, Booth R, Happe F. Neuropsychological heterogeneity in executive functioning in autism spectrum disorders. *International Journal of Developmental Disabilities* 2014;60(3):155-62. doi: 10.1179/2047387714Y.0000000047

40. Valeri G, Casula L, Napoli E, Stievano P, Trimarco B, Vicari S, et al. Executive Functions and Symptom Severity in an Italian Sample of Intellectually Able Preschoolers with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders* 2020;50(9):3207-15. doi: 10.1007/s10803-019-04102-0

41. Carotenuto M, Ruberto M, Fontana ML, Catania A, Misuraca E, Precenzano F, et al. Executive functioning in autism spectrum disorders: A case-control study in preschool children. *Current Pediatric Research* 2019;23:112-6.

42. Baltruschat L, Hasselhorn M, Tarbox J, Dixon DR, Najdowski AC, Mullins RD, et al. Addressing working memory in children with autism through behavioral intervention. *Research in Autism Spectrum Disorders* 2011;5(1):267-76. doi: https://doi.org/10.1016/j.rasd.2010.04.008

43. Wang Y, Zhang Y-b, Liu L-l, Cui J-f, Wang J, Shum DHK, et al. A Meta-Analysis of Working Memory Impairments in Autism Spectrum Disorders. *Neuropsychology Review* 2017;27(1):46-61. doi: 10.1007/s11065-016-9336-y

44. Joseph RM, Steele SD, Meyer E, Tager-Flusberg H. Self-ordered pointing in children with autism: failure to use verbal mediation in the service of working memory? *Neuropsychologia* 2005;43(10):1400-11. doi: https://doi.org/10.1016/j.neuropsychologia.2005.01.010

45. Blijd-Hoogewys EMA, Bezemer ML, van Geert PLC. Executive Functioning in Children with ASD: An Analysis of the BRIEF. *Journal of Autism and Developmental Disorders* 2014;44(12):3089-100. doi: 10.1007/s10803-014-2176-9

46. Volckaert AMS, Noël M-P. Training executive function in preschoolers reduce externalizing behaviors. *Trends in Neuroscience and Education* 2015;4(1):37-47. doi: https://doi.org/10.1016/j.tine.2015.02.001

47. Kenworthy L, Anthony LG, Naiman DQ, Cannon L, Wills MC, Luong-Tran C, et al. Randomized controlled effectiveness trial of executive function intervention for children on the autism spectrum. *Journal of Child Psychology and Psychiatry* 2014;55(4):374-83. doi: https://doi.org/10.1111/jcpp.12161

48. Phung JN, Goldberg WA. Promoting Executive Functioning in Children with Autism Spectrum Disorder Through Mixed Martial Arts Training. *Journal of Autism and Developmental Disorders* 2019;49(9):3669-84. doi: 10.1007/s10803-019-04072-3

49. Hilton CL, Cumpata K, Klohr C, Gaetke S, Artner A, Johnson H, et al. Effects of Exergaming on Executive Function and Motor Skills in Children With Autism Spectrum Disorder: A Pilot Study. *American Journal of Occupational Therapy* 2014;68(1):57-65. doi: 10.5014/ajot.2014.008664

50. Nakutin SN, Gutierrez G. Effect of Physical Activity on Academic Engagement and Executive Functioning in Children With ASD. *School Psychology Review* 2019;48(2):177-84. doi: 10.17105/SPR-2017-0124.V48-2