Journal of Systems and Integrative Neuroscience

Research Article ISSN: 2059-9781

The cognitive profile in Slovak children with autism spectrum disorders

Hana Celušáková*, Katarína Polónyiová and Daniela Ostatníková

Institute of Physiology, Faculty of Medicine, Comenius University, Sasinkova 2, 813 72 Bratislava, Slovakia

Abstract

This study aimed to identify strengths and weaknesses in a cognitive profile of children with Autism Spectrum Disorders (ASD) and to study relationship between the triad of impairments in ASD, delayed achievement of speech milestones and cognitive abilities. Our sample consisted of 30 children, male-to-female ratio 5:1, diagnosed with ASD using the Autism Diagnostic Interview - Revised and the Autism Diagnostic Observation Schedule. Results showed significant variations in their cognitive abilities as measured the Woodcock-Johnson International Editions. Cognitive efficiency, consisting of Processing speed and working memory, has been significantly reduced, yet individuals with ASD performed well on fluid intelligence, suggesting possible underestimation of their performance assessed with tests standardized for neurotypical population. We also identified three negative predictors of their overall IQ: inflexible adherence to specific non-functional routines or rituals, persistent preoccupation with parts of objects or non-functional elements of play materials and a delayed use of sentences.

Introduction

Autism spectrum disorders (ASD) are a group of neurodevelopmental disorders characterized by impairments in communication, reciprocal social interaction as well as restricted and repetitive behaviors or interests. ASD are often accompanied by delayed or impaired language development and cognitive deficits.

The upcoming International Classification of Diseases, 11th Revision [1] lists all Pervasive Developmental Disorders (PDD) within the category of Autism spectrum disorder, with 6 subtypes according to different levels of intellectual impairment and functional speech. This change directly requires evaluation of intellectual abilities, which will soon become a fundamental part of the diagnosis of ASD.

The average IQ in people with ASD is lower compared to general population, but the range seems to also be much wider, since the number of individuals with extreme IQ values is significantly larger in this group [2]. One third of children with ASD were classified as having intellectual disability (IQ ≤70), one quarter has an IQ in the borderline range (IQ 71–85), and about 40% to 45% of children have an IQ in the average range or higher [3,4]. Cognitive abilities in ASD seem to have uneven development expressed by significantly more intracognitive differences in their cognitive profile compared to general population. In the Wechsler Intelligence Scales, individuals with ASD showed significantly higher scores in Non-Verbal Performance Scale compared to their Verbal IQ. The Highest score was observed in WICS-IV subtests Block design (visual-spatial problem solving and mental rotation ability) and Matrix reasoning. On the other hand, the Comprehension subtest score, which requires understanding verbal language and social reasoning, was significantly lower. The studies also consistently show decreased Information processing, which includes Perceptual processing, Processing speed and Motor coordination [5-9].

The necessity to determine the cognitive abilities of individuals with ASD is often obstructed by a lack of clinical experience, recommended procedures and, especially in Slovakia, absence of appropriate diagnostic methods standardized for the Slovak population. Assessment of the child's developmental level or intellectual abilities is necessary in diagnostic process, too, because the requirements for communication and social skills of the child should also take into account his developmental level (mental age) and not just chronological age [10]. Most importantly, distinguishing the individual´s intellectual abilities and deficits is crucial for planning and implementing suitable interventions as well as selecting the appropriate form of education.

The present study

As previously mentioned, in Slovakia we have very little data on the intellectual abilities in autistic children. Professionals lack recommended procedures for effective assessment of their intellectual capacity and guidance how to incorporate the findings into effective intervention programs.

The aim of our study was to identify the cognitive profile in respect to strengths and weaknesses in children with autism spectrum disorder.

As previous research [5,6,8,9] suggests, we hypothesize that children with autism spectrum disorders differ from general public not only in the average IQ score, but more importantly in their broad cognitive abilities. Second important question is how are individual´s cognitive abilities connected to ASD symptoms and if some of the symptoms or delayed achievement of developmental milestones can serve as predictors of their future cognitive abilities.

Correspondence to: Hana Celušáková, Institute of Physiology, Faculty of Medicine, Comenius University in Bratislava, Sasinkova 2, 81372 Bratislava, Slovakia, Tel: +421 903 79 77 58; E-mail: celusakova1@uniba.sk; hana.celusak@gmail.com

Key words: *autism spectrum disorders, cognitive profile, speech milestones, predictors of IQ*

Received: October 28, 2020; **Accepted:** November 11, 2020; **Published:** November 16, 2020

Methods

Participants

Our sample consisted of children and adolescents with Autism spectrum disorders, diagnosed with ASD in The Academic Research Centre for Autism at the Institute of Physiology of The Faculty of Medicine, Comenius University in Bratislava between September 2016 and November 2018. The study included 30 children, 5 girls (16.7%) and 25 boys (83.3%). Boys were significantly predominant, male to female ratio 1:5, which follows the gender ratio in ASD as reported by the research studies [4]. The average age of our participants was 9.11 years (± 2.51 SD). Seven participants (23.3%) attended pre-school, two of them had their school attendance postponed, and twenty-three attended elementary school (76.6%).

All participants were diagnosed with an idiopathic autism spectrum disorder and met the inclusive age criteria of 5 to 18 years of age, the lower limit determined by the age limit for the administration of the Woodcock-Johnson International Editions II (WJ IE II). Children with autism as a part of the specific syndrome or children with other severe comorbidities (severe physical disability, suspected development of a psychotic illness, selective mutism, etc.) were excluded. Due to the need to understand verbal instructions in the test battery of cognitive abilities, only individuals with sufficiently developed speech (able to pass the ADOS-2 examination in Module 3, with the exception of 3 individuals from the Module 2) were included in the research study.

Materials/measures

The Woodcock-Johnson international editions II: The intellectual abilities were assessed by the WJ IE II, which measures current overall cognitive performance, with three subscales / factors: Verbal ability, Thinking ability, and Cognitive efficiency. The cognitive profile is formed by performance in seven subtests which represent an individual's broad abilities due to Cattell–Horn–Carroll (CHC) theory: Verbal Ability (Comprehension-Knowledge - Gc), Memory for Names (Long-Term Retrieval - Glr), Spatial Relations (Visual-Spatial Thinking - Gv), Sound Patterns (Auditory Processing - Ga), Concept Formation (Fluid Reasoning - Gf), Visual Matching (Processing Speed - Gs), Numbers Reversed (Short-Term Memory - Gsm) and Quantitative Concepts (Fluid Reasoning - Gf).

Overview of the procedure

Diagnosis confirmation: We assessed the presence of symptoms characteristic to ASD in the child's developmental history using the Autism Diagnostic Interview – Revised (ADI-R), which was carried out with the child's parent or primary caregiver. The current level of psychopathology was assessed using The Autism Diagnostic Observation Schedule (ADOS-2), a series of structured and semi-structured tasks which monitor a social interaction between the examiner and the person under assessment. ADOS-2 and ADI-R are the most reliable diagnostic tests for ASD and are considered the "gold standard" assessment measures. Two experts independently performing ADI-R and ADOS-2 had to come to an agreement to confirm the diagnosis.

Achievement of speech milestones: The 9th question of ADI-R examines the age when the child´s first words appeared. The discovery of first words is defined as a meaningful and regular use of more than 5 words (excluding calling a mother or a father) in order to communicate. When the milestone is reached later than by 24 months of age it is considered a significant delay according to ADI-R. Question 10 asks for the age when the first sentences appeared. The first sentences are defined as at least three-words of which there is at least one verb. It is a significant delay when a child has started using the first sentences later than by the 33rd month.

The study design was approved by the Ethics Committee of the Faculty of Medicine, Comenius University in Bratislava. Participation in the research was voluntary, unpaid, and participants were included into the research study after the informed consent form was signed by a child's legal guardian.

Results

Cognitive profile

The current intellectual performance of our sample oscillated from significantly below-average to the scores high above average. The sample´s mean IQ reached the zone of average range (94.57 ± 19.83). They achieved the highest average values in Thinking Ability (100.97 ± 18.31), and the lowest in Cognitive Efficiency (86.60 ± 18.27). Of the broad abilities, the highest average values were achieved in Fluid reasoning measured by the Concept Formation subtest (103.37 ± 17.12) and Long-Term Retrieval (102.40 ± 14.26). On the other hand, their scores were significantly reduced in Processing Speed measured by the subtest Visual Matching (81.43 ± 19.00) and Numbers Reversed measuring Short-Term Memory (91.60 ± 17.42). Visual representation of the cognitive profiles of our participants is shown in Figure 1.

The distribution of IQ scores in our research sample compared to the general population corresponded with the findings of Bulik-Sullivan *et al.* [2], the average was only slightly reduced (94.57 ± 19.83) in comparison to the general population´s average and the extremes at both poles were significantly more represented - high above-average and above-average represented in 16.6% vs 10% in general population, fewer children were in the range of the average (33.3% vs 50%) and five times more children in the range below average (10% vs 2%). In contrast, comparing our scores with the IQ ranges in the population of eight-year-olds with autism [4], our sample had more children with IQ above 85 (66.7% vs. 42.1%) and fewer children with IQ <70 (10% vs 33.4%), than expected.

To compare the means in IQ factors and broad abilities, we used the ANOVA test for repeated measurements, as the assumption of normal distribution was fulfilled and the Mauchly´s sphericity test did not show a violation of the sphericity assumption (IQ factors: $\chi 2$ (2) = 26,974, p = .471, broad abilities: $\chi 2$ (2) = 2.195, p = .334.) ANOVA test for repeated measures showed significant differences in their performance across subtests (IQ factors: F (7, 203) = 8,284, P <0,001, broad abilities: F (7, 203) = 8.284, P <0.001).

Post hoc tests using Bonferroni correction at broad abilities confirmed a statistically significant increase in the Concept Formation subtest compared to Visual Comparison (103.37 ± 3.12 vs 81.43 ± 3.47) and Inverted Numerical Series (103.37 ± 3.12 vs 91.60 ± 3.18). On the other hand, the Visual Comparison subtest scores were significantly reduced compared to all other sub-capabilities except for the Inverted Number Series subtest. For three IQ factors, post hoc tests using Bonferroni correction confirmed a statistically significant reduction in Cognitive Efficiency over Verbal Ability and Thinking Ability.

The triad of impairments in ASD and a profile of cognitive functions

The descriptive statistics and correlations between all variables are provided in Table 1. The ADI-R A scale describing the degree of

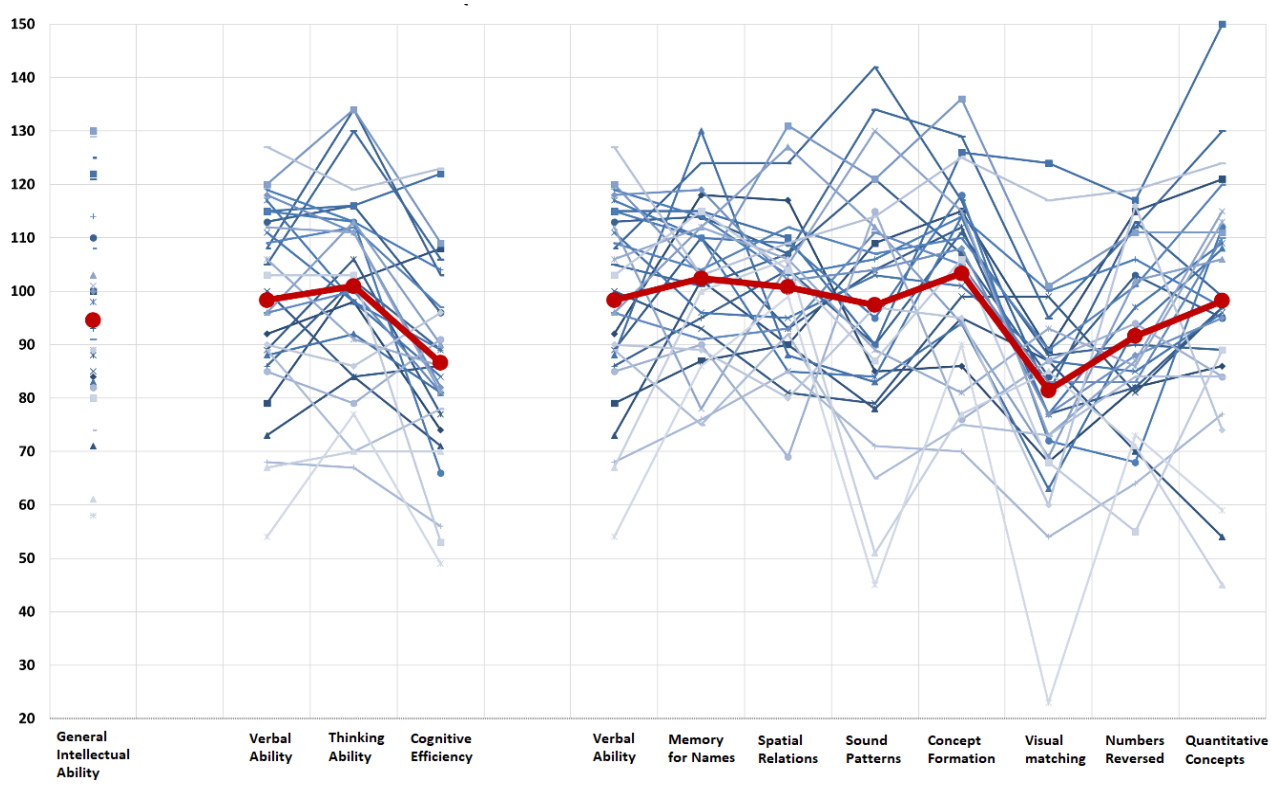

Figure 1. Woodcock-Johnson scores of individuals in our sample

Table 1. Descriptive statistics and correlations

	M	SD	1	2	3	4	5	6	7	8	9	10
General Intellectual Ability (1)	94.57	19.83										
Verbal ability (2)	98.33	18.12	.82***									
Thinking Ability (3)	10.97	18.31	.92***	.74***								
Cognitive Efficiency (4)	86.60	18.27	.86***	.58***	.61***							
Memory for Names (5)	102.40	14.26	.39*	.43*	.51**	.20						
Spatial Relations (6)	100.77	14.25	.55**	.40*	.69***	.25	.44*					
Sound Patterns (7)	97.40	22.82	.80***	.62***	.80***	.62***	.21	.34				
Concept Formation (8)	103.37	17.12	.83***	.67***	.88***	.6***	.31	.45*	.62***			
Visual matching (9)	81.43	19.00	.66***	.59***	.46*	.78***	.21	.20	.41*	.50**		
Numbers Reversed (10)	91.60	17.42	.80***	.46*	.58***	.94***	.17	.24	.61***	.54**	.51**	
Quantitative Concepts (11)	98.20	22.54	.76***	.69***	.68***	.66***	.26	.30	.59***	.67***	.56***	.58***
A: Qualitative Abnormalities in Reciprocal Social Interaction	.35	.18	-.35	-.33	-.35	-.30	-.35	-.38*	-.15	-.35	-.45*	-.21
A1: Failure to use nonverbal behaviors to regulate social interaction	.30	.18	-.08	-.25	-.08	.09	-.29	-.17	.06	.05	-.02	.13
A2: Failure to develop peer relationships	.37	.20	-.18	-.31	-.10	-.25	-.15	-.29	-.02	-.02	-.38*	-.13
A3: Lack of shared enjoyment	.36	.27	-.09	.18	-.14	-.18	-.18	-.24	-.01	-.19	-.30	-.17
A4: Lack of socioemotional reciprocity	.27	.18	-.32	-.22	-.35	-.30	-.26	-.28	-.20	-.38*	-.44*	-.21
B: Qualitative Abnormalities in Communication	.35	.13	-.29	-.15	-.39*	-.16	-.21	-.43*	-.35	-.33	-.24	-.13
B1: Lack of, or delay in, spoken language and failure to compensate through gesture	.22	.21	-.07	-.02	-.11	.01	-.13	-.09	-.07	-.07	.16	-.04
B2: Relative failure to initiate or sustain conversational interchange	.46	.27	-.21	-.13	-.13	-.24	-.13	-.18	-.07	-.04	-.16	-.26
B3: Stereotyped, repetitive or idiosyncratic speech	.33	.19	-.16	.09	-.22	-.05	.16	-.19	-.26	-.36*	-.22	.00
B4: Lack of varied spontaneous make-believe or social imitative play	.39	.24	-.15	-.05	-.31	-.13	-.27	-.34	-.20	-.28	-.32	-.07
C: Restricted, Repetitive, and Stereotyped Patterns of Behavior	.30	.13	-.38*	-.20	-.38*	-.31	.15	-.28	-.54**	-.39*	-.37*	-.23
C1: Encompassing preoccupation or circumscribed pattern of interest	.32	.22	-.13	-.04	-.13	-.17	.21	-.11	-.14	-.22	-.22	-.13
C2: Apparently compulsive adherence to nonfunctional routines or rituals	.18	.25	-.49**	-.34	-.47**	-.38*	-.19	-.49**	-.57***	-.29	-.38*	-.33
C3: Stereotyped and repetitive motor mannerisms	.15	.21	-.06	.14	-.07	-.10	.41*	.12	-.32	-.07	-.22	.01
C4: Preoccupations with part of objects or non-functional elements of material	.40	.20	-.49**	-.25	-.44*	-.39*	-.10	-.26	-.42*	-.61***	-.38*	-.39*
Language and Communication	.34	.21	-.40*	-.54**	-.22	-.42*	.00	-.15	-.19	-.17	-.29	-.39*
Reciprocal Social Interaction	.46	.17	-.09	-.10	.01	-.17	.10	-.25	.05	.12	-.14	-.17
Social affect	.42	.15	-.25	-.29	-.11	-.33	.02	-.27	-.09	.03	-.20	-.33
Restricted and Repetitive behaviors	.32	.16	-.25	-.01	-.20	-.29	.15	.01	-.22	-.29	-.13	-.25
ADOS-2 overall score	.39	.10	-.36	-.29	-.18	-.46*	.10	-.25	-.16	-.10	-.28	-.45*

Qualitative Abnormalities in Reciprocal Social Interaction showed a negative relationship with Spatial Relations (rs = -.376, p = .04) as well as with Visual matching (rs = -.452, p = .01), Failure to develop peer relationships (A2) (rs = -.376, p = -.41) and with Lack of socio-emotional reciprocity (A4) (rs = -.437, p = .02). Lack of socio-emotional reciprocity was also negatively associated to Concept Formation (rs = -.377, p = .04). The ADI-R B scale, described as Qualitative Abnormalities in Communication, showed negative relationships with Cognitive Efficiency (rs = -.392, p = .03) and Spatial Relations (rs = -.433, p = .02). Stereotyped, repetitive or idiosyncratic speech (B3) correlated negatively with Concept Formation (rs = -.363, p = .05). The ADI-R C scale, Restricted, Repetitive, and Stereotyped Patterns of Behavior correlated negatively with General intellectual ability (rs = -.381, p = .04), Thinking Ability (rs = -.383, p = .04), Sound Patterns (rs = .537, p > .01), Concept Formation (rs = -.385, p = .04) and Visual matching (rs = -.373, p = .04). The ADI-R C2 scale, Apparently compulsive adherence to nonfunctional routines or rituals, correlated negatively with General Intellectual Ability (rs = -.488, p < .01), Thinking Ability (rs = -.468, p < .01), Cognitive Efficiency (rs = -.375, p = .04), Spatial Relations (rs = -.492, p < .01), Sound Patterns (rs = -.571, p < .01), Visual matching (rs = -.381, p = .04) a Quantitative Concepts (rs = -.411, p = .02).

Stereotyped and repetitive motor mannerisms (C3) correlated negatively with Memory for Names (rs = -414, p = .02). preoccupations with part of objects or non-functional elements of material (C4) were negatively related to General Intellectual Ability (rs = -.487, p <= .01), Thinking Ability (rs = -.444, p = .01), Cognitive Efficiency (rs = -.393, p = .03), Sound Patterns (rs = -.423, p = .02), Concept Formation (rs = -612., p < .01), Visual matching (rs = -.383, p = .04), Numbers Reversed (rs = .394, p = .03) a Quantitative Concepts (rs = .455, p = .01). Overall ADOS-2 score was negatively associated with Cognitive Efficiency (rs = -.458, p = .03) and Numbers Reversed (rs = -.446, p = .01). Language and communication skills correlated negatively with General Intellectual Ability (rs = -.403, p < .01), Verbal ability (rs = -.537, p < .02), Cognitive Efficiency (rs = -.417, p = .02) and Numbers Reversed (rs = -.390, p = .03).

Relationship between delayed speech milestones and cognitive abilities in children with ASD

We compared children based on their speech delay measured by ADI-R question 9 (Age of the First Single Words) and ADI-R question 10 (Age of the First Phrases). Eight children (26.7%) started using more than 5 words later than in 24 months of age (ADI-R, question 9). Eleven children (36.7%) started using the first sentences later than in month 33 (ADI-R, question 10).

We compared the cognitive abilities in children with and without a delayed use of words or sentences, using a nonparametric Mann-Whitney U-test due to the normality of the distribution confirmed by the Shapiro-Wilk test, but a partial violation of the assumption of similarity of variances (Table 2).

Children with delayed verbal expression of the first words scored significantly lower on the scale Concept Formation (U=45.0, p=.04, r=.37). Similarly, children with delayed first phrases scored lower on the scale Concept Formation (U=15, p<.01, r=.70) as well as lower

Table 2. Comparison of cognitive abilities in children with delayed use of words or sentences

	Overall IQ	Verbal ability	Thinking ability	Cognitive Efficiency	Memory for Names	Spatial Relations	Sound Patterns	Concept Formation	Visual Matching	Numbers Reversed	Quantitative Concepts
Delayed use of first words											
Children without a delay (n=22)											
Mean	95.3	98.2	102.5	86.4	100.8	101.5	97.0	107.1	81.9	91.2	98.2
Median	95.0	104.0	102.5	86.5	102.5	104.0	100.0	110.5	84.5	88.5	97.0
SD	21.3	20.2	17.5	21.0	12.3	11.9	22.8	16.5	21.2	19.5	25.8
Children with a delay (n=8)											
Mean	92.6	98.8	96.8	87.1	106.9	98.6	98.6	93.0	80.3	92.6	98.3
Median	87.0	98.0	91.5	86.0	112.0	97.0	96.5	94.0	79.0	90.5	98.0
SD	16.2	11.4	21.1	7.8	19.0	20.2	24.5	15.1	12.2	10.6	10.6
Mann-Whitney U	76.00	80.00	69.00	85.00	65.00	73.50	86.50	45.00	79.50	84.00	81.50
Wilcoxon W	112.0	116.0	105.0	338.0	318.0	109.5	122.5	81.00	115.5	337.0	117.5
Z	-.563	-.375	-.892	-.141	-1.080	-.681	-.070	-2.018	-.399	-.188	-.305
Sig	.573	.707	.372	.888	.280	.496	.944	.044*	.690	.851	.760
Delayed use of first phrases											
Children without a delay (n=19)											
Mean	102.6	103.6	109.3	91.8	104.4	103.8	105.5	112.4	85.9	96.2	104.3
Median	100.0	108.0	111.0	96.0	104.0	105.0	106.0	114.0	84.0	101.0	109.0
SD	17.4	15.2	14.0	18.8	12.0	13.0	18.2	12.2	16.4	19.0	21.6
Children with a delay (n=11)											
Mean	80.7	89.3	86.5	77.5	99.0	95.5	83.4	87.7	73.6	83.7	87.6
Median	83.0	89.0	84.0	82.0	96.0	95.0	83.0	90.0	77.0	85.0	95.0
SD	16.2	19.9	16.0	13.7	17.6	15.4	23.9	12.5	21.4	11.1	20.9
Mann-Whitney U	40.50	58.00	29.00	60.00	81.00	64.50	49.50	15.00	74.50	61.00	56.50
Wilcoxon W	106.5	124.0	95.00	126.0	147.0	130.5	115.5	81.00	140.5	127.0	122.5
Z	-2.756	-2.002	-3.254	-1.917	-1.012	-1.723	-2.368	-3.853	-1.293	-1.872	-2.067
Sig	.006**	.045	.001**	.055	.311	.085	.018*	.000***	.196	.061	.039*

score in General Intellectual Ability (U=40.5, p=01.0, r=.50), Thinking Ability (U=29, p<.01, r=.59), Sound Patterns (U=49.5, p=.02, r=.43), and Quantitative Concepts (U=56.5, p=.04, r=.38).

Predictors of general intellectual ability

Multiple linear regression analysis was used to analyze possible predictors of General Intellectual Ability in children with ASD participating in the study. In our final model (F=(3,26)=8.794, p<.001)), three major predictors were identified: Apparently compulsive adherence to non-functional routines or rituals, Preoccupations with part of objects or non-functional elements of material and Age of First Phrases. All identified major predictors proved to have a negative effect on IQ. The increase in these indicators by 1 (due to the adjustment of data in the interval from 0 - no deficits to 1 – maximum deficits), proved the average IQ decrease by 28.12 points for Compulsive adherence to non-functional routines or rituals, resp. 27.46 points for Preoccupations with part of objects. When Use of First sentences was delayed, the average IQ was reduced by 15.72 points compared to the absence of this symptom. Table 3 shows the regression coefficient, the standard error of this coefficient and the p-value. The regression model explains up to 50.4% of the variance of the score in the total IQ.

Discussion

Cognitive profile

Our hypothesis stating that there are significant intracognitive variations in broad cognitive abilities in children with autism spectrum disorder, making up their overall intellectual abilities, has been confirmed. Individuals with PAS performed significantly higher in Verbal ability and Thinking Ability than in Cognitive Efficiency. These findings are consistent with several studies [8,11] which demonstrated that individuals with ASD score lower in WISC scales Processing Speed, Digit Span (short-term memory - Gsm) and Symbol search (processing speed- Gs) - the factors saturating Cognitive Efficiency in WJ IE II.

Several older studies on cognitive profiles of people with ASD described significantly higher Performance IQ compared to Verbal IQ in the Wechsler scales, while more current studies are presenting conflicting results [7,8,12]. As Charman *et al.* [13] point out, most beliefs about what the cognitive profile of individuals with ASD looks like were formulated several decades ago, when the diagnostic criteria, intelligence tests used, and disease prevalence were different. Our research sample did not confirm a significant difference between scores in the Thinking Ability (also saturated by factors Long-Term Retrieval and Fluid Reasoning) against Verbal ability. However, it should be taken into account that WJ IE II and WISC cannot be mechanically compared, because the Wechsler scales include several subtests that measure other factors as well in both Performance and Verbal IQ. For example, Comprehension subtest, assesses not only verbal skills but also the ability to understand social situations. It not a coincidence that the individuals with ASD show the worst performance in Comprehension subtest [8,14]. In WISC-V, it is no longer a mandatory subtest of the Verbal Comprehension Index, but clinically, failure in Comprehension can be a potential signal of ASD. In WJ IE II, on the other hand, the Thinking Ability also includes Long-Term Retrieval and Auditory Processing, which are not included in WISC.

Of the broad cognitive abilities, the highest average performance achieved by individuals with ASD was in Fluid Reasoning measured by Concept Formation subtest, which was significantly better compared to Processing speed and Short-Term Memory – in which, on the other hand, they showed the lowest scores. Interestingly, they achieved the best performance in Fluid Reasoning even though the subtest Concept Formation measuring it requires higher demands on comprehension of verbal instructions, mental flexibility and inhibition of the response during testing, than Matrices Reasoning in WISC do. Thus, it may be adversely affected by deficits in executive function and impaired speech comprehension, typical for ASD.

The best performance in Fluid Reasoning is consistent with previous findings [8,15], which also point out that autistic children and adults achieve significantly higher scores in Raven's Progressive Matrices (RPM) compared to overall IQ in the Wechsler intelligence scales. In contrast to the autistic population, no significant difference between the performance in RPM and WISC was found in neurotypical children. An interesting contribution to the discussion is the study of Mandy *et al.* [7], who suggested that for individuals with autism, tasks without a time limit that require abstract reasoning are their strong side, contrary to the weakness in Processing speed and Comprehension-Knowledge, which is also in line with our results.

These findings may contribute to a deeper understanding of cognitive abilities in ASD. It has long been assumed that their performance peaks in Cubes, Raven's progressive matrices or Matrix Reasoning in WISC are only isolated splinter skills, but it is questionable whether they might actually be manifestations of true cognitive abilities that can be underestimated by standard test batteries [8,16], mainly due to deficits in executive function and impaired speech comprehension [7,17]. The fact, that the results of measuring intelligence in individuals with ASD are different, sometimes significantly, depending on the instrument by which they are measured is known. However, this is probably the most overlooked fact in the research of this disease and we still cannot fully explain it. When measuring the cognitive abilities of individuals with ASD, it should always be kept in mind that we cannot rely on approximately the same results from different IQ tests, even if this applies to the general population.

The triad of impairments in ASD and cognitive abilities

Our hypothesis that there is a significant negative relationship between the degree of behavioral manifestations of the core ASD symptoms, overall intellectual performance and selected cognitive abilities was partially confirmed. Deficits in Language and communication present in direct observation (ADOS-2) were negatively associated with overall IQ, Cognitive Efficiency, and Verbal ability in WJ IE II. Likewise, the research of Joseph *et al.* [18] confirmed

Table 3. Coefficients of Multiple linear regression analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	St. Error	Beta		
(Constant)	116.475	6.187		18.824	.000
ADI-R C2	-28.119	10.943	-.358	-2.569	.016
ADI-R C4	-27.466	15.528	-.282	-1.769	.089
Age of First Phrases	-15.727	6.392	-.389	-2.460	.021

Note. ADI-R C2=Apparently compulsive adherence to nonfunctional routines or rituals, ADI-R C4=Preoccupations with part of objects or non-functional elements of material

that communication skills are closely related to verbal IQ and speech impairment which is an important mediating factor of the ASD symptoms manifested in communication.

Qualitative Abnormalities in Reciprocal Social Interaction based on the child's history (ADI-R) did not show a statistically significant negative association with overall IQ, although this trend was indicated. Restricted, Repetitive, and Stereotyped Patterns of Behavior scale (RRSPB) in ADI-R showed the highest number of negative correlations with cognitive abilities – with overall IQ and with a subtest measuring Thinking Ability. These findings are consistent with those of Bishop *et al.* [19] that the prevalence of most RRSPB (Self-harm, Unusual Preoccupations, Repetitive Use of Objects, Unusual Sensory Interests, Hand and Finger Mannerisms or Other Complex Mannerisms or Stereotyped Body Movements) was negatively associated with nonverbal IQ.

We also observed a negative relationship between Apparently compulsive adherence to non-functional routines or rituals and overall IQ, Thinking Ability, Cognitive Efficiency. Out of the broad spectrum of cognitive abilities there was a negative association with Visual-Spatial Thinking, Processing Speed, Auditory Processing and Quantitative Reasoning. Weakened central coherence, the inability to distinguish the essential from the insignificant, and the clinging to details, can play an important role here [20].

Fluid intelligence correlated negatively with Preoccupations with part of objects and Unusual Sensory Interests, but also with Verbal Rituals, which points to a strong association with reduced mental flexibility and difficulty in initiating new, non-routine activities. Miller *et al.* [21] showed similar results, a higher rate of RRSPB was associated with a problematic transition to a new type of tasks and with a repetition of older, previously learned answers.

There was also a negative association between total IQ and Restricted, Repetitive, and Stereotyped Patterns of Behavior, which is consistent with the findings of a longitudinal study by Gotham *et al.* [22], which showed that individuals with a higher rate of ASD symptoms have a lower IQ.

Relationship between delayed speech milestones and cognitive abilities

Deficits in Speech development and Qualitative Abnormalities in Communication are among the core symptoms of ASD and are often the first cause of parents' concerns about their child's development. Retrospective studies show language regression, the loss of already acquired language skills most often between 18-22 months of age, in 20% to 30% of ASD cases [23-25], however, new findings from prospective studies suggest that a regressive pattern of onset may be much more common than previously thought (69% of parents rating, 88% of examiners rating), perhaps the rule rather than the exception [26,27]. About 63% of children diagnosed with ASD also have a language disorder [28] and 25% children is nonverbal or using just few words [29].

According to the latest research, Meeting Language Milestones seems to have the most significant prognostic power - especially Age of First Single Words and Age of First Phrases [30-32]. In our study, children with delayed Age in expressing the First Single Words scored significantly lower only in Fluid intelligence. In contrast, children with delayed Age in expressing the First Phrases scored significantly lower in several subtests including overall IQ, Thinking ability, Sound Discrimination, Concept formation and Quantitative Concepts.

This discrepancy, that Age of First Phrases showed a more significant effect on IQ in our study, might be caused by the limitation in our research sample, which including only children with developed functional speech at the age of testing, which was a prerequisite for the use of the WJ IE II test battery. Therefore, our sample lacked children with the most severe speech disorders – nonverbal or using few words and there was not a single child with the parent reported history of language regression. This criterion also significantly reduced the size of the research sample – our academic research center is primarily concentrated on providing the first ASD examination of suspected children. Most of the children did not reach a sufficient level of speech for WJ IE II Administration.

As a result of this criterion, our research sample was also predominantly composed of individuals with an IQ> 70, which does not correspond to epidemiological studies [4]. Our research sample did not sufficiently cover ASD population with significant cognitive deficits, on the contrary, a higher proportion of children with an IQ higher than 85 was included. On the other hand, the use of the WJ IE II test battery expanded the amount of information obtained on the cognitive abilities and deficits of the examined individuals, which would not be possible using any other test with current Slovak standards.

Delayed sentence use indicating a negative impact on current cognitive performance. Children had significantly reduced verbal abilities - they knew fewer words, had deficits in determining synonyms, antonyms and verbal analogies, lower thinking abilities as well as fluid intelligence and mathematical abilities.

WJ IE II is not primarily intended to objectify the depth of language impairment, whether its lexical - semantic or pragmatic component. In the future, however, it could be beneficial to try to objectify the manifested weaknesses, especially since our sample was a group of children with ASD who had the best developed speech out of all children diagnosed in our center. Because this group at first glance "has no problem with speech", their deficits can be easily overlooked. Especially children with ASD without intellectual deficit, which usually attend regular classes may need specific educational adaptations, due to impairments in receptive and/or expressive language, i.e., understanding and/or language formulation difficulties.

Predictors of general intellectual ability

In the present study, we identified three significant predictors of current intellectual performance in children with ASD - Apparently compulsive adherence to non-functional routines or rituals, Preoccupations with part of objects or non-functional elements of material and Delayed Age of First Phrases.

Conclusion

Since the level of cognitive abilities and deficits is the most serious factor influencing future functioning of individuals with ASD, and it is important to pay increased attention to it also from a clinical point of view. Significantly reduced Cognitive Efficiency (consisting of Processing Speed and Working memory), negatively affects individual´s performance not only in cognitive tests, but especially in the education process and in their everyday life's activities. Our findings propose that the individual analysis of the cognitive profiles of people with ASD is much more important for a general practice than just the estimate of their overall IQ.

Another important message is that while assessing the cognitive abilities of autistic individuals, different methods often produce

different results, and these results need to be interpreted sensitively with consideration of their individual specific sensory interests and hypersensitivity, clumsiness, impaired speech comprehension and production and reduced process speed. The main advantage of the WJ IE II test battery is the assessment of cognitive effectiveness independently of other sub-abilities, which means better assessment of the strengths and weaknesses of a child with ASD. And although the conclusions of our research cannot be generalized to the whole ASD population, due to the size of our sample, we can say it is suitable for IQ assessment in verbal children with average to higher intelligence. A significantly expanded and more proportional (sorted by overall IQ, age, and gender) sample is recommended for a future research.

In the present study, we identified three significant predictors of current intellectual performance in children with ASD - Apparently compulsive adherence to non-functional routines or rituals, Preoccupations with part of objects or non-functional elements of material and Delayed Age of First Phrases. These results stress the fact that the early intervention aimed at developing functional speech is truly meaningful, but also emphasize that even children with ASD who have sufficiently developed language may suffer other impairments, which may not appear obviously. Savant skills such as above-average vocabulary or encyclopedic knowledge of a particular area of interest may coexist with impaired pragmatic domain of language and impaired working memory, difficulty understanding complicated instructions, lack of fluency in ideas, clinging to details, and a reduced ability to mentalize the emotional experiences of others. In other words, above-average abilities in partial cognitive functions do not compensate for the socio-communication deficits, which are the core symptoms of the disease and often result in significantly reduced adaptive abilities.

A comprehensive approach, which focuses not only on the overall level of intellectual capacity presented by IQ, but differentiates the strengths and weaknesses of a child, is a strong foundation for effective intervention. Moreover, it also allows searching for appropriate forms of inclusion in the school environment preventing the development of psychiatric comorbidities in ASD children such as depression and anxiety disorders in adolescence and adulthood.

Acknowledgement

The study was supported by the Slovak Research and Development Agency (grant number APVV-15-0045 and APVV-15-0085).

References

1. WHO (2019) ICD-11 - International Classification of Diseases 11th Revision.
2. Bulik-Sullivan B, Finucane HK, Anttila V (2015) An atlas of genetic correlations across human diseases and traits. *Nat Genet* 47: 1236-1241. [Crossref]
3. Christensen DL (2016) Prevalence and characteristics of autism spectrum disorder among children aged 8 years — Autism and developmental disabilities monitoring network, 11 Sites, United States, 2012. *MMWR Surveill Summ* 65. [Crossref]
4. Maenner MJ (2020) Prevalence of autism spectrum disorder among children aged 8 Years — Autism and developmental disabilities monitoring network, 11 Sites, United States, 2016. *MMWR Surveill Summ* 69.
5. Charman T, Jones CRG, Pickles A (2011) Defining the cognitive phenotype of autism. *Brain Res* 1380: 10-21.
6. Kanai C, Toth G, Itahashi T (2016) Inteligence, handbook of assessment and diagnosis of autism spectrum disorder. *Springer* 379-402.
7. Mandy W, Murin M, Skuse D (2015) The Cognitive profile in autism spectrum disorders. *Key Issues in Mental Health* 180: 34-45.
8. Nader AM, Jelenic P, Soulières I (2015) Discrepancy between WISC-III and WISC-IV Cognitive Profile in Autism Spectrum: What Does It Reveal about Autistic Cognition? *PLOS ONE* 10: e0144645.
9. Zander E, Dahlgren SO (2010) WISC-III index score profiles of 520 Swedish children with pervasive developmental disorders. *Psychological assessment* 22: 213.
10. Johnson CP, Myers SM (2007) Identification and Evaluation of Children with Autism Spectrum Disorders. *Pediatrics* 120: 1183-1215.
11. Oliveras-Rentas RE, Kenworthy L, Roberson RB (2012) WISC-IV Profile in High-Functioning Autism Spectrum Disorders: Impaired processing speed is associated with increased autism communication symptoms and decreased adaptive communication abilities. *J Autism Dev Disord* 42: 655-664.
12. Yu TY, Chou W, Chow JC (2018) IQ discrepancy differentiates levels of fine motor skills and their relationship in children with autism spectrum disorders. *Neuropsychiatr Dis Treat* 14: 597-605.
13. Charman T, Pickles A, Simonoff E (2011) IQ in children with autism spectrum disorders: data from the special needs and autism project (SNAP). *Psychol Med* 41: 619-627.
14. Mayes SD, Calhoun SL (2008) WISC-IV and WIAT-II profiles in children with high-functioning autism. *J Autism Dev Disord* 38: 428-439.
15. Dawson G, Rogers S, Munson J, et al. (2010) Randomized, controlled trial of an intervention for toddlers with autism: the Early Start Denver Model. *Pediatrics* 125: e17-23.
16. Courchesne V, Meilleur AA, Poulin-Lord MP (2015) Autistic children at risk of being underestimated: School-based pilot study of a strength-informed assessment. *Molecular autism* 6: 12.
17. Kjellmer L, Fernell E, Gillberg C (2018) Speech and language profiles in 4- to 6-year-old children with early diagnosis of autism spectrum disorder without intellectual disability. *Neuropsychiatr Dis Treat* 14: 2415-2427. [Crossref]
18. Joseph RM, Tager-Flusberg H, Lord C (2002) Cognitive profiles and social-communicative functioning in children with autism spectrum disorder. *J Child Psychol Psychiatry* 43: 807-821.
19. Bishop SL, Richler J, Lord C (2006) Association between restricted and repetitive behaviors and nonverbal IQ in children with autism spectrum disorders. *Child Neuropsychol* 12: 247-267.
20. Happé F, Frith U (2006) The weak coherence account: detail-focused cognitive style in autism spectrum disorders. *J Autism Dev Disord* 36: 5-25.
21. Miller HL, Ragozzino ME, Cook EH (2015) Cognitive set shifting deficits and their relationship to repetitive behaviors in autism spectrum disorder. *J Autism Dev Disord* 45: 805-815.
22. Gotham K, Pickles A, Lord C (2012) Trajectories of autism severity in children using standardized ADOS Scores. *Pediatrics* 130: e1278-e1284.
23. Meilleur A-A S, Fombonne E (2009) Regression of language and non-language skills in pervasive developmental disorders. *J Intellect Disabil Res* 53: 115-124. [Crossref]
24. Bradley CC, Boan AD, Cohen AP (2016) Reported history of developmental regression and restricted, repetitive behaviors in children with autism spectrum disorders. *Journal of Developmental & Behavioral Pediatrics* 37: 451-456.
25. Barger BD, Campbell JM, McDonough JD (2013) Prevalence and onset of regression within autism spectrum disorders: a meta-analytic review. *J Autism Dev Disord* 43: 817-828.
26. Ozonoff S, Gangi D, Hanzel EP (2018) Onset patterns in autism: Variation across informants, methods, and timing. *Autism Research* 11: 788-797.
27. Estabillo JA, Matson JL, Cervantes PE (2018) Autism symptoms and problem behaviors in children with and without developmental regression. *J Dev Phys Disabil* 30: 17-26.
28. Levy SE, Giarelli E, Lee LC (2010) Autism spectrum disorder and co-occurring developmental, psychiatric, and medical conditions among children in multiple populations of the United States. *J Dev Behav Pediatr* 31: 267-275.
29. Norrelgen F, Fernell E, Eriksson M (2015) Children with autism spectrum disorders who do not develop phrase speech in the preschool years. *Autism* 19: 934-943.
30. Mouga S, Correia BR, Café C (2020) Language predictors in autism spectrum disorder: Insights from neurodevelopmental profile in a longitudinal perspective. *J Abnorm Child Psychol* 48: 149-161.
31. Kenworthy L, Wallace GL, Powell K (2012) Early language milestones predict later language, but not autism symptoms in higher functioning children with autism spectrum disorders. *Research in Autism Spectrum Disorders* 6: 1194-1202.
32. Mayo J, Chlebowski C, Fein DA (2013) Age of first words predicts cognitive ability and adaptive skills in children with ASD. *J Autism Dev Disord* 43: 253-264.