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Heterogeneity of cognitive profiles in students with borderline intellectual functioning

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Summary

Aim. Borderline intellectual functioning (BIF) is a clinical entity of polyetiological nature which manifests in heterogeneity of cognitive deficits. The aim of this study was to identify groups of homogenous cognitive profiles within a heterogeneous population of students with BIF.

Method. Cognitive profiles of 114 participants with borderline intellectual functioning were assessed based on different patterns of their performance on the Wechsler Intelligence Scale for Children – Revised.

Results. Through a hierarchical cluster analysis we identified four distinct cognitive profiles: a) children with severe verbal skills deficits and average visual-spatial abilities; b) children with short-term memory and attention deficits; c) children with ACID profile, typical for learning disabilities; d) children with 'flat' cognitive profile where all verbal and performance skills were on borderline IQ level.

Conclusions. Identifying strengths and limitations of distinct cognitive profiles among students with borderline intellectual functioning has important implications for further assessment strategies and distinctive approach in designing educational and developmental interventions.

Key words: borderline intellectual functioning, intelligence quotient, cognitive profiles

Introduction

Borderline intellectual functioning (BIF) ranges between the average IQ and a mild intellectual disability (between – 1.01 and – 2.00 *SD*) [1], remaining within the bounds of normality. Despite its simple definition, it constitutes a complex clinical entity, surprisingly absent from or vaguely described in international diagnostic classifications. The International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) of the World Health Organization [2], defines BIF as a condition involving deficits in cognitive functioning and awareness (R41.83), but no further information is provided. The 11th Revision of ICD, accepted on the 25th of May, 2019 by the 72nd World Health Assembly, that came into effect on the 1st of January, 2020, codes BIF as MB21.Y: Other specified symptoms and signs involving cognition. These involve: symptoms, signs, and clinical findings indicative of a disturbance in mental abilities and processes related to attention, memory, judgment, reasoning, problem solving, decision making, or comprehension, or the integration of these functions [3]. No other details are listed. Specifically, as before, it is not included within the category of disorders of intellectual development (6A00). Thus, it is conceptualized as an indicator of intellectual disturbances, but not a condition itself.

The American Psychiatric Association in its 5th edition of the Diagnostic and Statistical Manual of Mental Disorders [1] describes BIF (V62.89) as a condition that may require clinical attention and interfere with treatment effectiveness and its trajectory. It mentions the importance of differentiating BIF and mild intellectual disability, thus advises the assessments of both intellectual functioning and adaptive skills. However, as Wieland and Zietman [4] report, it no longer provides information on IQ boundaries (as compared with DSM-IV-TR), which results in no actual definition at all. This limited knowledge encourages further studies, exploring areas beyond current reports on educational difficulties of students with BIF [5], such as different trajectories of cognitive development and the heterogeneity of cognitive functioning among individuals with BIF, and its consequences for conducting differential assessment [6, 7].

Heterogeneous cognitive deficits in individuals with BIF reflect its polyetiological nature [6]. Although the majority of individuals with BIF share many noncognitive similarities (e.g., educational and vocational disadvantages, inability to achieve personal independence, and social rejection) [8, 9], their cognitive impairments may vary in degree and nature [6]. Moreover, BIF co-occurs with other developmental disorders, such as attention deficit hyperactivity disorder (ADHD) [10], fetal alcohol syndrome (FAS) [11], or autism spectrum disorder (ASD) [10] and mental health issues, i.e., anxiety and behavioral disorders [12, 13].

In Poland, Spionek [14] and Kostrzewski [15] conducted independent studies which brought similar results: they identified heterogeneous deficits in cognitive functioning among individuals with BIF. The participants of both studies, although their Full IQ scale was between – 1.01 and – 2.00 *SD,* exhibited significantly different cognitive profiles. Both researchers identified similar subgroups who manifested: a) poor reasoning, b) poor visual and auditory perception, and c) slow information processing. Also, both researchers identified a subgroup whose all cognitive skills (verbal and performance skills) were on the below average level. As these studies were conducted over thirty years ago, this issue requires re-examination. A recent study [16] on cognitive profiles of Polish students with BIF reported that participants scored best in the WISC-R in Coding and Picture Arrangement subtests, and poorest in Arithmetic, Vocabulary, and Information. Furthermore, Jankowska et al. [17] observed significant changes in the WISC-R over time; Verbal IQ decreased and Performance IQ increased with age. These analyses, however, report the results of the entire group of participants with BIF. Also, results obtained by other researchers [10, 18] confirmed the instability of an IQ in the children and adolescents with BIF. The growing body of research [19, 20, 21] referring to the cognitive functioning of students with BIF highlights their lower information processing abilities, working memory problems, difficulties with executive functioning, and attention deficits. However, research more likely indicates the diverse nature of the above cognitive difficulties among students with BIF. This is also confirmed by recent Italian studies of Baglio et al. [9] which indicated that children with BIF typically show a heterogeneous profile of neuropsychological functioning, which affects differently the quality of their school achievement and everyday life functioning.

Thus, the aim of the present study was to identify distinctive cognitive profiles of a group of children with BIF (identification of homogeneous subgroups within a cognitively heterogeneous population of students with BIF), based on different patterns of their performance on an IQ test.

Participants and procedure

114 children with BIF: 72 (36.8%) boys and 42 (63.2%) girls, M_{age} = 11.6 years, participated in the study. They were selected from a population of students who, within one academic year, were referred to and assessed by the six Tri-City psychological and pedagogical counselling centers due to their poor school performance. From the cohort of students assessed as with BIF (126; an estimated IQ score between 70 and 84; – 1.01 and – 2.00 *SD*), those with co-occurring developmental or mental health disorders were excluded. Consequently, after obtaining parental consent, we carefully re-analyzed the assessments of 114 students with BIF.

Materials and method

All students' IQ level was assessed with the Polish adaptation of the Wechsler Intelligence Scale for Children – Revised (WISC-R) [22]. The participants had an average Full IQ (FIQ) score of $M = 78.65$ ($SD = 4.45$; $Min = 70.00$; $Max = 85.00$; Shapiro-Wilk $W = 0.941$; $p < 0.001$), with a Verbal IQ (VIQ) score of $M = 77.14$ ($SD = 8.22$; $Min = 58.00$; $Max = 102.00$; Shapiro-Wilk $W = 0.986$; $p = 0.293$), and a Performance IQ (PIQ) score of $M = 84.01$ ($SD = 8.30$; $Min = 59.00$; $Max = 102.00$; Shapiro-Wilk $W = 0.985$, $p = 0.248$).

In Poland, the licensed, 2008 Polish adaptation of the WISC-R is the currently used version for research and educational assessment purposes and the newest available version of the Wechsler Intelligence Scale for Children. It was adapted, normalized and published by a leading publisher of psychological and educational assessment materials and methods: the Psychological Test Laboratory of the Polish Psychological Association. The Polish adaptation of the WISC-R meets the conditions of reliability and validity [22, 23]. Internal consistency coefficients (as measured with a Cronbach's α) have ranged from 0.76 for the Performance Scale, 0.87 for the Verbal Scale, to 0.87 for the Full Scale. Correlation coefficients with the Raven's Standard Progressive Matrices (SPM) have ranged from 0.47 to 0.69 for the Full Scale. No other intelligence test that would allow to assess profile performance was available at the time of testing.

The WISC–R norms are calculated for children aged 6.0 to 16.11 years. We transformed the collected raw scores to age-scaled scores using the scoring manual (standard scores for subtests: $M = 10$; $SD = 3$; standard scores for FIQ, VIQ and PIQ $M = 100.00$; $SD = 15.00$). Standard scores between 1 and 4 indicate severe deficits, 5 and 6: moderate deficits, 7: borderline, 8–12: average scores, 13: above average, 14–15: high, 16–19: significantly high [23].

Additionally, evidence of socioeconomic status, developmental and educational history were gathered (questionnaire and interviews).

Statistics

Hierarchical cluster analysis was applied to the WISC-R standard scores of the students with BIF to identify subgroups of students with different cognitive profiles.

In the first step (for cross validation purposes), the study population was randomly split into a training sample ($n = 79$; 61%) and validation sample ($n = 35$; 39%) [24–28]. The result of the crosstab analysis allowed us to accept the hypothesis that there are no differences between groups in frequency distribution ($\chi^2 (3) = 3.139$; $p = 0.371$; $f = 0.157$), and that the participants were assigned to the samples randomly.

In the second step, the Ward's method (based on the squared Euclidean distance) was applied to the training sample [29] to classify those participants into groups with homogenous WISC-R profiles (henceforth called clusters). We determined the number of clusters based on the information from the dendrogram and the agglomeration schedule [30] – we stopped the cluster analysis after the 70th of total 73 stages. This allowed us to determine four clusters representing the profiles of WISC-R in the population of students with BIF. Profile elevation, dispersion, and shape of WISC-R scores were all considered in generating this typology. The participants were assigned to obtained clusters based on the distance from the clusters means (between the participants' WISC-R scores and the clusters means) [25–28].

The strong internal validity of this classification was confirmed in a discriminant analysis in which we confirmed 100% of correct classification of the validation sample to the cluster membership (Table 1). This allowed us to empirically confirm that the optimal number of clusters was four.

Table 1. **Classification results of matching validation and training samples within four groups with homogenous WISC-R profiles**

Sample	Cluster	Predicted group membership				Total
		A	B	C	D	
Training	A	22 (95.7)			1 (4.3)	23 (100)
	B		17 (94.4)	1 (5.6)		18 (100)
	C		2 (11.8)	15 (88.2)		17 (100)
	D				21 (100)	21 (100)
Validation	A	12 (100)				12 (100)
	B		9 (100)			9 (100)
	C			3 (100)		3 (100)
	D				11 (100)	11 (100)

Note. Raw scores given; percent results in parenthesis. 94.9% of original grouped cases correctly classified in training sample; 100.0% of original grouped cases correctly classified.

The analysis of variance (ANOVA) with a *post hoc* Tukey test was used to compare four clusters and assess statistical significance of differences in the WISC-R subtests scores between the clusters. A paired sample t-test was applied to determine the significance of difference between the WISC-R Verbal and Performance Scale subtests scores within each cluster.

Additionally, to provide a more in-depth analysis of the WISC-R profiles, Bannatyne's recategorization model [31] and Kaufman's three-factor model [32] were applied. The Bannatyne's model includes four factors: 1) Spatial (SpA; the mean score of Picture Completion, Object Assembly and Block Design); 2) Verbal Conceptual (VCA; the mean score of Comprehension, Similarities and Vocabulary); 3) Acquired Knowledge (AqK; the mean score of Information, Arithmetic and Vocabulary); 4) Sequential (SqA; the mean score of Digit Span, Picture Arrangement and Coding). Kaufman's three-factor model [32] includes: 1) Verbal Comprehension (VC; the mean score of Information, Similarities, Vocabulary, Comprehension); 2) Perceptual Organization (PO; the mean score of Picture Completion, Picture Arrangement, Block Design, and Object Assembly); 3) Freedom from Distractibility (FD; the mean score of Arithmetic, Digit Span and Coding).

Results

The means and standard deviations of the WISC-R scaled scores for each of the four clusters, named: A, B, C, and D, are presented in Table 2. Although FIQ results for all four clusters were at BIF level, significant differences between VIQ and PIQ were found within all clusters, except Cluster D. In Cluster A and Cluster B, VIQ was significantly lower than PIQ ($t(34) = 12.70$; $p \leq 0.005$; $d = 3.40$ and $t(26) = 4.13$; $p \leq 0.005$; $d = 1.16$, respectively). In Cluster C, VIQ was significantly higher than PIQ ($t(19) = 2.30$; $p = 0.033$; $d = 0.81$). In Cluster D, the difference between VIQ and PIQ failed to reach significance ($t(31) = 0.16$; $p = 0.874$; $d = 0.04$). Moreover, in Cluster B and C, the scores in VIQ and PIQ were identical, though reversed.

Furthermore, the four groups differed in the discrepancy of the results between the subtests in the Performance Scale (PS) $F(3, 110) = 4.404$; $p = 0.006$; $\eta^2 = 0.10$, but not in the Verbal Scale (VS) $F(3, 110) = 0.768$; $p = 0.514$; $\eta^2 = 0.02$, with Cluster C having the greatest variance of the subtests results in both scales ($M = 6.94$; $SD = 5.02$; 95% CI [4.59; 9.29] and $M = 9.85$; $SD = 6.87$; 95% CI [6.63, 13.07], respectively).

Table 2. **Means and standard deviations of the WISC-R scales for four identified clusters**

	Cluster A (n = 35)		Cluster B (n = 27)		Cluster C (n = 20)		Cluster D (n = 32)	
Scale	M	SD	M	SD	M	SD	M	SD
Full Scale IQ	78.29	4.27	77.78	3.90	77.85	5.62	79.50	4.20
Verbal IQ	70.09	6.73	76.67	5.20	83.10	8.26	81.53	5.75
Performance IQ	91.49	5.86	83.15	5.97	76.45	8.13	81.28	5.90
Verbal Scale	5.31	0.89	6.02	0.80	7.03	1.29	7.36	0.91
Information	4.49	2.02	5.93	1.52	6.45	2.67	5.88	1.70
Similarities	5.89	1.98	6.59	2.08	8.65	1.63	7.22	1.91
Arithmetic	5.66	2.35	4.93	2.23	5.35	2.18	8.19	2.38
Vocabulary	3.63	1.86	7.00	1.90	7.15	2.37	5.81	1.97
Comprehension	6.74	1.79	7.44	2.14	9.30	2.13	8.53	2.41
Digit Span	5.46	2.38	4.26	3.03	5.30	2.68	8.53	2.40
Performance Scale	8.80	0.78	8.80	0.78	6.51	0.99	7.31	0.88
Picture Completion	8.86	2.18	6.82	2.06	8.00	1.89	6.75	2.00
Picture Arrangement	9.14	1.94	10.56	2.03	8.65	2.85	7.28	2.04
Block Design	8.31	1.73	5.63	1.62	6.00	2.71	7.09	2.31
Object Assembly	9.11	2.25	7.37	2.22	6.80	1.85	6.19	2.10
Coding	8.57	2.69	7.96	2.74	3.10	2.02	9.22	2.41

Cluster A differed from other clusters in having the lowest VIQ (on the borderline of mild intellectual disability), and the highest PIQ that fell within the range of average IQ. Thus, it is characterized by the greatest discrepancy between verbal abilities and visual-spatial abilities in comparison to other clusters. Substantial deficiencies were observed in Information and Vocabulary subtests that were significantly below the mean score ($t(34) = 2.65$; $p = 0.012$; $d = 0.33$ and $t(34) = 5.98$; $p \leq 0.005$; $d = 1.22$, respectively), compared to all other subscale scores of VS and subtests scores in other clusters ($F(3, 110) = 5.463$; $p = 0.002$; $\eta^2 = 0.13$ and $F(3, 110) = 19.857$; $p \leq 0.005$; $\eta^2 = 0.035$, respectively).

In PS, the subtests did not differ significantly from the scale mean or from each other. In Cluster A, the scores in Block Design ($F(3, 110) = 10.112$; $p \leq 0.005$; $\eta^2 = 0.21$) and Object Assembly ($F(3, 110) = 11.433$; $p \leq 0.005$; $\eta^2 = 0.23$) subtests were significantly higher than in all other clusters. Likely, very low scores in VS lowered FIQ to BIF level, even though PIQ does not suggest a lowered intellectual ability.

In Cluster B, the discrepancy between VIQ and PIQ was also significant, with visual-spatial abilities outperforming verbal skills. However, in contrast to Cluster A, both remained within the range of BIF. The lowest results were observed in Arithmetic ($F(3, 110) = 12.23$; $p \leq 0.005$; $\eta^2 = 0.25$), Digit Span ($F(3, 110) = 15.086$; $p \leq 0.005$; $\eta^2 = 0.29$) and Block Design ($F(3, 110) = 10.112$; $p \leq 0.005$; $\eta^2 = 0.21$) – this score did not differ from an analogical Cluster C score, which were also the lowest among all other clusters. Arithmetic and Digit Span both significantly differed from the mean score in VS ($t(26) = 2.50$; $p = 0.019$; $d = 0.42$ and $t(26) = 3.55$; $p \leq 0.005$; $d = 0.93$, respectively) and all other VS subscale scores. The highest result was observed in Picture Arrangement, which was significantly higher than all other subscale scores and the mean of PS ($t(26) = 7.26$; $p \leq 0.005$; $d = 2$). Furthermore, this result was also the highest among all other clusters ($F(3, 110) = 11.401$; $p \leq 0.005$; $\eta^2 = 0.24$).

In Cluster C, VIQ was significantly greater than PIQ, which differentiated it from clusters A and B. Although verbal skills outperformed visual-spatial abilities, the subtest scores were very uneven in both scales; the differences between Comprehension and Digit Span ($t(19) = 5.36$; $p \leq 0.005$) and Picture Arrangement and Coding ($t(19) = 6.53$; $p \leq 0.005$), the highest and the lowest results in VS and PS, were statistically significant. The lowest scores were observed in Information, Arithmetic, Digit Span, and Coding. The score in Coding was significantly lower than all other subscale scores of PS and also the lowest among all four clusters ($F(3, 110) = 27.556$; $p \leq 0.005$; $\eta^2 = 0.43$). The scores in Comprehension and Similarities were higher than VS mean ($t(19)= 4.82$; $p \leq 0.005$; $d = 1.32$ and $t(19) = 5.40$; $p \leq 0.005$; $d = 0.95$, respectively) and the highest among these subscale scores in all four clusters ($F(3,110) = 7.744$; $p \leq 0.005$; $\eta^2 = 0.17$ and $F(3, 110) = 9.213$; $p \leq 0.005$; $\eta^2 = 0.20$, respectively). It was the most scattered profile among the four clusters

Cluster D was characterized by an even cognitive profile with no differences between VIQ and PIQ, both at BIF level. The highest results were observed in Coding (on an average level) and, together with Arithmetic and Digit Span, were the highest in these scales scores among all four clusters ($F(3, 110) = 12.23$; $p \leq 0.005$; $\eta^2 = 0.25$;

F(3, 110) = 15.086; $p \leq 0.005$; $\eta^2 = 0.29$ and F(3, 110) = 27.556; $p \leq 0.005$; $\eta^2 = 0.43$, respectively). The lowest results were observed in Information and Vocabulary (on a moderate deficit level), however, verbal skills measured by these subtests were not as severely impaired as in Cluster A.

The analysis of information concerning the participants, obtained through the analysis of a socioeconomic status, developmental and educational history, revealed that the only difference between clusters emerged in Cluster A, in which children had a delayed speech development in their early childhood ($\chi 2$ (3) = 10.545; $p = 0.014$).

The Bannatyne's factors analysis (Table 3) revealed that children in all clusters did poorly in the Acquired Knowledge with Cluster A scoring the lowest (F(3, 110) = 14.516; $p \leq 0.005$; $\eta^2 = 0.28$; SpA > SqA > VCA > AqK). Cluster A scored the highest in Spatial factor (F(3, 110) = 23.132; $p \leq 0.005$; $\eta^2 = 0.39$).

Cluster C was the best at Verbal Conceptualization and the worst at Sequential factor (F(3, 110) = 14.949; $p \leq 0.005$; $\eta^2 = 0.30$ and F(3, 110) = 26.57; $p \leq 0.005$; $\eta^2 = 0.42$, respectively; VCA > SpA > AqK > SqA). Cluster B and D showed SqA > VCA > SpA > AqK characteristic with a slight difference in the Sequential factor (0.75; 95% CI [0.01; 1.49]; $p = 0.046$).

Table 3. **Means and standard deviations of the Bannatyne's factors analysis for clusters**

	Cluster A		Cluster B		Cluster C		Cluster D	
Factors	M	SD	M	SD	M	SD	M	SD
Spatial (SpA)	8.76	1.24	6.60	1.12	6.93	1.12	6.68	1.32
Verbal Conceptual (VCA)	5.42	1.23	7.01	1.20	8.37	1.47	7.19	1.11
Acquired Knowledge (AqK)	4.59	1.37	5.95	1.12	6.32	1.76	6.63	1.19
Sequential (SqA)	7.72	1.22	7.59	1.8	5.68	1.50	8.34	1.23
Differences between factors within clusters								
SpA – VCA	3.34*	1.76	-0.41	1.65	-1.43*	1.88	-0.51	1.71
SpA – AqK	4.17*	1.92	0.65*	1.63	0.62	2.38	0.05	1.82
SpA – SqA	1.04*	1.96	-0.99*	2.14	1.25*	1.80	-1.67*	1.93
VCA – AqK	0.83	1.65	1.06*	1.65	2.05*	1.59	0.56*	1.27
VCA – SqA	-2.30*	1.93	-0.58	2.07	2.68*	1.66	-1.16*	1.62
AqK– SqA	-3.13*	1.71	1.64*	2.23	0.63	2.18	-1.72*	1.80

Note. * p < 0.05

Kaufman's three-factor model [32] analysis (Table 4) revealed the following patterns: a) Cluster A: PO > FD > VC; b) Cluster B: PO > VC > FD; c) Cluster C: VC > PO > FD; d) Cluster D: FD > VC > PO. Cluster B and C scored poorly in Freedom from Distractibility, Cluster A scored the lowest in Verbal Comprehension (F(3, 110) = 28.819; $p \leq 0.005$; $\eta^2 = 0.44$), and Cluster D the lowest in Perceptual Organization

($F(3, 110) = 23.040$; $p \leq 0.005$; $\eta^2 = 0.39$), but the highest in Freedom from Distractibility ($F(3, 110) = 40.835$; $p \leq 0.005$; $\eta^2 = 0.53$).

Table 4. **Means and standard deviations of the Kaufman factors analysis for clusters**

	Cluster A		Cluster B		Cluster C		Cluster D	
Factors	M	SD	M	SD	M	SD	M	SD
Verbal Comprehension (VC)	5.19	0.98	6.74	0.99	7.89	1.48	6.86	1.03
Perceptual Organization (PO)	8.86	1.01	7.59	0.82	7.36	1.32	6.83	1.02
Freedom from Distractibility (FD)	6.56	1.40	5.72	1.62	4.58	1.40	8.65	1.13
Differences between factors within clusters								
VC – PO	-3.67*	1.49	-0.852*	1.32	0.525	1.94	0.031	1.42
VC – FD	-1.38*	1.72	1.03*	2.03	3.30*	1.84	-1.79*	1.60
PO – FD	-2.29*	1.89	1.88*	1.65	2.78*	2.18	1.81*	1.56

Note. * $p < 0.05$

Discussion

We identified four types of the WISC-R profiles in the group of students with BIF, which exhibited distinctive impairments and strengths. The characteristics of these diverse profiles are presented below.

Cluster A manifests severe deficits in verbal skills (that bordered a mild intellectual disability) and average visual-spatial skills, which was confirmed by high scores in Spatial and Perceptual Organization and very low results in Verbal Conceptual, Acquired Knowledge and Verbal Comprehension factors in Bannatyne's and Kaufman's classification, and delayed speech development in early childhood. A significant advantage of PIQ over VIQ [33] may indicate a delayed (impaired) language development and/or verbal skills deficits. However, a significant difference between VIQ and PIQ might also result from a variety of factors, including: preferred mode of expression, vulnerability to time pressure (while performing tasks), or the brain trauma [23]. Nonetheless, identical profile has been previously identified as possible language disorder [34] and, according to earlier Polish studies [14], this Cluster manifests a disharmonious developmental disability that includes fragmentary deficits in auditory and linguistic functions.

Furthermore, Bishop [35, 36] reported that children with language deficits usually have the lowest results in Vocabulary, Comprehension and Digit Span (also confirmed in our study). Furthermore, Kaufman's [37] pattern of Perceptual Organization > Verbal Comprehension and Freedom from Distractibility was observed among students with auditory perception deficits. Undoubtedly, students in Cluster A would benefit the most from educational programs focusing on improving their verbal skills, including literacy skills.

In Cluster B, visual-spatial skills were higher than verbal skills, however, in contrast to Cluster A, both remained within the range of BIF. Low scores in Arithmetic, Digit Span and Block Design suggest short-term memory, working memory and attention deficits, which were confirmed by low scores in Kaufman's Freedom for Distractibility factor, but not in Bannatyne's recategorization model. Possibly, an average score in Picture Arrangement and Coding resulted in no decrease in Bannatyne's Sequential factor, which, among other skills, measures attention and memory abilities [38]. This may indicate that these deficits manifest in students in Cluster B primarily in tasks that require verbal information processing.

Short-term memory deficits [39], working memory deficiencies [21, 40] and attention problems are frequent in BIF [34], including high comorbidity with ADHD [10, 11]. As individuals with BIF present difficulties in mental manipulation of abstract information [9, 41], difficulties in attention and memory may become apparent when a student processes verbal and/or numerical content. Therefore, therapeutic interventions for Cluster B students should include the training of short-term memory, working memory and attention, e.g., through educational games. Furthermore, instructions for these students should be very specific, based on tangible, real-life examples and allow for physical manipulation of study aids [6, 41].

In Cluster C, VIQ were higher than PIQ. The lowest scores were observed in Information, Arithmetic, Digit Span, Coding, and the highest in Comprehension, Similarities and Picture Arrangement, which indicated an uneven cognitive profile for both verbal and non-verbal skills, similar to the ACID profile [32]. ACID profile (low scores in Information, Arithmetic, Digit Span, and Coding confirmed in Cluster C) is considered by some as characteristic for dyslexia [42], as its typical deficits include impaired working memory and attention [43]. Furthermore, the pattern of factors according to Bannatyne: SpA > AqK > SqA and Kaufman: VC > PO > FD, also confirmed in our study, is characteristic for learning disabilities (LD) [38, 42]. Delayed speech development is also a typical symptom of the risk of dyslexia [43].

In Poland, the widespread assessment practice recommends diagnosing dyslexia from 85 points in an IQ test [44]. However, as ICD-10 [2] advocates diagnosing dyslexia from the IQ level of 70 points, and Siegel [45] claims that intelligence assessment is unnecessary for the diagnosis of learning disabilities, in our study dyslexic students in Cluster C could in fact be incorrectly assessed as students with BIF. Comprehension and Similarities scores were the highest in this Cluster, suggesting average understanding and reasoning skills, which could indicate dyslexia, as reading comprehension problems result directly from deficits in word decoding and recognition skills [46]. Thus, Cluster C may represent in fact a Specific LD, not BIF. However, not all studies confirmed ACID profile as characteristic for dyslexia [16, 47]. Moreover, children with BIF also exhibit literacy problems: writing errors, simplified reading strategies and poor reading comprehension [11, 39, 48], and their speech development is delayed

[11]. According to Mazurkiewicz-Gronowska and Turczyn-Iskrzak [16], the WISC-R subtests differentiating dyslexia and BIF are: Digit Span, Picture Completion, Picture Arrangement, Object Assembly, and Coding. Furthermore, low scores in Coding and Information have been suggested as frequent in students with LD, but not in those with impaired linguistic development [49], which is in line with our results. Ozkan et al. [50] reported that primary school students with BIF scored higher than their peers with SLD in minor neurological symptoms, specifically sensory integration and motor coordination, but did not differ from them in copying figures tasks and auditory-verbal short-term memory. Children with SLD were better at emotion regulation. Similarly, inferior ability to discriminate and monitor emotions was reported as characteristic of BIF [51]. These differences might help to discriminate between the two groups during the assessment. Children who manifest Cluster C difficulties would benefit most from evidence-based phonological awareness trainings and reading instruction: namely, literacy interventions, designed for children with SLD.

In Cluster D verbal and nonverbal cognitive skills were both at BIF level. In this even cognitive profile, all verbal and non-verbal skills are between – 1.01 to – 2.00 *SD* below the average. In Cluster D, the best abilities included: short-term memory, attention, sequential processing. The poorest abilities included: abstract thinking and reasoning, general knowledge, and recall of information. Deficits in such skills are responsible for impaired deep learning, which is characteristic for students with BIF, and were confirmed in our study by low results in Bannatyne's Acquired Knowledge and Kaufman's Verbal Comprehension. Furthermore, such profile has been already identified by Mazurkiewicz-Gronowska and Turczyn-Iskrzak [16] as typical for students with BIF, where the best scores in the WISC-R emerged in Coding (in our study 9.22), and poorest in Information and Vocabulary (in our study 5.88 and 5.81). Average results in Coding indicate well developed rote memory, which is a relative strength of students with BIF [52], ineffective, though, for deep learning and generalization of knowledge (for which logical memory is required; this type of memory is poorly developed in persons with BIF). Therefore, for students with typical BIF cognitive profile, as the one identified in Cluster D, Shaw [53] recommends a framework which includes demonstrating and practicing new concepts and knowledge through: a) physical manipulation of concrete objects, b) investing extra effort in linking new activities with existing knowledge (multiple revisions of the content of previous classes), c) very detailed guidance on how and when to apply new knowledge, and d) increased pace of practicing new skills.

The identification of the distinct cognitive profiles among heterogeneous group of individuals with BIF has important implications for three main reasons: a) the design of educational and developmental neuropsychological interventions targeting specific limitations of students classified to different clusters, b) the choice of teaching strategies which should be based on their particular strengths, c) further differential assessment criteria and strategies ensuring identification of different BIF subgroups (as demonstrated in this study), and proper recognition of other developmental disabilities co-occurring with BIF [6, 10, 52]. For instance, we are unsure if Cluster A and Cluster C should be treated as BIF, as they majorly fulfill the classification criteria for specific reading and spelling disability, or dyslexia. However, the diagnosis of dyslexia for Cluster C would require a change in Polish assessment practices, as the FIQ was below 85 points. We would recommend such a change, to follow the newest practical and theoretical suggestions [3, 45]. It may involve different adjustment of requirements during school instruction and external examination according to a particular country legislation. Moreover, different treatment approaches are most effective in work with children with diverse cognitive profiles within BIF. All persons with BIF, however, could benefit from flexible assertive community treatment (FACT; therapy outside the hospital, e.g., at home, in the library), as a recent 6-year longitudinal study in the Netherlands [54] showed that it was successful in the improvement of social and psychiatric functioning in individuals with BIF. To conclude, correct assessment is crucial for the educational and professional opportunities of students, as well as for their everyday life functioning and well-being.

Limitations

In this study we did not test for the external validation of cognitive profiles. In a future study, additionally a battery of tests measuring general knowledge, language comprehension and expression, math skills, reading and writing skills, attention processes, visual and auditory impairments, executive functions, etc. should be administered to identify, for instance, dyslexia. Furthermore, our sample size may have reduced confidence in the generalizability of the results. A small sample reduces statistical power to identify smaller effects, thus, possibly certain effects may have remained unnoticed. Therefore, we recommend a replication of this study in a larger group. Our data, however, demonstrate significant differences between clusters to support our hypotheses. Moreover, we used an older version of the WISC. Thus, the actual result might be 7–9 points lower than the obtained one [55]. However, since the average total score in our study was 78.65 points, our participants would generally still have remained within BIF intellectual range.

Future studies should also replicate with the new version of the WISC (WISC-V) and provide detailed analysis with index scores: the Verbal Comprehension Index (VCI), Visual Spatial Index (VSI), Fluid Reasoning Index (FRI), Working Memory Index (WMI), and Processing Speed Index (PSI). For example, a recent study by Pulina et al. [40], which used the WISC-IV, reported that Italian children with BIF, as a whole group, manifested a 'spiky' cognitive profile, as compared with their typically developing peers, who presented a 'flat' profile (and scored higher in all compared factors). Among the BIF group, the lowest score was obtained in the Working Memory factor, and the highest in the Perceptual Reasoning factor. It would be interesting to investigate if it would be possible to identify profiles analogical to those found in our study using these factors.

Conclusions

Based on different patterns of performance on the WISC-R scale, we identified four types of homogenous cognitive profiles of a heterogeneous population of students with BIF. Each revealed distinctive impairments and strengths: a) profile exhibiting severe deficits in verbal skills and average visual-spatial abilities; b) profile where short-term memory and attention deficits are the most prominent; c) ACID profile typical for learning disabilities; d) 'flat' cognitive profile where all verbal and performance skills were on borderline IQ level. These dissimilarities in cognitive functioning impose the need for different assessment strategies and distinctive approach in designing educational and developmental interventions.

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