RESEARCH PAPER

EFFECTS OF EXECUTIVE FUNCTIONS TRAINING IN PRIMARY SCHOOL STUDENTS WITH BORDERLINE INTELLECTUAL FUNCTIONING THROUGH A MULTI-METHOD, MULTI-INFORMANT INTERVENTION: A PILOT STUDY

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Abstract

Objective: Borderline Intellectual Functioning (BIF) impacts cognitive functioning and adaptive behavior. Recent studies have demonstrated the efficacy of Executive Functions trainings to support daily-living skills in several clinical populations. However, although the relationship between Executive Functions and BIF has been studied, few studies have explored the effects of cognitive enhancement training for BIF children. Given the pivotal significance of Executive Functions in learning, orchestrating cognitive processes, and modulating affective and behavioral responses, our study aimed to evaluate the efficacy of cognitive enhancement training targeting Executive Functions in a group of 23 children diagnosed with Borderline Intellectual Functioning devoid of neurodevelopmental impairments.

Method: We included a multiple assessment based on several informants (children, teachers, parents, and tutors) and provided individualized cognitive enhancement training focused on Executive Functions through both digital and analog activities. The training was highly customized, structured and monitored at various stages of the process activities. The training was composed of 20 sessions, each lasting 2 hours, held twice a week for each child.

Results: The obtained results confirmed the efficacy of cognitive enhancement training in improving Executive Functions, the primary target of the intervention, particularly in attention, verbal fluency, planning, inhibitory control, working memory, and flexibility. Furthermore, improvements were observed by all the informants in other cognitive functions, learning, and adaptive behaviors.

Conclusions: Our study contributes to the understanding of BIF, emphasizing the efficacy of neuropsychological enhancement through personalized training for EF.

Key words: borderline intellectual functioning, executive functions, neuropsychology, cognitive enhancement, child neuropsychology

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1. Introduction

Borderline Intellectual Functioning (BIF) is a condition characterized by milder deficit in intellectual abilities, statistically represented by an Intelligent Quotient (IQ) score ranking between 70 and 85 or between -1 to -2 standard deviations below the average score (Peltopuro et al., 2014). This cognitive profile is combined with adaptive difficulties (Vianello & Cornoldi, 2017) in daily activities across practical (organization, planning, responsibility, self-control), conceptual (learning, reasoning, language) or social (interpersonal communication, social judgment, awareness of one’s own and others' thoughts and feelings) domains (DSM-5, American Psychiatric Association - APA 2013). These challenges can lead to restricted access to education, limited independence, and hindered engagement in social activities, thereby affecting the overall quality of life for children with BIF and their families (Martínez-Leal et al., 2020). These children face challenges when it comes to environmental challenges and social situations (Martínez-Leal et al., 2020). They display difficulties in the social domain (Sätilä et al., 2022) such as social information processing, recognition of emotions, social participation as already highlighted by Peltopuro and colleagues (2014). Delays in learning due to cognitive weaknesses and difficulties in social domain may also increase the risk of school failure (Salvador-Carulla et al., 2013; Fernell and Ek, 2010 in Blasi et al., 2021).

In some cases, BIF may present comorbidities with Neurodevelopmental Disorders such as, for example, Autism Spectrum Disorder (ASD), Attention Deficit Disorder/Hyperactivity Disorder (ADHD), language and behavioral disorders (Vianello & Cornoldi, 2017). Furthermore, BIF leads to an increasing risk of neurocognitive problems and it enhances social vulnerability, social exclusion and mental health issues (Wieland and Zitman, 2016; Martínez-Leal et al., 2020). Also, BIF can considerably impact individuals’ lives, limiting independent living, invalidating their abilities to lead independent lifestyles, achieve academic career and success in adulthood (Salvador-Carulla et al., 2013; Martínez-Leal et al., 2020). Indeed, it is estimated that from 12% to 25% of people with BIF display also psychopathological problems such as phobias, depression and mood disorders, personality disorders, substance abuse and behavioral disorders (Salvador-Carulla et al., 2013; GENCAT Recommendations for caring for people with Borderline Intellectual Functioning, 2017; Sätilä et al., 2022), both externalizing and internalizing (Kok et al., 2016).

BIF prevalence is estimated varying in different studies and across countries; for example, among 2.5-7% of Italy, 3% of Spain and 12.3% of the British population (Vianello and Cornoldi; 2017; GENCAT Recommendations for caring for people with Borderline Intellectual Functioning, 2017); the overall prevalence worldwide is estimated to be 7–14% (Sätilä et al., 2022).

The risk factors generally associated with BIF currently included genetic causes (mainly genetic syndromes or chromosomal abnormalities), pre-natal factors related to mothers' health and habits during pregnancy, neonatal/perinatal suffering, neurological disorders and alterations and psycho-social vulnerability factors (Baglio et al., 2014; Sätilä et al., 2022). BIF could be also associated with genetic conditions such as Fragile X Syndrome, Prader-Willi Syndrome, Williams Syndrome, Velocardiofacial Syndrome and del22q11.2 syndrome (De Smedt et al., 2003; Salvador-Carulla et al., 2013). Recently, genetic polymorphisms related to the mechanisms of synaptic plasticity, neuronal maturation and neurotransmission have been investigated (Blasi et al., 2021) and a high correlation between gray matter volumes and IQ was found (Baglio et al., 2014).

The diagnostic framework of BIF (Salvador-Carulla et al., 2013) is currently debated. Both the Fifth volume of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5 and DSM- 5 TR; American Psychiatric Association - APA, 2013 and 2022) and the International Statistical Classification of Diseases and Related Health Problems (World Health Organization, WHO ICD-10 1993 and ICD-11, 2021) do not provide standard definitions of BIF (Girimaji and Pradeep, 2018). DSM- 5 and DSM 5 TR (APA 2013 and 2022) include the BIF among the "*Other Conditions That May Be a Focus of Clinical Attention*" and suggest using this category when the BIF impact on treatments or prognosis (American Psychiatric Association – APA DSM 5, 2013; DSM 5- TR, 2022). The ICD - 10 does not consider the BIF as a distinct functioning profile but as a specifier of other conditions (Vianello and Cornoldi, 2017) and inserts it among the "Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified" specifically among the "*Symptoms and signs involving cognition, perception, emotional state and behavior*". Finally, the ICD-11 mentions Borderline Intellectual Functioning in the "*Neurodevelopmental Disorders*' ' section into the "Disorders of Intellectual Development" category. Although ICD-11 does not consider BIF a diagnostic disorder, it suggests supporting BIF people (see Girimaji & Pradeep; 2018). This lack of clear diagnostic criteria inevitably leads to clinical and practical consequences; first, in terms of diagnostic issues itself. Children with Borderline Intellectual Functioning are often misdiagnosed with Neurodevelopmental Disorders (e.g., Specific Learning Disorder, speech disorder, Intellectual disability - ID) or undiagnosed and so may not receive any treatment (Vianello and Cornoli, 2017).

As previously mentioned, BIF people show a Full-Scale IQ (FSIQ) score between 70 and 85 (from -1 to 2 standard deviations below average score) (Peltopuro et al., 2014). It has recently been highlighted that, in terms of intelligence profile, BIF children differ in comparison to children with Intellectual Disability (ID), typically developing children and children with Specific Learning Disorders (SLD) (see Pulina et al., 2019) as assessed by Wechsler Intelligence Scale for Children (WISC-IV; Wechsler, 2003). In their study, Pulina and colleagues (2019) highlighted the presence of an uneven profile, at WISC-IV (Wechsler, 2003) for BIF children. According to indices analysis, higher scores emerged at the Perceptual Reasoning Index (PRI) and lower scores at the Working Memory Index (MWI); in contrast, typically developing children showed a more homogeneous profile. A discrepancy was also found between the General Ability Index- GAI (higher) than on the Cognitive Proficiency Index- CPI (lower). The BIF children' IQ profile does not appear to change with comorbidities (such as ADHD or Specific Learning Disorders) but comorbidities seem to have an impact on GAI and CPI increasing their discrepancy.

Executive functions (EFs) are a set of cognitive processes that guide our behavior implemented by different neuronal networks in the frontal cortex (Denes, Pizzamiglio et al., 2019). These processes allow us to plan actions, reason and solve problems, adapt behaviors to the environment as well as achieve school and work goals (Denes, Pizzamiglio et al., 2019). The executive functions, although there is no clear definition, include cognitive domains such as attention, flexibility, inhibition, working memory and planning (Denes, Pizzamiglio et al., 2019). Executive dysfunctions are found in frontal lobe lesions but also in some psychiatric disorders (such as schizophrenia and depression), neurological conditions (as Parkinson Disease) as well as in neurodevelopmental disorders (Ozonoff & Jensen, 1999; Denes, Pizzamiglio et al., 2019; Keller & Brighenti, 2023). The development of Executive Functions in childhood occurs mainly from 3/5 years old and by the first decade of life to mature and continue in adolescence and adulthood (see Erostarbe-Pérez et al., 2022). Recent studies highlighted that among EFs, working memory (Alloway, 2010), play an important role in supporting learning (Pulina et al., 2019) even more than the IQ (Diamond and Lee, 2011).

Children with BIF may display specific neuropsychological issues especially in EFs, memory (Van der Molen et al., 2014), language, motor abilities (Blasi et al., 2021; Sätilä et al.; 2022) as well as attention (Baglio et al., 2014). In general, children with BIF show lower outcome than peers in memory tests (Peltopuro et al., 2014) especially in short term memory (Baglio et al., 2014) when compared to children with the same mental or chronological age (Água Dias et al., 2019). Also, they show deficits in visual attention compared to ADHD and typically developing children (Predescu et al., 2020). Regarding EFs, poorer performance compared to peers was found in BIF children in planning, shifting, processing speed, problem solving and inhibition (Alloway, 2010; Peltopuro et al., 2014; Predescu et al., 2020) as well as in working memory (Stefanelli and Alloway, 2020) both in verbal and visuo-spatial domains (Alloway, 2010). Deficits in working memory that increased with the degree of Intellectual Disability has been found in comparative studies among BIF, Intellectual Disability and typically development children (Schuchardt et al., 2010). Moreover, for ID and BIF, executive functioning is considered a more relevant diagnostic marker than IQ (Greenspan, 2017) and, in addition, difficulties in executive functions underlie weaknesses in learning (Pulina et al., 2019). Finally, in BIF children, EFs were linked to behavioral issues and social functioning (Schuiringa et al., 2016).

Generally, interventions tailored on children' needs (Kok et al., 2015) are provided for BIF addressing children, teachers and parent's needs. Educational training to support basic skills are aimed at improving learning and adaptive behaviors and, as for the school, they are helpful to plan personalized and flexible learning programs according to the characteristics of each child (Vianello and Cornoldi, 2017). Several studies have highlighted the usefulness of parent-training interventions as well as psychological and behavioral training for BIF children to reduce externalizing problem behavior (van Herwaarden et al., 2022) and the effectiveness of social, emotional and behavioral skills training for BIF adolescents (Nestler and Goldbeck, 2011).

To support executive functions in children, computers or combined training with games and neuropsychological tasks are used (Diamond and Lee, 2011). Particularly, executive functions training shows to be effective for cognitive enhancement in children, especially in ADHD (Shuai et al., 2017).

Although the relationship between executive functions and BIF has been studied, few research has explored the effect of cognitive enhancement training for BIF children. Regarding BIF, computer-based working memory training has been described as effective in children (Roording-Ragetlie et al., 2017) and adolescence (Van der Molen et al., 2010).

The primary goal of our pilot study was to evaluate the efficacy of individualized cognitive training for Executive Functions (EFs) in a group of BIF children.

2. Methods

2.1. Participants

This pilot study was carried out within the High Performance Learning (HPL) Training Center, a center open to citizens and families with children with BIF for their cognitive enhancement. The HPL Center is a private center funded by private and public institutions that provides personalized cognitive enhancement for children with Borderline Intellectual Functioning. Participation in the activities of the Center is free of charge for families. We promoted HPL activities, collected requests, and recruited children with Borderline Intellectual Functioning through an open call, collaborating with neuropsychiatrists and psychologist of National Health Service, schools, psychologists, educators, and parents. The recruiting phase started in September 2022 and ended in February 2023.

The inclusion criteria to be enrolled in the pilot study were: children attending primary school, diagnosis of Borderline Intellectual Functioning made by a specialized clinical unit or a Full Scale IQ scores between 70 and 85 (evaluated with WISC-IV; Wechsler, 2003) or, for a Full Scale IQ between 85 and 90, a significant statistical difference between Cognitive Proficiency Index (CPI) and General Abilities Index (GAI) with GAI> CPI (according to Italian Standardization Norms for WISC-IV; Wechsler, 2003); absence of behavioral or conduct problems or ADHD or ASD that could significantly compromise participation as evaluated by the professionals (neuropsychiatrists and/or psychologist from National Health Service) who referred the participants, absence of Intellectual Disability. According to inclusion criteria, 23 children were enrolled in the pilot study. Demographic characteristics, as well as Full Scale IQ scores are summarized in **table 2**.

78 applications have been made to access the HPL Centre. Of these, 48 were boys and 28 girls and 2 requests were made in a generic way not specifying the gender. 36 children were excluded (see **table 1** for details) and 7 have been put on the waiting list for next year's training program due to budget limit, 12 requests were unsuccessful/have been withdrawn.

Children did not exhibit any emotional issues or mood disorders according to professionals' evaluations, nor were any of them taking medication for behavioral or emotional problems. One girl was on antiepileptic therapy. For 17 out of 23 children, the school was providing personalized academy curricula with tailored facilities. 7 children underwent other rehabilitation therapies: specifically, for 2 children, a family-focused educative intervention was activated; 1 child received private homework assistance once a week, 3 children received speech therapy once a week, and 1 child received speech therapy and psychomotor therapy once a week.

We collected demographic and sociological data through a specially created form. The families included in the training came from various social, economic, and cultural backgrounds. None of the families declared themselves to be in a very easy economic situation reporting some economic difficulties or facing significant financial challenges. Overall, families reporting any level of economic difficulty constitute

Table 1. *Exclusion criteria*

	N
ASD	1
Age >10 y.	8
ADHD	1
Specific Learning Disorder (SLD)	2
Without diagnosis	2
IQ out of the range	11
Intellectual developmental disorder	5
Others	6
Total	36

Table 2. *Characteristics of the entire sample (n=23)*

Gender	N	Mean age (SD)	Age Min- Max	Mean FSIQ (SD)	FSIQ Min- Max
Male	14	8.92 (0.99)	7-11	77.85 (5.8)	71-89
Female	9	8.78 (0.67)	8-10	79.3 (5.05)	69-85
Total Sample	23	8.87 (0.86)	7-11	78.4 (5.45)	69-89

78.26% of the sample (n=18).

6 children have foreign origins, either from both parents or from one of them. The average educational level of the mothers was 13.21 years (standard deviation = 3.52, ranging from 8 to 18); for fathers, the average educational level was 11 years (standard deviation = 4.21, ranging from 5 to 22).

2.2. *Assessment*

After a medical history collection, a complete neuropsychological evaluation of attention, memory and executive functions and learning (language, reading, writing, mathematics) was conducted (see **table 3** for details).

Specifically, selective auditory and visual attention were evaluated through a set of tests from the Battery for the Neuropsychological Evaluation - for children between 5-11 years (BVN 5-11; Bisiacchi et al., 2005-2023). As for the executive functions, an EFs screening was made through the children's version of the Frontal Assessment Battery (FAB- Italian version by Scarpa et al., 2006). Cognitive flexibility and verbal fluency were evaluated by BVN 5-11 (Bisiacchi et al., 2005-2023). We evaluated cognitive inhibition through Numerical Stroop (extracted from the Italian Battery for ADHD-BIA; Marzocchi, Re, Cornoldi, 2021). Planning has been evaluated with the Tower of London (BVN 5-11; Bisiacchi et al., 2005-2023). To assess memory, working memory was evaluated through Digit Span Backward, short-term memory was evaluated through Digit Span Forward and Immediate Recall memory test (BVN 5-11; 2005-2023). Long term memory was evaluated through Delayed Recall memory test (BVN 5-11; Bisiacchi et al., 2005-2023).

In addition, we asked parents and teachers to fill out a specific questionnaire for executive functions in developmental age, the Comprehensive Executive Function Inventory (Italian Edition of CEFI; Naglieri and Goldstein, 2014). This tool allows to evaluate the executive functioning of children in different life contexts (e.g. home and school).

To monitor children's adaptive behaviors and for time and feasibility reasons we have extracted some items from the Vineland Adaptive Behavior Scales-II – Second Edition (Sparrow, Cicchetti and Balla, 2005). Chosen items are summarized in **table 4**. These items were the main domains of observations by the tutors who used them as a guide to monitor pre- training and post-training adaptive behaviors changes through a tailored observational grid. For each item, scores have been assigned according to the Vineland Adaptive Behavior Scales-II manual.

In addition, each child has been asked to self-assess his/her cognitive functioning. In particular, the areas to be assessed were attention, writing, memory, reading, calculating, planning on scale from 1 (minimum) to 3 (maximum) each using a tailored pedagogical narration (see Moletto & Zucchi, 2013).

Table 3. *Cognitive domain assessed*

Domain	Component	Sub-Component	Test
Executive Functions	Attention	Auditory	Selective Auditory Attention – BVN
		Visual	Selective Visual Attention – BVN
	Fluency		Phonemic Fluency – BVN
			Categorical fluency – BVN
	Inhibition and Cognitive flexibility	Cognitive	Numeric Stroop – BIA
		Motor	Conflicting instructions – FAB
			Inhibitory Control (Go-no-Go) – FAB
	Working Memory	Verbal	Digit Span Backward – BVN
	Planning		Tower of London – BVN
			Programming - FAB
Memory	Shorth Term	Verbal	Digit Span Forward- BVN
		Verbal	Immediate Recall- BVN
		Visual-spatial	Tapping Memory Test – BVN
	Long Term	Verbal	Delayed Recall - BVN
Preconditions to learning	Language		Auditory discrimination- BVN
			Repetition- BVN
			Phonemic analysis- BVN
			Phonemic fusion- BVN
			Naming - BVN
			Syntactic comprehension- BVN
Learning	Reading		Text reading- BVN
	Writing		Text writing - BVN
	Counting		Counting- BVN

Note: BNV: Batteria per la Valutazione Neuropsicologica 5-11 - BIA: Batteria Italiana per l'ADHD - FAB: Frontal Assessment Battery

Table 4. *Vineland-II selected items filled by tutors*

Scale	Sub-Scale	Selected Items n°
Communication	Receptive	12, 13, 14, 17, 19
	Expressive	39, 41, 47, 48, 52
	Written	9, 10, 11, 12, 14
Daily living Skills	Personal	27
	Domestic	4, 5
	Community	10, 21, 22
Socialization	Play and Leisure	18, 19, 22, 24
	Interpersonal relationships	16, 19, 26, 27, 30, 31, 32, 34
	Coping	8, 10, 12, 15

2.3. *Training structure*

For each child an Individualized Cognitive Enhancement Plan was developed. The training sessions were in groups of 2 participants. For each child there were 2 EFs training sessions per week, each lasting 2 hours. Each child attended 20 training sessions.

Each session was divided in several moments:

1. General part with all the children involved in the project
   a. welcome and play time
   b. temporal orientation activity
   c. emotion's game
2. Specific activities in small group
   a. cognitive training
   b. game break alone or with the other child
   c. cognitive training
   d. self-evaluation (about the activities and the session)

Activities proposed were extracted from a pool of 117 exercises organized in the main EF domains. Each activity included 3 levels of difficulty (basic, intermediate, advanced) consisting of observable tasks the child had to complete. Proposed activities were both computer-based and pencil-paper activities. Considering neuropsychological test scores, CEFI' scores and observations, we established 3 starting levels for each child and each EFs (attention, flexibility, inhibition, working memory, planning): basic, intermediate, and advanced. We defined criteria for level upgrading: 1) level is passed when a specific task is completed three times correctly, 2) children do not ask for help to complete the task and 3) when there is a generalization of the strategy, so the child uses the learned strategy to the different tasks.

The project itself also involved children' teachers in a tailored 3-hour educational training to enhance their knowledge about the characteristics of BIF and help them to develop useful strategies for their BIF students.

2.4. *Data analysis*

Jamovi Suite (The Jamovi Project, 2022) was used for data visualization and statistical analysis. The groups' raw scores were compared through a nonparametric method, Wilcoxon signed-rank test, to test the efficacy of individualized cognitive training for Executive Functions (EFs). Multiple repeated measures Wilcoxon's rank tests were carried out for each outcome measure. Through the Wilcoxon' W differences between the paired or matched data values are used to test for a difference between the two populations or two observations in the same group. We used a Wilcoxon signed-rank test because scores of the population were not normally distributed. A p-value <0.05 was considered as statistically significant.

3. Results

Means and standard deviations for all outcome measures were computed for both measurement occasions separately (i.e., pre-test and post-test; **table 5**, **6**, **7**). Data were divided into four separate tables according to the source of information (performance-based measurement, parent and teacher report, self-report, tutor-report). **Table 5** reports the performance-based results before and after treatment. BIA scores were significantly lower ($p < .05$) in the post-test conditions except for Total Baseline time, Interference Time and Baseline time/item. BVN' executive functioning, memory, preconditions to learning and learning results had a statistically significant increase ($p < .05$). In the FAB scores the significant increase in the results was considerable ($p <.05$) except for the Inhibitory control/ Go-no go subtest. Results of the others-report scales were summarized in **table 6**. No statistically significant changes were detected from parents whose scores were similar in the pre and post intervention conditions. 5 out of 9 teachers-reports CEFI scales (Full scale, Initiation, Planning, Self-monitoring, Working Memory) were statistically significant ($p < .05$) highlighting a statistically significant increase of the teacher's perception of children' executive functioning abilities. **Table 7** reports children' self-report assessment whose results reflect a statistically significant increase of memory abilities ($p < .05$). Eventually, Vineland-II items showed a statistically significant improvement ($p < .01$) in the areas involved in the training (**table 8**).

4. Discussion

Results of research on BIF participants underlined a specific neuropsychological functioning pattern (Alloway, 2010; Baglio et al., 2014; Peltopuro et al., 2014; Van der Molen et al., 2014; Água Dias et al., 2019; Predescu et al., 2020; Stefanelli and Alloway, 2020; Blasi et al., 2021; Sätilä et al.; 2022) as we found in our 23 BIF participants of this pilot study. Considering the preeminent role of EF during everyday life we trained several cognitive and non-cognitive domains to better help participants in their home and school daily activities. Indeed, after the personalized

Table 5 *Cognitive domain assessed*

Domain	Component	Sub-Component	Test	Test scores	Pre-test M (SD)	Post-test M (SD)	Wilcoxon's W	p-value
Executive Functions	Attention	Auditory	Selective Auditory Attention – BVN	BVN Selective Auditory Attention	28.17 (5.193)	35.09 (3.999)	0.00	<.001**
		Visual	Selective Visual Attention – BVN	BVN Selective Visual Attention	7.09 (2.172)	9.30 (1.769)	0.00	<.001**
	Fluency		Phonemic Fluency – BVN	BVN Phonemic Fluency	17.87 (7.759)	23.43 (7.216)	0.00	<.001**
			Categorical fluency – BVN	BVN Categorical Fluency	32.70 (7.672)	38.61 (6.051)	4.00	<.001**
	Inhibition and Cognitive flexibility	Cognitive	Numeric Stroop – BIA	BIA Identity Errors	4.96 (4.50)	2.13 (1.71)	190	<.001**
				BIA Counting Errors	2.74 (3.37)	1.17 (2.42)	156	<.001**
				BIA Total Baseline Time	21.2 (8.74)	18.8 (5.53)	176	0.111
				BIA Total Stroop Time	167 (46.3)	155 (52.1)	211	0.014*
				BIA Interference Time	0.49 (0.51)	0.54 (0.44)	126	0.645
				BIA Baseline time/item	1.77 (0.728)	1.57 (0.460)	176	0.115
				BIA Mean Stroop Time/item	2.22 (0.617)	2.07 (0.695)	210	0.030*
		Motor	Conflicting instructions – FAB	FAB Sensitivity to Interference	2.000 (1.000)	2.522 (0.511)	5.00	0.005**
			Inhibitory Control - FAB	FAB Go-no go	2.435 (0.788)	2.652 (0.487)	6.00	0.094
	Working Memory	Verbal	Digit Span Backward – BVN	BVN Digit Span Backward	2.70 (0.559)	3.30 (0.635)	0.00	<.001**
	Planning		Tower of London – BVN	BVN Tower of London	7.57 (2.313)	9.65 (1.027)	0.00	<.001**
			Programming - FAB	FAB Motor series	1.652 (1.191)	2.304 (0.926)	13.00	0.002**
		Full Scale - FAB		FAB Full Scale	6.174 (1.899)	7.478 (1.410)	4.00	<.001**
Memory	Shorth Term	Verbal	Digit Span Forward- BVN	BVN Digit Span Forward	4.17 (0.834)	4.43 (0.590)	11.00	0.033*
		Verbal	Immediate Recall- BVN	BVN Immediate Recall	51.83 (14.525)	63.87 (12.204)	16.5	<.001**
		Visual-spatial	Tapping Memory Test – BVN	BVN Tapping Memory Test	3.87 (0.968)	4.43 (0.945)	0.00	<.001**
	Long Term	Verbal	Delayed Recall - BVN	BVN Delayed Recall	7.17 (2.570)	9.13 (2.474)	0.00	<.001**
Preconditions to learning	Language		Auditory discrimination- BVN	BVN Auditory discrimination	31.43 (4.907)	34.26 (2.378)	0.00	<.001**
			Repetition- BVN	BVN Nonwords Repetition	12.83 (2.674)	14.04 (1.397)	0.00	<.001**
			Phonemic analysis- BVN	BVN Phonemic Analysis	43.39 (10.049)	48.78 (5.712)	0.00	<.001**
			Phonemic fusion- BVN	BVN Phonemic Fusion	29.17 (11.934)	32.78 (10.339)	0.00	<.001**
			Naming - BVN	BVN Naming	12.65 (2.461)	14.78 (2.449)	0.00	<.001**
			Syntactic comprehension-BVN	BVN Syntactic comprehension	13.39 (2.743)	15.70 (1.690)	3.5	<.001**
Learnings	Reading		Text reading- BVN	BVN Text Reading syll/sec	1.60 (1.041)	1.85 (1.059)	1.00	<.001**
	Writing		Text writing - BVN	BVN Text Writing- Correct Words	15.70 (8.008)	19.48 (8.543)	14.00	<.001**
	Counting		Counting- BVN	BVN Counting	4.09 (2.557)	5.78 (3.118)	3.5	<.001**

Note. Significant at * p < .05, ** p < .01. *BNV*: Batteria per la Valutazione Neuropsicologica 5-11; *BIA*: Batteria Italiana per l'ADHD; *FAB*: Frontal Assessment Battery

Table 6. *Means, standard deviations and the results of the repeated measures Wilcoxon's W across parent and teacher report CEFI outcome scales*

	Parent-report				Teacher-report			
Test	Pre-test M (SD)	Post-test M (SD)	Wilcoxon's W	p-value	Pre-test M (SD)	Post-test M (SD)	Wilcoxon's W	p-value
Full Scale	221.0 (57.42)	231.6 (45.14)	102.5	0.332	181.9 (42.20)	192.8 (49.00)	65.0	0.024*
Attention	29.4 (7.52)	29.9 (6.66)	94.0	0.492	22.0 (7.99)	23.2 (8.21)	81.5	0.121
Emotion Regulation	27.4 (6.96)	25.3 (6.48)	136.5	0.955	25.7 (7.87)	26.0 (9.26)	109.0	0.290
Flexibility	15.8 (4.40)	16.4 (3.22)	51.0	0.312	11.9 (3.86)	12.3 (4.23)	78.5	0.165
Inhibitory Control	28.0 (7.55)	27.4 (7.59)	122.5	0.751	24.7 (8.19)	24.7 (8.41)	99.5	0.426
Initiation	24.3 (12.06)	24.4 (5.18)	62.0	0.055	17.7 (5.75)	19.7 (6.41)	57.5	0.023*
Organization	27.1 (11.62)	24.7 (5.55)	116.0	0.807	19.2 (6.67)	19.9 (6.41)	102.5	0.142
Planning	27.2 (6.58)	28.1 (5.35)	85.5	0.358	19.1 (5.33)	21.0 (6.41)	48.0	0.010*
Self-monitoring	27.1 (6.50)	27.3 (5.28)	91.5	0.612	21.4 (5.43)	23.0 (5.60)	70.5	0.035*
Working memory	28.2 (8.30)	28.4 (6.34)	121.0	0.583	20.0 (5.68)	23.0 (6.98)	44.5	0.004**

Note. Significant at * p < .05, ** p < .01.

Table 7. *Means, standard deviations and the results of the repeated measures Wilcoxon's W across children self-report scales*

Test	Pre-test M (SD)	Post-test M (SD)	Wilcoxon's W	p-value
Attention	1.96 (0.825)	2.17 (0.887)	38.00	0.176
Writing	2.13 (0.694)	2.22 (0.795)	15.00	0.357
Memory	1.74 (0.810)	2.22 (0.850)	9.50	0.017*
Reading	2.35 (0.714)	2.35 (0.832)	18.00	0.529
Counting	1.91 (0.900)	2.09 (0.848)	25.00	0.246
Planning	2.39 (0.839)	2.48 (0.846)	12.00	0.397

Note. Significant at * p < .05, ** p < .01.

Table 8. *Means, standard deviations and the results of the repeated measures Wilcoxon's W across Vineland-II selected items tutor-report scales*

	Domain	Pre-test M (SD)	Post-test M (SD)	Wilcoxon's W	p-value
Communication	Receptive	5.57 (1.973)	8.00 (1.679)	4.50	< .001 **
	Expressive	4.96 (1.821)	8.35 (1.799)	0.00	< .001 **
	Written	9.00 (2.828)	10.87 (1.660)	0.00	< .001 **
Daily living skills	Personal	1.41 (0.666)	1.73 (0.456)	0.00	0.005 **
	Domestic	2.57 (1.273)	3.43 (0.843)	0.00	0.002 **
	Community	8.22 (3.370)	9.87 (3.109)	14.50	0.002 **
	Play and Leisure	10.35 (2.886)	13.52 (2.274)	0.00	< .001 **
Socialization	Interpersonal relationships	5.22 (2.152)	6.96 (1.224)	0.00	< .001 **
	Coping	5.17 (2.208)	6.61 (1.699)	0.00	< .001 **

Note. Significant at * p < .05, ** p < .01.

training, the neuropsychological test' scores showed an improvement in all cognitive domains at group level.

Our training was focused on Executive Functions, but we unexpectedly found a generalization of several EF to other cognitive domains (see **table 5**). Furthermore, results showed a significant effect of the training both on the learning' preconditions and learning abilities (such as reading, writing and counting). These findings are in line with literature highlighting the role of Executive Functions in guiding cognitive processes and supporting learning (Alloway, 2010; Diamond and Lee, 2011; Pulina et al., 2019; Denes, Pizzamiglio et al., 2019).

The impact of the training for EFs was observed on different domains such as attention, verbal fluency, planning, inhibitory control, working memory and flexibility (see **table 5**). We did not find significant improvements in the executive speed scale but found a statistically significant reduction in the number of errors (see data from BIA Test). We assumed that this result can be considered an increase of the accuracy in responding and a measure of lower impulsivity. We did not find significant improvement in the motor component of inhibitory control. Our activities foreseen a minor intervention in this cognitive domain, mostly providing computer-based activities, structured games or so called "paper and pencil" activities. This can be considered a target domain to address in future research.

The neuropsychological assessment was standardized as well as criteria and procedures for training difficulty levels. At the same time, the EFs enhancement training has been highly personalized to meet the needs of each child, in line with literature (Kok et al., 2016). In line with previous studies that highlighted the efficacy of a EFs computer-based training for BIF (Van der Molen et al., 2010; Roording-Ragetlie et al., 2017) as well as for neurodevelopmental disorders such ADHD (Shuai et al., 2017) our training provided computerized and customized activities.

Furthermore, we adopted an ecological and multi-informant multi-method model considering all the professional and non-professional actors revolving around the child. This can be considered a strength of our pilot study that included parents' and teachers' point of view in the assessment procedures and partially in the intervention. Indeed, we made a standardized assessment of Executive Functions not only through neuropsychological tests but also through the completion of questionnaires by parents and teachers.

Results of teachers' scales (see **table 6**) showed significant behavioral changes in BIF students in their initiative, planning, self-monitoring and working memory abilities. In contrast, parents do not observe significant changes due to training in home life contexts. Several explanations can be taken into account. First, teachers were directly involved through classroom interventions and specific training: they increased their knowledge of BIF and EFs, were trained to observe and monitor behaviors and to act in order to reduce child executive dysfunctions in classrooms.

At the opposite, although literature highlighted the efficacy of parent-training as a procedure to generalize children' abilities (Nestler and Goldbeck, 2011; Vianello and Cornoldi, 2017; van Herwaarden et al., 2022), our training did not include treatment or training for parents: this can be considered as a limit of our study.

Secondly, among BIF's parents there were different ethnic and cultural backgrounds, various languages and communication difficulties and we also could not provide foreign versions of CEFI: it could have had a possible impact on their responses and our results. Therefore, we recognize the need to use different tools in the future, adapted to the native languages of the families, which can equally capture any generalizations of training results in everyday contexts.

The discrepancy between parents' and teachers' perspectives on children's executive functioning in everyday life contexts has been recently highlighted (Schneider, Ryan, & Mahone, 2020) as well as in the literature other authors have highlighted how rating-based assessments compared to performance-based ones show a low degree of agreement (Toplak, West, Stanovich, 2013).

Due to financial and time limitations we could not assess through a standardized procedure the adaptive behaviors from parents' perspective. However, our pre- and post- training assessment throughout a grid filled by tutors in HPL Center according to Vineland-II selected items, underlined significant improvements in all investigated areas (communication, daily living skills, socialization). Adaptive behaviors difficulties concur together with IQ to BIF diagnosis determining the major issues in everyday life contexts for people with BIF (Salvador-Carulla et al., 2013; Martínez-Leal et al., 2020). We found a generalization of cognitive trained abilities to adaptive behaviors (see **table 8**) as highlighted by the Vineland-II' items filled in by the tutors. This result can explain the connection between EFs and behaviors (Schuiringa et al., 2016; Denes, Pizzamiglio et al., 2019) and highlighted the generalizability of an individualized intervention of EFs on adaptive behaviors.

Eventually, BIF children report subjective improvements in their memory abilities in line with the results of neuropsychological tests (see **table 7**). Collecting the direct opinion of children with BIF in the evaluation of the efficacy of the training, in our opinion, enhances self-determination (Vicente et al., 2020) in line with the United Nation Convention on the Rights of Persons with Disabilities (United Nation, 2006).

This is a pilot study realized in a naturalistic setting but the small sample limits to generalize our results to similar settings or children. In addition, because the primary aim of this study was to help and provide effective training, we considered it not ethical to include the control group such as a waiting list. We could not test children, parents and teachers and not be able to offer them treatment or training. In future studies will be necessary to expand the sample and include a control group.

5. Conclusions

In 2017, through the Girona Declaration on Borderline Intellectual Functioning (see GENCAT Recommendations for caring for people with Borderline Intellectual Functioning, 2017), a panel of international experts called for the implementation of actions aimed to increase awareness, to foster interdisciplinary collaboration to improve health policies, research, diagnostics and interventions for people with BIF. Our study, in line with the literature and in accordance with the Declaration, promoted the knowledge of BIF highlighting the efficacy of neuropsychological enhancement through personalized training for EFs.

At the same time, our results suggest the importance of directly involving families and schools in inclusion pathways and training in an integrated perspective. Early interventions for BIF children could change their developmental trajectory giving them the opportunity to reach their life goal and to promote their quality of life.

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