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Executive functions and their relationship with intellectual capacity and age in schoolchildren with intellectual disability

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Abstract

Background There is certain empirical evidence of, on the one hand, a positive correlation between executive functions (EFs) and intelligence in people with intellectual disability (ID) and, on the other hand, a slower rate of development of EFs in these people relative to people without ID. This evidence is not, however, unequivocal, and further studies are required.
Methods We analysed the relationship between development of EFs and both age and intellectual capacity, in a sample of 106 students with either ID or borderline intellectual functioning (BIF) at a special education centre [63 boys and 43 girls, 11–18 years old, mean total intelligence quotient (TIQ) of 59.6]. We applied nine instruments to evaluate both neuropsychological development (working memory, inhibitory control, cognitive flexibility, planning, processing speed and verbal fluency) and behavioural development [teachers' perceptions of the EFs of their students by Behavior Rating Inventory of Executive Function – Second Edition (BRIEF-2) School]. ID and BIF groups were statistically compared in terms of mean performance measures in EF tests. We looked at the correlation between EFs and age, and correlations between EFs and intelligence: TIQ, fluid intelligence [measured by the perceptual reasoning (PR) sub-index of Wechsler Intelligence Scale for Children-IV (WISC-IV)] and crystallised intelligence (measured by the verbal comprehension (VC) sub-index of WISC-IV). Regression models were built for variables with strong correlation.
Results In most of the tests used to evaluate EFs, the ID subgroup performed significantly worse than the subgroup with BIF. In general, teachers' thought that participants had 'medium–low' levels of EFs. TIQ, by WISC-IV scale, correlated significantly with scores in all tests for all EFs. The PR sub-index correlated significantly with 14 of the tests for EFs; 35% of the variation in PR can be explained by variation in performance in Picture Span (working memory) and Mazes (planning). The VC sub-index correlated weakly with seven of the EF tests. We found significant correlations in the ID group between age and scores in all tests of working memory and inhibitory control. Age – considering all participants – did not correlate with any of the variables of teachers' perception except for working memory, and this correlation was not strong.

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Conclusions The results of our study are consistent with descriptions of the typical population: (1) fluid intelligence is more related to EFs than crystallised intelligence is; and (2) working memory capacity is the EF most strongly related with general, fluid and crystallised forms of intelligence. The results suggest that as children and adolescents with ID/BIF get older, their capacities for working memory and inhibitory control increase; development of the other EFs studied was less evident.

Teachers' perceptions of the EFs of children with ID or BIF were independent of intellectual capacity and age. More research is needed to delve further into the development of EFs in people with ID/BIF.

Keywords age, borderline intellectual functioning, executive functions, intellectual disability, intelligence quotient

Background

The term *executive functioning* was first used by Luria, to describe the functioning of the frontal lobe of the brain, which is related with capacity to take initiative, motivation, the formulation of goals, development of action plans and self-monitoring of behaviour (Luria *et al.* 1964; Luria 1973). It was Muriel Lezak (1982, 1987), however, who named the executive functions (EFs) and defined them as the mental abilities essential for carrying out effective, creative and socially acceptable behaviour. Since then, the EFs have been redefined in many ways and the term is now considered to be a 'conceptual umbrella' (Soprano 2003; Zelazo & Carlson 2012) that is still awaiting a clear, formal and agreed definition. Despite this, there is unanimous agreement on the importance of these functions in the development of complex adaptive behaviour in humans (Jurado & Rosselli 2007).

A key piece of research for conceptualisation of EFs is that carried out by Miyake *et al.* (2000). These authors used confirmatory factor analysis to study the internal structure of executive functioning in a typical population. They found three factors that although separate were not completely independent of each other: (1) updating or working memory, (2) inhibition and (3) shifting or flexibility. Over the years, this tri-factor model has been verified various times (Friedman *et al.* 2006, 2008, 2011, 2016; Friedman & Miyake 2017).

Subsequent to the Miyake *et al.* (2000) study, numerous researchers have used factor analysis to study EFs in the general population. Tirapu-Ustárroz *et al.* (2017), in a review paper, concluded that the tri-factor model, for the typical population, was the model best supported by the evidence but added that there are studies that suggest or raise the possibility of new factors, such as verbal fluency (Pineda *et al.* 2000; Fisk & Sharp 2004), planning (Weintraub *et al.* 2005; Brandt *et al.* 2009) and processing speed (Bondi *et al.* 2002; Rose *et al.* 2011).

In a later review focussing on studies of executive functioning in typical children (Tirapu-Ustárroz *et al.* 2018), the studies employed not only measures of working memory, inhibitory control and cognitive flexibility but also measures of verbal fluency, planning and processing speed (Huizinga *et al.* 2006; Van der Ven *et al.* 2012; Reyes *et al.* 2014).

Similarly, with regard to people with intellectual disability (ID)/borderline intellectual functioning (BIF), the most studied EFs are working memory, inhibitory control and cognitive flexibility, followed by verbal fluency (Menghini *et al.* 2010), planning (Danielsson *et al.* 2010) and processing speed (Hooper *et al.* 2018).

Capacities for processing speed, working memory, inhibitory control and cognitive flexibility are related to each other. Lee *et al.* (2013), in a study on development of EFs in children and teenagers of typical intelligence, reported that, throughout most of childhood, inhibitory control and cognitive flexibility are closely associated with processing speed and that, as a child matures, processing speed becomes more independent. McAuley and White (2011) found that processing speed accounted for significant variance in the developmental trajectory of working memory and inhibition. With regard to ID, Schuiringa *et al.* (2017) suggest that the ability of children with ID to resolve EF tasks can depend on the amount of time the children are given to carry out the tasks. Meanwhile, Biesmans *et al.* (2019) suggest that reduced processing speed of people with ID might affect their performance in neuropsychological tasks that draw on other EFs.

There are, of course, diverse measures used to evaluate EFs in research. Some studies approach EFs from a neuropsychological angle and others adopt a behavioural perspective; studies using both types of evaluation are scarce, especially so in the case of research on the ID/BIF population.

We consider neuropsychological and behavioural tests to be complementary and consider that both are necessary to advance our understanding of cognitive functioning in children with cognitive deficit. For this reason, in this study, we use both types of evaluation tool. In the literature, the tendency is to suppose that there is no consistency between neuropsychological test results and the measures of behavioural evaluation (Eslinger & Damasio 1985; Levine *et al.* 1998). In particular, Toplak *et al.* (2013), in their review of the relationship between neuropsychological tests of EFs and behavioural measures of EFs [the Behavior Rating Inventory of Executive Function (BRIEF) questionnaire], found the correlation between these two types of evaluation to be weak ($r = 0.15$).

Despite certain differences in detail, studies of EFs in ID and BIF populations generally follow similar research objectives to those of studies into EFs in typical populations. One of the questions common to studies of both typical and ID populations is whether or not EFs are related to general intelligence. In this respect, Duncan *et al.* (1995) found evidence of a positive correlation between EFs and intelligence: patients with frontal lobe lesions had poor performance in Raven's Progressive Matrices Test. Later, however, Friedman *et al.* (2006) found working memory to be the only EF that correlated strongly with fluid intelligence in the population with typical intelligence; working memory was also the EF with the greatest correlation with crystallised intelligence. Following the Friedman *et al.* (2006) study, other researchers have analysed the relationship between EFs and intelligence, whether fluid or crystallised, generally arriving at the conclusion that, in people of typical intelligence, EFs are more clearly related with fluid than with crystallised intelligence (Arffa 2007; Salthouse & Pink 2008; Floyd *et al.* 2010).

With regard to studies focussed on people with ID or BIF, results tend to suggest that EFs and intelligence are related (Schuchardt *et al.* 2010; Memisevic & Sinanovic 2014; Biesmans *et al.* 2019), although there is uncertainty about the magnitude and nature of that relationship. For example, there are studies in populations with ID that support the observations of Friedman *et al.* (2006) concerning typical populations: that the correlation between EFs and intelligence is principally concerned with working memory (Schuchardt *et al.* 2010; Osório *et al.* 2012; Memisevic & Sinanovic 2014; Biesmans *et al.* 2019). However, we are not aware of any study that addresses the relationship between EFs and the two types of intelligence (fluid and crystallised) separately in a population with ID. Therefore, we believe the study reported here to be the first to analyse these relationships; and, to do so, the perceptual reasoning (PR) and verbal comprehension (VC) sub-indices of Wechsler Intelligence Scale for Children-IV (WISC-IV) were used, as indicated in the documentation on the Wechsler intelligence scales, as variables to represent fluid intelligence and crystallised intelligence, respectively.

Another area of EF research common to studies of populations both with and without ID focusses on how the various different EFs develop over time, from infancy to adolescence. Although it is now established that, in the typical population, EFs start to emerge during the first year of life (Diamond 2002; Espy 2004; Sastre i Riba *et al.* 2015), there are many different theories and conclusions about development of EFs with age (Welsh *et al.* 1991; Anderson 2002).

Welsh *et al.* (1991), after studying the performance at EF tasks of 110 participants (between 3 and 28 years old), described three landmark stages in the executive development of children with typical intelligence in relation to the moment in which they attained adult-level performance: (1) capacity to resist distraction, at around 6 years of age; (2) capacity to organise, evaluate hypotheses and control impulses, at 10 years of age; and (3) competence and accuracy in verbal fluency, performance of motor sequences and complex planning, which continue developing through adolescence (as evidenced by the fact that 12-year-olds were significantly less skilled than adults).

Diamond (2002), in the book *Principles of Frontal Lobe Function*, in a chapter about development of EFs in the typical population, affirms that, in typical development, EFs arise between 8 and 9 months of age with intentional searching for objects desired by but not visible to the baby; by 12 months of age, babies are able to inhibit learned responses and thus change their response in order to get an object; at 3 years of age, children start to anticipate and predict the difficulties of a task; and at 4 years of age, they maintain information mentally and inhibit automatic behaviour.

Differences in the conclusions of Diamond (2002) and Welsh *et al.* (1991) might be explained by the fact that these authors based their conclusions on results derived from different neuropsychological measures. Furthermore, Diamond (2002) studied EFs from the first year of life, while Welsh *et al.* (1991) studied EFs from the age of 3 years.

In agreement with Diamond (2002), Anderson (2002) observes that, at 3 years of age, children with typical development already have the capacity to inhibit automatic behaviour and that cognitive flexibility starts to appear. Anderson (2002), however, confers special importance on the period between 6 and 12 years of age.

A meta-analysis showed that capacity for planning develops maximally between 5 and 8 years of age, although there is continued improvement until adulthood (Romine & Reynolds 2005). There are, however, authors who consider planning to be amongst the last abilities to develop in the typical child (Welsh *et al.* 1991; Anderson *et al.* 1996); and other studies suggest that adult levels of performance in EFs are reached in late adolescence (Luciana *et al.* 2005; Best & Miller 2010). In relation to cognitive flexibility, Espy (1997) observed that this arises between 3 and 5 years of age, but other researchers, such as Anderson (2002) and Zelazo and Frye (1998), observe that 7-year-old children still have difficulties making mental transitions between categories in a classification task, improve considerably between 6 and 9 years of age and continue improving until adolescence.

With regard to the study of the development of EFs in children and adolescents with ID, the evidence begins to suggest that there is a persistent delay in development of EFs and that the rate of acquisition is slower than in non-ID subjects (Cornish *et al.* 2013; Hooper *et al.* 2018). The details of how the EFs develop in the ID population remain to be elucidated.

In view of the foregoing, in the current study, we take a look, from a neuropsychological and behavioural perspective, at EFs in children and adolescents with ID and BIF. We ask the following research questions (RQs) and test the following hypotheses:

- RQ1: What is the relationship between intellectual capacity and performance in neuropsychological tests of EFs?
  - O: Hypothesis 1: There will be significant correlation between total intelligence quotient (TIQ) and performance in neuropsychological tests of EFs.
  - O: Hypothesis 2: There will be significant correlation between PR and performance in most tasks of neuropsychological tests of EFs.
  - O: Hypothesis 3: There will not be a significant correlation between VC and performance in most tasks of neuropsychological tests of EFs.
- RQ2: What is the relationship between scores in tests (neuropsychological and behavioural) and age for these children and adolescents with ID and BIF?
  - O: Hypothesis 4: There will be significant correlation between performance in most tasks of the neuropsychological tests of EFs and age.
  - O: Hypothesis 5: There will be significant correlation between age and most of the perceptions of EF levels made by teachers.

As far as we know, there are currently few studies with such a broad sample of children and adolescents with ID and BIF as that used in the study reported here. Neither are there studies with such a complete battery of evaluation tests as that employed here, which covers all EFs from both a neuropsychological and behavioural perspective. Furthermore, as far as we know, the present study is the first to address the relationship, in the ID/BIF population, between performance at EF tasks and fluid intelligence (represented by PR) and crystallised intelligence (represented by VR). In this sense, the results of this work may help neuropsychologists and special-education teachers to better direct standardised evaluations and interventions and didactic strategies.

Method

Participants

The study involved 106 students and their teachers from a special-education school in Madrid. Of these students, 63 were boys and 43 girls, all between 11 and 18 years old (mean = 15 years; SD = 2 years). Mean TIQ was 59.61 (SD = 10.05). The aetiology of cognitive deficits differed between students: cognitive deficits were linked to perinatal events in 30% of the students or to a known syndrome in 34%; in the other 36%, the aetiology was unclear. Seventy-nine participants were not receiving pharmacological treatment; 27 were receiving some type of medication (anti-psychotic or anti-epileptic medication and stimulants).

For some of the statistical analyses, the sample was divided into two groups: a group with ID (45 ≤ TIQ ≤ 69; mean = 55.34 and SD = 6.44) comprising 37 girls and 46 boys between 12 and 18 years of age (mean = 15 years; SD = 2 years); and a group with BIF (70 ≤ TIQ ≤ 84; mean = 75.04 and SD = 3.15) comprising 6 girls and 17 boys between 11 and 17 years of age (mean = 15 years; SD = 2 years).

Inclusion criteria were having a TIQ between 45 and 84 and being between 11 and 18 years old (chronologically). Participants who started or finished a course of pharmacological treatment during the period of evaluation were excluded.

Measures

Measurement of intelligence was by means of the Spanish adaptation of the WISC-IV (Wechsler 2005), which was the measure chosen by the school the participants attended. All the tools chosen for neuropsychological evaluation of EFs include scales for the typical child population. In addition, all measure at least one of the following capacities (according to the respective authors): working memory, inhibitory control, cognitive flexibility, planning, processing speed and verbal fluency. The selected tests are described in more detail as follows:

- *Digits* and *Letters and Numbers* of WISC-IV (Wechsler 2005). These measure working memory (predominantly auditive). In *Digits*, a series of numbers spoken by the examiner must be repeated in order and then in reverse order. In *Letters and Numbers*, numbers spoken by the examiner must be put in ascending order and letters, in alphabetical order.
- *Coding* and *Symbol Search* of WISC-IV (Wechsler 2005). These measure processing speed. In *Coding*, the subject must rapidly copy symbols paired with numbers. In *Symbol Search*, the subject must rapidly indicate if any of the symbols in a column on the left of the page are also in a column on the right. Reliability coefficients for the aforementioned four subtests from WISC-IV lie between 0.72 and 0.91. In our study, we used total unprocessed scores in each test.
- *Picture Span* of WISC-V (Wechsler 2015). This measures working memory (predominantly visual). Here, the subject must observe some pages with drawings of objects on them and then, on another page, select the pictures previously seen in order. The reliability coefficient is greater than or equal to 0.78. In our study, we used total unprocessed scores.
- The Stroop Color and Word Test (Golden 1994). Sub-tasks *Word* and *Color* measure processing speed: the subject must rapidly read words (*Word*) and say colours (*Color*). The sub-task *Word–Color* measures inhibitory control as the subject must suppress the tendency to read words and instead name the colour in which the word is printed. Reliability coefficients are 0.88, 0.79 and 0.71, respectively. In our study, we used the number of correctly spoken items in 45 s per sheet.
- The *Five Digit Test* (Sedó 2007). This measures processing speed in subtasks *Reading* and *Counting*, inhibitory control in *Choosing* and cognitive flexibility in *Shifting*. In the first two tasks, the subject must rapidly read the values of some numbers (*Reading*) and count how many asterisks there are in a group (*Counting*). Subsequently, the subject must count the numbers whose values are different to the sum of the set, which requires inhibition of the tendency to read the numbers (*Choosing*). In the final test, the subject proceeds as in *Choosing* except that when the box is thick, he or she must read the number (*Shifting*). Reliability coefficients fall between 0.86 and 0.94. In our study, we used the time spent on each subtask.
- *Phonemic Fluency and Semantic Fluency and Category Switching* of Delis–Kaplan Executive Function System (D-KEFS) (Delis *et al.* 2001). The first two tasks measure verbal fluency and the third measures cognitive flexibility. In all these tasks, the subject must say a series of words in 60 s: words that begin with 'f', 'a' and 's' (*Phonemic Fluency*); animals and children's names (*Semantic Fluency*); and alternate between types of fruit and types of furniture (*Category Switching*). Reliability coefficients are in the ranges of 0.68–0.81; 0.53–0.75; and 0.53–0.73, for the three tests, respectively. In our study, we used the total number of words fulfilling the condition.

- *Animal Sorting* of NEPSY-II (Korkman *et al.* 2014). This measures cognitive flexibility. The subject must look for different classification criteria to establish two different groups of the animals drawn on eight cards. The reliability coefficient is 0.66. In our study, we used the number of correct responses.
- *Mazes* from WISC-R (Wechsler 1994). This measures planning. The subject must find the routes through mazes of increasing complexity (without lifting the pencil from the page) within a time limit. The reliability coefficient of this test is between 0.43 and 0.80. In our study, we used total unprocessed score.
- *Tower of London* (Culbertson & Zillmer 2006). This measures planning. The subject must rapidly place some balls in the same positions as on the examiner's board, using as few movements as possible. The reliability coefficient for number of movements is 0.80. In our study, we used the number of excess movements (calculated by subtracting, for each item, the number of necessary movements from the number of movements made).

In addition, evaluation of EFs from the behavioural point of view in the context of the classroom was carried out on the basis of the opinions expressed by teacher-tutors in response to the adaptation to Spanish of the *Behavior Rating Inventory of Executive Function – Second Edition* (BRIEF-2; Gioia *et al.* 2017). This questionnaire provides clinical scales that are combined into three general indices: the Behaviour Regulation Index, based on the Inhibit and Self-Monitor scales; the Emotion Regulation Index comprising the Shift and Emotional Control scales; and the Cognitive Regulation Index, which combines the Initiate, Working Memory, Plan/Organize, Task-Monitor and Organization of Materials scales. The reliability coefficients of the various scales are in the range of 0.74 to 0.93.

Procedure

Once students who fulfilled the inclusion criteria had been recruited, the neuropsychological tests were started, on an individual basis for each student. Tests were carried out in the school, in the Guidance Department. The BRIEF-2 questionnaire was given to the respective teacher-tutors. Neuropsychological tests of EFs were always performed in the same order, alternating tests according to sensory modality (visual or auditory) and to the EF being evaluated. The time needed to evaluate intelligence was about 1 h, and the time needed to complete the neuropsychological tests of EFs was about 2 h. All the tests selected have scales for children with typical development. We scored participants' performance in the Five Digit, Stroop and D-KEFS tests and in BRIEF-2, taking the chronological age of the student into account. In the case of the WISC-R, WISC-IV, WISC-V and NEPSY-II scales, the scores of those over 17 years of age were obtained on the basis of the upper age limit for these scales (16 years and 11 months); the same approach was used with the Tower of London test (which has an upper age limit of 15 years and 11 months).

Data analysis

Statistical analysis was carried out with SPSS.21 software.

First, each measure of performance for each participant in each test was transformed to a *T*-score (with mean = 50; SD = 10). Our interpretation of these *T*-scores is shown in Table 1; thus, we use a single classification of scores to facilitate interpretation of our results. Because BRIEF-2 questionnaire scores are such that a higher score indicates worse performance (which is the reverse of what occurs with neuropsychological tasks), we inverted the *T*-scores (by subtracting them from 100) in order to establish a common criterion for comparison. The degree of normality of the distributions was determined by means of the

Table 1 Relationship between *T*-scores and performance levels

T-score ($\bar{x}$ = 50; *s* = 10)	Performance level
≥76	Very high
66–75	High
56–65	Medium–high
46–55	Medium
36–45	Medium–low
26–35	Low
≤25	Very low

asymmetry coefficient and by diagrams with histograms and a superimposed normal curve.

Intellectual disability and BIF groups were established, and the descriptive statistics for each variable were calculated for each group. The non-parametric Mann–Whitney *U*-test (for independent samples) was used to compare the mean values, in the two groups, of variables from both the neuropsychological tests (Table 2) and the BRIEF-2 questionnaire (Table 3). In the study comparing measures of neuropsychological evaluation variables, scores in WISC-IV tests measuring working memory (Digit Span and Letter–Number Sequencing) and processing speed (Coding and Symbol Search) were excluded because these measures are part of the TIQ score, which is the variable employed to place participants in the BIF or ID subgroups of participants. Finally, in cases where differences were statistically significant, Cohen's *d* was calculated to indicate the size of the effect.

Study of the relationship between intellectual capacity and performance in neuropsychological tests of executive functions (Research Question 1)

We carried out analyses based on the Pearson and Spearman correlations (depending on whether variables were normally distributed or not) between TIQ and the various measures of EF performance. Also, we analysed the correlations between performance in EF tests and PR and VC, respectively. PR is considered to be a measure of capacity for fluid intelligence and VC, a measure of capacity for crystallised intelligence. In cases in which there was

Table 2 Descriptive statistics of executive function variables for the intellectual disability and borderline intellectual functioning groups and for differences between these groups

Variables of neuropsychological tests	ID group (*n* = 83) Mean (SD)	BIF group (*n* = 23) Mean (SD)	*P* value	Cohen's *d*
Working memory				
Digit Span (WISC-IV)	30.1 (8.8)	41.3 (7.6)	–	–
Letter–Number Sequencing (WISC-IV)	29.2 (8.9)	38.2 (8.6)	–	–
Picture Span (WISC-V)	33.6 (9.2)	43 (13.1)	<0.001	0.83 (0.38)
Inhibitory control				
Word–Color (Stroop)	31.5 (7.7)	37.4 (9)	0.008	0.70 (0.33)
Choosing (Five Digit Test)	29.6 (2.8)	32.2 (5.9)	0.002	0.56 (0.27)
Cognitive flexibility				
Category Switching (D-KEFS)	36.1 (9)	44.3 (10.4)	0.001	0.84 (0.39)
Animal Sorting (NEPSY-II)	28 (9.2)	31.1 (9.7)	0.103	–
Shifting (Five Digit Test)	29.7 (3.2)	30.8 (3.6)	0.006	0.32 (0.16)
Planning				
Mazes (WISC-R)	40.9 (10.7)	53.6 (8.4)	<0.001	1.32 (0.55)
Excess movements (Tower of London)	32.5 (11)	36.5 (17.7)	0.119	-
Processing speed				
Coding (WISC-IV)	28.0 (5.8)	35.3 (5.7)	–	–
Symbol Search (WISC-IV)	30.8 (5)	39.1 (9.8)	–	–
Word (Stroop)	30.6 (7.7)	34.1 (7.1)	0.46	–
Color (Stroop)	27.5 (6.7)	35 (9.6)	0.001	0.90 (0.41)
Reading (Five Digit Test)	30.1 (2.6)	32.4 (4.6)	0.006	0.62 (0.29)
Counting (Five Digit Test)	29.5 (2.2)	31.1 (4.4)	0.006	0.46 (0.22)
Verbal fluency				
Phonemic Fluency (D-KEFS)	32.8 (8.4)	39.1 (9.7)	0.008	0.69 (0.33)
Semantic Fluency (D-KEFS)	35.2 (9.1)	42.3 (10.3)	0.002	0.73 (0.34)

T-scores: mean = 50; standard deviation = 10. Min., minimum; Max., maximum; SD, standard deviation; IQA, interquartile amplitude. In blue: low performance. Non-parametric Mann–Whitney *U*-test. ID, intellectual disability; BIF, borderline intellectual functioning. The tests Digit Span, Letter–Number Sequencing, Coding and Symbol Search were not included when comparing means because these tests determine total intelligence quotient (TIQ), a variable that was used to place participants in the BIF or ID subgroups.

Table 3 Descriptive statistics of BRIEF-2 scores for the intellectual disability and borderline intellectual functioning groups and for differences between these groups

	ID group (n = 83); $\bar{x}$ (SD)	BIF group (n = 22); $\bar{x}$ (SD)	*P* value	Cohen's *d*
Clinical scale				
Inhibit	37.1 (13.5)	40.3 (15.6)	0.219	–
Self-Monitor	34.4 (14.1)	36 (11.5)	0.592	–
Shift	34.8 (11.8)	42.1 (10.9)	0.013	0.64 (0.30)
Emotional Control	40.5 (14.4)	40.6 (14.5)	0.984	–
Initiate	43.1 (9.2)	46.4 (10.3)	0.139	–
Working Memory	37 (10.4)	42.1 (9.3)	0.049	0.52 (0.25)
Plan/Organize	40 (7.4)	42.9 (7.8)	0.116	–
Task-Monitor	39.5 (9.4)	43.5 (7.3)	0.074	–
Organization of Materials	44 (12.3)	43.8 (15.2)	0.553	–
Indices				
Behaviour Regulation Index	35.2 (13.3)	38 (14)	0.41	–
Emotion Regulation Index	35.9 (13.6)	40.4 (13.1)	0.173	–
Cognitive Regulation Index	39.1 (8.1)	42.7 (8.8)	0.096	–
Global Executive Composite	35.8 (9.8)	40.1 (10)	0.133	–

T-scores: mean = 50; standard deviation = 10. *T*-scores have been inverted by subtracting them from 100. Non-parametric Mann–Whitney *U*-test. ID, intellectual disability; BIF, borderline intellectual functioning; $\bar{x}$, mean; SD, standard deviation. In blue: low performance.

moderate correlation, we evaluated, by means of simple linear regression, the possible predictive value of TIQ, PR and VC for the EF concerned and vice versa. In cases in which the unstandardised residual was normal, we obtained parametric coefficients; in all other cases, the regression line was calculated using Theil's incomplete method. In cases in which it was possible to build regression models with two measured variables, we did multiple regression analysis.

Study of the relationship between age and executive function performance (Research Question 2)

The Pearson or Spearman correlation coefficients were calculated for the possible relationship between direct scores in each test and age of participant. BRIEF-2 direct scores correspond to the sum of the values given by the teachers to each item of the questionnaire (1 point = never; 2 points = sometimes; and 3 points = frequently). Note that, with the BRIEF-2 questionnaire, for the items evaluated, a higher score corresponds to worse EF performance.

Results

Exploration of mean performance values of the participants at different evaluation tests

The BIF group performed statistically better than the ID group for the tests: Picture Span (*working memory*), Word–Color and Choosing (*inhibitory control*), Category Switching and Switching (*cognitive flexibility*), Mazes (*planning*), Color, Reading and Counting (*processing speed*) and Letter Fluency and Category Fluency (*verbal fluency*). However, there were no significant differences between the groups with respect to Animal Sorting, Tower of London or Word (Table 2).

With respect to the results of behavioural evaluation, teachers generally felt that their students had medium–low performance of EFs. They considered the capacities most affected in students with ID were *Self-Monitor* and *Shift*. Similarly, *Self-Monitor* was the capacity most compromised in students with BIF. At the other end of the scale, the most conserved capacity in ID students was *Organization of Materials*, and in BIF students, it was *Initiate*. Therefore, teachers perceived the EF performance of students with BIF to be slightly better than that of students with ID on all the clinical scales of BRIEF-2 except for *Organization of Materials*. However, the only statistically significant differences amongst these perceptions were in *Shift* and *Working Memory* (Table 3).

Relationship between intellectual capacity and performance in neuropsychological tests of executive functions (Research Question 1)

To study the relationship between TIQ and performance in EF tests, the WISC-IV test variables measuring *working memory* and *processing speed* were excluded because they constitute part of TIQ.

With regard to the relationship between TIQ and *working memory*, there was a strong and significant correlation between TIQ and performance in Picture Span (Table 4). It was possible to build a regression model with these two variables, and 22.6% (R^2 = 0.226) of variation in TIQ can be explained by a linear dependency of TIQ on score in Picture Span; this does not imply that the converse is also the case (Table 5).

There were moderate statistically significant relationships between TIQ and individual variables measuring *inhibitory control*, *processing speed* and *verbal fluency*. Relationships between TIQ and individual variables reflecting *cognitive flexibility* and *planning* were also significant, but the correlation was small or moderate. With regard to the relationship between TIQ and *planning*, the strongest correlation was observed between TIQ and performance in Mazes (Table 4).

When TIQ is taken as the dependent variable, 21% of the variation in TIQ can be explained by a linear dependency on performance in Mazes (Table 5). And, when TIQ is taken as the independent variable, the same percentage (21%) of the variation in performance in Mazes can be explained by TIQ. It is concluded, therefore, that the relationship between these two variables is bidirectional, that is, they influence each other (Table 5).

Finally, multiple regression analysis, taking TIQ as the dependent variable and scores in Mazes and Picture Span as independent variables, indicated that 38% of the variation in TIQ can be explained by combined differences in performance in the Mazes and Picture Span tasks.

Table 4 Correlation between total intelligence quotient and executive function variables

Variables of neuropsychological tests	Total intelligence quotient (TIQ)		
	Pearson's *r*	Spearman's rho	*N*
Working memory			
Picture Span (WISC-V)		0.54**	106
Inhibitory control			
Word–Color (Stroop)	0.36**		104
Choosing (Five Digit Test)		0.36**	102
Cognitive flexibility			
Category Switching (D-KEFS)	0.29**		106
Animal Sorting (NEPSY-II)	0.32**		106
Shifting (Five Digit Test)		0.31**	102
Planning			
Mazes (WISC-R)	0.46**		106
Excess movements (Tower of London)	0.23*		106
Processing speed			
Word (Stroop)	0.33**		104
Color (Stroop)	0.39**		104
Reading (Five Digit Test)		0.35**	105
Counting (Five Digit Test)		0.32**	102
Verbal fluency			
Phonemic Fluency (D-KEFS)	0.30**		106
Semantic Fluency (D-KEFS)	0.37**		106

*Two-tailed significance ($P < 0.05$).
**Two-tailed significance ($P < 0.01$).
***Two-tailed significance ($P < 0.001$).
WISC, Wechsler Intelligence Scale for Children; D-KEFS, Delis–Kaplan Executive Function System.

With regard to the study of the relationships between PR and performance in EF tests (including those of WISC-IV), there were significant correlations with 14 of the neuropsychological tests (Table 6). Picture Span and Mazes have the strongest correlation with PR index (as we found with TIQ). The multiple linear regression study indicates that 35% of the variation in PR can be accounted for by variance in scores for these two EF tasks.

Concerning the relationships between VC and performance in EF tests (including those of WISC-IV), in general, correlations were weak (Table 7). The strongest correlations – although still weak – were between VC index and performance in working memory tasks (Digits and Letters and Numbers).

Table 5 Simple linear regression lines

Regression line	Estimate	SE	LL 95% CI	UL 95% CI	*P*
TIQ = 43.799 + 0.443 × Picture Span (*T*)	0.44	0.08	0.28	0.60	<0.001
Picture Span (*T*) = 5.263 + 0.511 × TIQ	0.51	0.09	0.33	0.69	<0.001
TIQ = 42.145 + 0.4 × Mazes (*T*)	0.40	0.08	0.25	0.55	<0.001
Mazes (*T*) = 12.348 + 0.526 × TIQ	0.53	0.10	0.33	0.72	<0.001
PR = 55.098 + 0.428 × Picture Span (*T*)	0.43	0.12	0.20	0.66	<0.001
Picture Span (*T*) = 16.906 + 0.267 × PR	0.27	0.07	0.12	0.41	<0.001
PR = 42.951 + 0.628 × Mazes (*T*)	0.63	0.10	0.43	0.82	<0.001
Mazes (*T*) = 12.251 + 0.447 × PR	0.45	0.07	0.31	0.59	<0.001
VC = 55.242 + 0.301 × Digits (*T*)	0.30	0.10	0.10	0.40	0.004
Digits (*T*) = 15.579 + 0.261 × VC	0.26	0.09	0.09	0.44	0.004

CI, confidence interval; LL, lower limit; UL, upper limit; SE, standard error; TIQ, total intelligence quotient; PR, perceptual reasoning; VC, verbal comprehension.

Table 6 Correlation between perceptual reasoning and executive function variables

Variables of neuropsychological tests	Perceptual reasoning			
	Pearson's *r*	Spearman's rho	Sig. (two-tailed)	*N*
Working memory				
Digit Span (WISC-IV)	0.24*		0.013	106
Letter–Number Sequencing (WISC-IV)	0.31**		0.001	106
Picture Span (WISC-V)		0.40**	<0.001	106
Inhibitory control				
Word–Color (Stroop)	0.27**		0.006	104
Choosing (Five Digit Test)		0.30**	0.002	102
Cognitive flexibility				
Category Switching (D-KEFS)	0.15		0.136	106
Animal Sorting (NEPSY-II)	0.35**		<0.001	106
Shifting (Five Digit Test)		0.21*	0.034	106
Planning				
Mazes (WISC-R)	0.53**		<0.001	106
Excess movements (Tower of London)	0.26**		0.007	106
Processing speed				
Coding (WISC-IV)	0.37**		<0.001	106
Symbol Search (WISC-IV)	0.39**		<0.001	106
Word (Stroop)	0.08		0.426	104
Color (Stroop)	0.17		0.080	104
Reading (Five Digit Test)		0.15	0.131	106
Counting (Five Digit Test)		0.23*	0.015	106
Verbal fluency				
Phonemic Fluency (D-KEFS)	0.20*		0.036	106
Semantic Fluency(D-KEFS)	0.26**		0.007	106

*Two-tailed significance ($P < 0.05$).
**Two-tailed significance ($P < 0.01$).
WISC, Wechsler Intelligence Scale for Children; D-KEFS, Delis–Kaplan Executive Function System.

Table 7 Correlation between verbal comprehension and executive function variables

Variables of neuropsychological tests	Verbal comprehension			
	Pearson's *r*	Spearman's rho	Sig. (two-tailed)	*N*
Working memory				
Digit Span (WISC-IV)	0.28**		0.004	106
Letter–Number Sequencing (WISC-IV)	0.27**		0.005	106
Picture Span (WISC-V)		0.23*	0.017	106
Inhibitory control				
Word–Color (Stroop)	0.01		0.913	104
Choosing (Five Digit Test)		0.26**	0.006	106
Cognitive flexibility				
Category Switching (D-KEFS)	0.20*		0.037	106
Animal Sorting (NEPSY-II)	0.22*		0.021	106
Shifting (Five Digit Test)		0.11	0.271	106
Planning				
Mazes (WISC-R)	0.27**		0.005	106
Excess movements (Tower of London)	0.02		0.797	106
Processing speed				
Coding (WISC-IV)	0.18		0.059	106
Symbol Search (WISC-IV)	0.18		0.068	106
Word (Stroop)	0.15		0.129	104
Color (Stroop)	0.12		0.237	104
Reading (Five Digit Test)		0.13	0.169	106
Counting (Five Digit Test)		0.11	0.243	106
Verbal fluency				
Phonemic Fluency (D-KEFS)	0.13		0.173	106
Semantic Fluency (D-KEFS)	0.15		0.125	106

*Two-tailed significance ($P < 0.05$).
**Two-tailed significance ($P < 0.01$).
WISC, Wechsler Intelligence Scale for Children; D-KEFS, Delis–Kaplan Executive Function System.

Relationship between age and executive function performance (Research Question 2)

For analysis of results from the neuropsychological evaluation, we only included participants with ID, after first checking for significant differences between the ID and BIF groups.

The analysis of correlation is based on direct scores, as opposed to *T*-scores, because the direct scores are more independent of age than *T*-scores (which depend on the scales of the various tests, which are typically adjusted for age).

There were moderately significant correlations between chronological age of ID participants and scores in the neuropsychological tests of *working memory* (Table 8). However, it was not possible to build a valid linear regression model with any of these variables, not even with score in Digit Span, which was the measure of working memory that correlated most strongly with age.

There were slightly-to-moderately significant correlations between chronological age and variables for *inhibitory control*. Similarly, the correlations between age and other scores in EF tasks vary. There was no significant correlation between age and *letter fluency*. The correlation between age and *category fluency* was significant but slight. Correlations between age and scores in tasks evaluating *processing speed* were not significant except for moderately significant correlation with Coding and slightly significant correlations with Symbol Search and Reading. There were no significant correlations between age of ID participants and variables measuring *cognitive flexibility* or *planning* (Table 8). In summary, our results suggest that *working memory* is the EF that is most strongly related to age.

Table 8 Correlation between age and executive function variables for the intellectual disability group

Variables of neuropsychological tests	Age (12–18 years)			
	Pearson's *r*	Spearman's rho	Sig. (two-tailed)	*N*
Working memory				
Digit Span (WISC-IV)	0.41**		<0.001	83
Letter–Number Sequencing (WISC-IV)	0.33**		0.002	83
Picture Span (WISC-V)		0.31**	0.005	83
Inhibitory control				
Word–Color (Stroop)	0.25*		0.023	82
Choosing (Five Digit Test)		−0.31**	0.005	79
Cognitive flexibility				
Category Switching (D-KEFS)	0.14		0.218	83
Animal Sorting (NEPSY-II)	−0.02		0.847	83
Shifting (Five Digit Test)		−0.19	0.097	79
Planning				
Mazes (WISC-R)	0.08		0.454	83
Excess movements (Tower of London)	0.19		0.086	83
Processing speed				
Coding (WISC-IV)	0.39**		<0.001	83
Symbol Search (WISC-IV)	0.22*		0.043	83
Word (Stroop)		−0.05	0.660	82
Color (Stroop)		−0.20	0.075	79
Reading (Five Digit Test)	0.22*		0.047	82
Counting (Five Digit Test)	0.14		0.224	82
Verbal fluency				
Phonemic Fluency (D-KEFS)	0.17		0.126	83
Semantic Fluency (D-KEFS)	0.25*		0.021	83

*Two-tailed significance ($P < 0.05$).
**Two-tailed significance ($P < 0.01$).
WISC, Wechsler Intelligence Scale for Children; D-KEFS, Delis–Kaplan Executive Function System.

Turning to the study of the correlation between age and development of EFs according to the perception of teachers, in this study, too, we used direct scores from the questionnaire scale, but the data of all participants (both ID and BIF) were pooled, because it was established that there were no significant differences between the ID and BIF groups in terms of scores in the questionnaire. The only significant correlation found was between age and teacher perception of *Working Memory*. According to the teachers' impressions, there was no significant relationship between chronological age of students and development of the abilities *Inhibit*, *Self-Monitor*, *Shift*, *Emotional Control*, *Initiate*, *Plan/Organize*, *Task-Monitor* and *Organization of Materials* (Table 9).

Discussion

Our data suggest that children and adolescents with BIF perform significantly better than children and adolescents with ID in neuropsychological tests of EFs, although performance in both groups was lower than that corresponding to their chronological age. The same results were observed in a study, which was methodologically similar to ours, on *working memory* (Schuchardt *et al.* 2010).

With regard to teachers' perceptions of EFs in their students with ID and BIF, in general, perceptions were that performance was 'medium–low', with *Self-Monitor* being the most deteriorated capacity. For the ID group, the most conserved capacity was *Organization of Materials*; for the BIF group, it was *Initiate*. Differences between groups were only

Table 9 Correlation between age and BRIEF-2 variables (N = 105)

	Age (11–18 years)	
BRIEF-2	Pearson's r	Significance (two-tailed)
Clinical scale		
Inhibit	−0.02	0.798
Self-Monitor	−0.03	0.777
Shift	0.17	0.076
Emotional Control	0.13	0.176
Initiate	0.01	0.897
Working Memory	−0.20*	0.037
Plan/Organize	−0.03	0.728
Task-Monitor	−0.14	0.146
Organization of Materials	−0.13	0.173
Indices		
Behaviour Regulation Index	−0.03	0.770
Emotion Regulation Index	0.17	0.086
Cognitive Regulation Index	−0.14	0.150
Global Executive Composite	−0.03	0.795

*Two-tailed significance ($P < 0.05$).

BRIEF-2, Behavior Rating Inventory of Executive Function – Second Edition.

significant in *Shift* and *Working Memory*. In comparison with our results, Memisevic and Sinanovic (2014) obtained higher levels of statistical significance for differences between groups. Hutchison *et al.* (2015) studied a sample of 25 children with Prader–Willi syndrome and found that the teachers' perceptions of *Initiate* and *Organization of Materials* capacities were medium–low and the remaining capacities were perceived to be affected to a clinically significant degree. Pritchard *et al.* (2015) indicated that teachers perceived difficulties in all of the BRIEF domains for a sample of 188 children with Down's syndrome. In the first edition of the American version of BRIEF (Gioia *et al.* 2000), the authors provide means and standard deviations for 16 children and adolescents with ID; the subjects in this sample had more difficulty than the control group in all domains and especially in the *Working Memory* domain.

Our results are in agreement with the recent research finding that *Organization of Materials* is one of the strong points of children and adolescents with ID. Loveall *et al.* (2017) studied development of EFs in a sample of 112 children, adolescents and adults with Down's syndrome and found *Organization of Materials* to be a strong point, while *Self-Monitor* and *Shift* were weak points. Our study, therefore, confirms this idea that, according to the perception of teachers, *Organization of Materials* is the most developed and conserved capacity in children and adolescents with ID and BIF. The explanation of this finding could be that, generally, in special-education centres, students are formally encouraged to be autonomous and that this is reflected in scores for items in the *Organization of Materials* domain. In contrast, *Self-Monitor* and *Shift* might not be given so much emphasis in these educational contexts; if this is the case, these domains should be targets for intervention, with, for example, Meichenbaum's self-instructional training.

Concerning the relationship between TIQ and EFs, our results show that all EFs correlate significantly with general intellectual capacity. This is in agreement with recent results demonstrating a relationship between intelligence and working memory, cognitive flexibility and inhibitory control in adults with ID (Biesmans *et al.* 2019). Along the same lines, Friedman *et al.* (2006) proposed that in so far as a person suffers greater dysfunction in EFs, the more strongly the level of executive functioning may correlate with intelligence. This hypothesis has recently been called into question by Biesmans *et al.* (2019) on the basis of findings from a study of a heterogeneous sample of people with ID.

Of all the relationships between TIQ and EFs studied in our data, the strongest correlation was that between Picture Span score, which measures working memory, and TIQ. This relationship has been described for populations with normal intelligence (Kane *et al.* 2005; Friedman *et al.* 2006) and is beginning to be clarified in people with ID: a significant positive correlation (r = 0.80) has been found between measures of working memory and TIQ in children with moderate ID (Osório *et al.* 2012). Similarly, Schuchardt *et al.* (2010) and Memisevic and Sinanovic (2014) show that the level of working memory in people with ID depends on their mental age.

In our study, the correlation values between EFs and tasks related to PR index (fluid intelligence) were mostly significant. In contrast, correlation values between EFs and tasks determining VC index (crystallised intelligence) were predominantly not significant. These results for the ID population are in line with what has been reported by other authors for populations with typical development (Arffa 2007; Salthouse & Pink 2008; Floyd *et al.* 2010). Furthermore, our data suggest that the EF most strongly related with both fluid intelligence and crystallised intelligence is *working memory*, rather than *inhibitory control* or *cognitive flexibility* (Friedman *et al.* 2006; Arffa 2007). Friedman *et al.* (2006) suggested that the slight correlation between crystallised intelligence and *inhibitory control* and *cognitive intelligence*, respectively, could be explained by that part of the variability in these two EFs that is attributable to variability in *working memory*.

The reason why EFs tend to correlate more strongly with fluid intelligence than with crystallised intelligence might be linked to the type of sensorial information used in the evaluation tasks. Fluid intelligence tasks are predominantly based on visuospatial information; crystallised intelligence tasks are predominantly based on auditory–verbal information. It is possible that the neuropsychological tests of EFs lean more heavily, generally speaking, on visuospatial information than on verbal information.

Consequently, as pointed out by Danielsson *et al.* (2012), it is important to explore the differences between verbal and non-verbal tasks used to measure EFs in people with ID/BIF. For the same reason, we recommend that neuropsychologists, before starting evaluation of EFs in people with ID/BIF, should check whether there is any discrepancy in the levels of verbal and non-verbal skills and, if there is, should determine which sensorial modality is most developed (verbal skills are more auditory and non-verbal skills are more visual). Higher measures of the EFs of a person with ID could be obtained by using test based on the sensory modality that is most developed in that person. These considerations also reflect the need to develop more tests – tests based on the verbal–auditory modality – with which to evaluate EFs.

Furthermore, to explore the maximum potential of a person, we recommend that neuropsychologists be flexible about how some tests are performed. For example, if the objective of the evaluation is to test potential reasoning capacity, the test may be more informative if the normal time limits are not adhered to, because subjects with ID need more time to process the information and emit a response. Also, ID/BIF subjects may need more reminders about the instructions because they can forget them easily as a result of poor working memory. Other ways to resolve these issues would be to create tests specifically for people with ID/BIF or to adapt instructions and to establish ID/BIF-appropriate scales for existing tests that have been designed for the typical population.

Regarding the relationship between development of EFs and age, our data show a positive correlation between age and performance in neuropsychological tasks requiring working memory and inhibitory control. Auditory working memory was the EF that correlated most strongly with age. There were no significant correlations between age of ID participants and variables measuring *cognitive flexibility* or *planning*, and the correlations between age and the other scores in EF tasks vary. However, these findings are not sufficient to rule out definitively any improvement in these capacities as children and adolescents with ID get older. Improvement of working memory and inhibitory control capacities with age has also been described by Van der Molen *et al.* (2014), who, on the basis of a study of 119 children with ID, observed that development of these EFs continued until 15 years of age. Van der Molen *et al.* also found that development in the other capacities evaluated stopped at 10 years of age. Our results coincide with this latter finding: performance in tasks requiring processing speed and verbal fluency did not have a clear pattern of relationship with age, and scores in tasks involving cognitive flexibility and planning showed no significant improvement with age.

According to Diamond (2002) and Anderson (2002), working memory and inhibitory control are the first EFs to begin development in the child without cognitive deficit. If this holds true for the child with ID/BIF, even though the developmental ages of the participants in our study are lower than their chronological ages, initiation of development of working memory and inhibitory control in our participants would still be expected to have occurred many years previous to the study. This would explain the variability in the relationships between age and performance in tasks requiring *processing speed* and *verbal fluency* and explain the absence of a correlation between age and scores in tasks involving *cognitive flexibility* and *planning*, respectively. Similarly, according to Espy (1997), at 7 years of age, children still have difficulty changing mentally between categories (*cognitive flexibility*) and continue improving in this capacity until adolescence. Espy's results are consistent with those of Lee *et al.* (2013), who demonstrated the existence of a bi-factorial EF structure (*working memory* in conjunction with *inhibitory control* vs. *cognitive flexibility*) in children between 5 and 13 years of age. According to the latter authors, this suggests that executive control becomes more and more specialised and independent. Finally, in this respect, *planning* is regarded by some authors to be one of the last capacities to develop (Welsh *et al.* 1991; Anderson *et al.* 1996).

In the case of people with ID, the current viewpoint is to consider there to be a persistent delay in the development of EFs and there to be a slower rate of acquisition of capacities than that corresponding to chronological age (Cornish *et al.* 2013; Hooper *et al.* 2018). In their study, Hooper *et al.* (2018) observed a slight improvement in *auditory working memory* but not in *inhibitory control*, *cognitive flexibility*, planning or *speed of processing*; these are all findings consistent with the current work and that of Van der Molen *et al.* (2014). Danielsson *et al.* (2010) did not observe significant changes in capacity for either *planning* or *verbal fluency* in a dual task studied over a period of 5 years with a sample of adults with ID.

It is worth mentioning that a common problem in evaluation of EFs is that evaluation measures tend to be inter-related. Therefore, to be able to carry out factor analysis for the different measures of EFs, especially in different age groups, it is necessary to have a large sample. In the future, we hope to increase the size of our sample and investigate how the factorial structure of EFs differs in the population of children with ID/BIF in different age groups, and to be able to compare that with existing data for schoolchildren with typical development. Lee *et al.* (2013) found, in a typical population, that in early childhood there was a process of differentiation with a two-factor structure while in adolescence this process had a three-factor structure; it might be helpful, for example, to know if this pattern is the same in children with borderline ID.

Finally, our results suggest that there is no relationship between teachers' perception of their students' EFs and student age, with the exception of a slight correlation between perception of performance in *Working Memory* and age. In contrast, Loveall *et al.* (2017), in a transversal study from infancy to adulthood of subjects with Down's syndrome, observed different curvilinear patterns in perception of development in terms of *Shift*, *Inhibit*, *Working Memory* and *Plan/Organize*. Maldonado-Belmonte (2016) reported a positive correlation between age and normal development of *Inhibit*, *Emotional Control*, *Working Memory* and the global *Metacognition* and *Global Executive Composite* scores.

Limitations

Amongst the methodological limitations that came to light over the course of the study, we consider the heterogeneity in the participants especially relevant. The participants, schoolchildren, were of different chronological age, with different intellectual levels, with cognitive deficits of different aetiologies and under different pharmacological treatments. Another limitation is that, in contrast to other studies focussed on people with ID, we did not have an available control group of subjects with typical intelligence and similar mental ages to our sample. Furthermore, our sample was not big enough to allow for statistical analysis of age subgroups, and so it was not possible to study development of EFs by age. Lastly, it would have been opportune to use an additional neuropsychological test for *planning*; this was not possible through lack of access to the test.

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Conflict of Interest

The authors whose names are listed above certify that they have NO affiliations with or involvement in any organisation or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employments, consultancies, stock ownership or other equity interest; and expert testimony or patent-licencing arrangements) or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Data Availability Statement

Author elects to not share data.

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