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Intelligence and Executive Functions: A Comprehensive Assessment of Intellectually Gifted Children

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Abstract

Objective. Executive functions (EFs) play a key role in cognitive and behavioral functioning. Their multiple forms and implications for daily life behaviors mean they are sometimes equated with intelligence. Several elements even suggest that intellectually gifted children (IGC) may present better executive functioning than typical developing children (TDC, children with intelligence in the average range). However, no study has ever completely tested this hypothesis by a comprehensive assessment of EFs in IGC.

Method. Results of 30 IGC and 35 TDC aged from 6 to 16 years old were compared through a comprehensive assessment of EFs (inhibition, flexibility, and planning), comprising performance-based and daily life measures.

Results. IGC did not differ from TDC in EF performance-based measures. However, they scored higher in parents' and some teachers' ratings, suggesting higher indicators of difficulties in daily life.

Conclusions. Contrary to expectations, high intellectual level does not appear to be associated with superior EFs. Surprisingly, parents and teachers of IGC reported more complaints about their executive functioning in everyday life. We put forward different hypotheses to explain this contrast. Further research is needed to better understand this phenomenon, in which neuropsychology has a fundamental role to play.

Keywords: Executive functions; Neuropsychology; Intelligence; High IQ; Gifted children

Introduction

Intelligence

The definition of intelligence has a porous border, depending on what population is considered (Sternberg & Kaufman, 1998), as this concept is closely linked to the period and to the kind of skills valued by the culture considered (Pang, Esping, & Plucker, 2017). Although there is no international consensus, experts agree on some common characteristics, such as the idea of general ability. This implies the possibility to reason, plan, solve problems, think abstractly, comprehend complex

ideas, learn from experience, and the ability to adapt to one's environment (Gottfredson, 1997; Sternberg & Kaufman, 1998; Thorndike, 1921). Measures of intelligence are classically based on the psychometric conception that a single latent factor, known as the *g* factor, underlies intelligent behaviors (Johnson Nijenhuis, & Bouchar, 2008; Spearman, 1904). Advances in methods and statistics (McGrew, 1997), cognitive psychology (Cornoldi, 2006), neuropsychology (Miller & Maricle, 2018), and neurosciences (Hampshire, Highfield, Parkin, & Owen, 2012) all support the hypothesis of there being several segmented domains of intelligence (fluid or crystallized intelligence in Cattell's theory, 1963, for instance) and contribute to their identification.

Executive functions

Executive functions (EFs) are high-level cognitive processes involved in the regulation of thoughts and behaviors (Gilbert & Burgess, 2008; Miyake & Friedman, 2012). They enable us to mentally play with ideas, create a plan and initiate its execution, resist temptations, and stay focused until its completion. Different EFs are usually distinguished, such as inhibition, cognitive flexibility, WM (working memory), planning or problem solving (Diamond, 2013). Although closely interrelated, each EF seems to show a particular developmental pattern (Hartung, Engelhardt, Thibodeaux, Harden, & Tucker-Drob, 2020; Jurado & Rosselli, 2007). The healthy development of EFs is critical for aspects of later life security, such as health, wealth, and educational attainment (Thompson & Steinbeis, 2020). EFs are especially vulnerable during childhood due to their early and extended development. Indeed, executive dysfunctions are found in various clinical settings, such as pregnancy outcomes, neurodevelopmental disorders, and neurologic, genetic, or chronic diseases (Maricle & Avirett, 2018; Roy et al., 2020). For these reasons, their assessment occupies a significant place in pediatric practice.

Intelligence and EFs

Although a distinction between EFs and intelligence has been made by the psychometric approach, their similarities and/or relationships are still a subject of debate (Ardila, 2018; Brydges, Reid, Fox, & Anderson, 2012; Friedman et al., 2006). On the one hand, many EF theories establish links with intelligence, especially fluid intelligence (Diamond, 2013). Some authors even consider that EF is an important factor influencing *g* (Ardila, 2018; Maricle & Avirett, 2018; Sternberg & Gardner, 1982; Viana-Sáenz, Sastre-Riba, Urraca-Martínez, & Botella, 2020) and that an adequate measure of intelligence must necessarily include EF recruitment (Ardila, Pineda, & Rosselli, 2000). This position may be supported by predictive or correlational studies of EFs and intelligence (Arffa, 2007; Duan, Wei, Wang, & Shi, 2010; Schweizer & Moosbrugger, 2004; van Aken, van der Heijden, Oomens, Kessels, & Egger, 2019). At a biological level, neuroimaging data revealed a shared brain network (Kuwajima & Sawaguchi, 2010) that could support this hypothesis, but also showed a common genetic variance (Nikolašević et al., 2020). Some studies on patients with frontal lobe lesions tend to confirm this hypothesis, as they may demonstrate EF deficits accompanied by substantial losses of fluid intelligence (Duncan, Burgess, & Emslie, 1995; Roca et al., 2010). On the other hand, some elements tend to qualify this relationship, which may be considered as weak (Arffa, 2007; Tanabe, Whitaker, O'Callaghan, Murray, & Houskamp, 2014), depending on the kind of intelligence (mostly fluid intelligence) and EF considered (Arffa, 2007; Benedek, Jauk, Sommer, Arendasy, & Neubauer, 2014; Duan et al., 2010; Friedman et al., 2006).

In this context, a direct study of populations with high and average intelligence without any medical/neurological conditions could provide some answers about these relationships through an analysis of EF measures and reports of executive functioning in daily life.

EFs in intellectually gifted children

Statistically, a child or an adult can be considered to have a significantly higher intelligence when their Full Intelligence Scale Quotient (FISQ) reaches the 130 cut-off. Studies often label this population as "gifted," although the definition is somewhat tenuous and identification criteria vary from one study to another (Carman, 2013; McBee & Makel, 2019).

Studies on EFs of intellectually gifted children (IGC) cover various issues, such as the conceptual overlap between EFs and intelligence or the clinical implications of their executive functioning for their academic achievement/performances (Arffa, 2007; Arffa, Lovell, Podell, & Goldberg, 1998; Guez, Peyre, Le Cam, Gouvrit, & Ramus, 2018; Montoya-Arenas, Aguirre-Acevedo, Díaz Soto, & Pineda Salazar, 2018). Some authors have described a great variability in their EFs, even suggesting difficulties (Hernández Finch, Speirs Neumeister, Burney, & Cook, 2014), whereas others reported average to superior EFs in IGC. One of the most cited studies included an analysis of tests evaluating EF in children with different intelligence quotient (IQ) levels (average to high intelligence and IGC; Arffa, 2007). Since then, it has been generally assumed that IGC may present higher executive functioning (Vogelaar et al., 2017; Whitaker et al., 2013), whereas the study cited mainly indicated that higher IQ

score correlated more with EF than non-EF measures. By examining the sparse data available on the topic of EFs in IGC, recent literature tends to show that IGC do not present an overall higher executive functioning. A meta-analysis failed to find differences between IGC and typically developing children (TDC) for most of EF measures (inhibition, flexibility, and planning) except for those of verbal and visual WM, where IGC demonstrated superior performance than TDC (Viana-Sáenz et al., 2020). These results were further corroborated by a systematic review (Bucaille, Jarry, Brochard, Peudenier, & Roy, 2022).

Some authors have pointed out limitations in the study of EFs in IGC, starting from the need to apply well-defined criteria of IGC (FISQ ≥ 130). Moreover, it has been suggested that EFs should be examined in a systematic way, as most studies have only focused on one or just a few EFs (Arffa et al., 1998; Calero, García-Martín, Jiménez, Kazén, & Araque, 2007; Duan, Shi, Sun, Zhang, & Wu, 2009; Johnson, Im-Bolter, & Pascual-Leone, 2003; Leikin, Paz-Baruch, & Leikin, 2013). Particular attention should be paid to the impurity of EF tasks, as this can compromise the reliability and validity of measures if the involvement of non-executive processes is not taken into account. This is the case for some studies that did not interpret executive measure in combination with a control condition (Arffa, 2007)—for instance, the Stroop Color-Word Test or Trail Making Test—, or did not provide the scoring method ensuring that non-executive processes were taken into account (Montoya-Arenas et al., 2018). Furthermore, only one paper has addressed EFs in the daily life of IGC (Hernández Finch et al., 2014). This previous study does not include a statistical comparison with TDC and only used descriptive statistics for comparison with normative data. Mean scores were inferior to the clinical significance ($T \geq 65$) but a wide score dispersion was found. Correlations of rating measures with academic achievement were not significant. Links between performance-based and rating measures were not studied. Usually, studies on clinical populations (e.g., prenatal alcohol exposure, pediatric brain tumor survivors, epilepsy, young preterm children) have found little or no correlations between these two kinds of measures, and only low to moderate relations when they do appear (Bernes et al., 2021; de Vries et al., 2018; Modi, Vannest, Combs, Turnier, & Wade, 2018; O’Meagher, Norris, Kemp, & Anderson, 2019). Parents have tended to report more executive problems than teachers, except for attention-deficit hyperactivity disorder where scores seem to converge and are related to the symptomatology (Miranda, Colomer, Mercader, Fernández, & Presentación, 2015; Soriano-Ferrer, Félix-Mateo, & Begeny, 2014). Yet, assessment with a rating scale is essential when evaluating EFs, as it is considered to be a more ecologically valid measure and more representative of children’s complex daily lives (Blijd-Hoogewys, Bezemer, & van Geert, 2014).

Aim of the study

The present study aimed to better characterize the executive functioning of IGC by including the latest methodological recommendations, i.e., identification of IGC through strict criteria (FISQ ≥ 130), and comparison of their results with TDC identified based on their estimated IQ being within the average range (usually not checked in this type of study). A thorough assessment, comprising daily life rating scales and a comprehensive performance-based assessment was made. Performance-based measures were chosen with the goal of better “isolating” the contribution of executive abilities (Guerra et al., 2020; Roy et al., 2016), as previous studies on EFs in IGC did not control the influence of basic processes on executive performance or did not take specific executive measures into consideration.

Given the link described between EF(s) and intelligence (Arffa, 2007; Cattell, 1987; Diamond, 2013) and the evidence of comparable-to-superior EFs in IGC (Arffa, 2007; Arffa et al., 1998; Leikin et al., 2013), we hypothesized that IGC should demonstrate (i) better scores in performance-based measures, (ii) lower scores on daily life EF rating scales (suggesting better functioning in their daily life), and (iii) significant correlations between EF measurements and IQ in the whole population but especially in IGC.

Method

Participants

The minimum age for participation was 6 years old and the maximum age was 16 years old. Children were included in the IGC sample if their IQ was equal to or above the 130 cut-off on the current intelligence scale at the time of IGC identification (i.e., WPPSI-III/IV, WISC-IV/V). For ethical reasons, all subjects had to be assessed prior to their enrollment in the study by a psychologist not involved in the present research as this study was not designed to identify potential IGC in the general population.

The control group comprised TDC not suspected to be intellectually gifted and not identified as such. Their IQ was estimated before their enrollment in the study either by the psychologist of this study or by a student in their final years of study who had been specially trained for this research. Children were included in this group based only on their scores in the Matrix reasoning

and Vocabulary subtests (WISC-V), which enabled us to obtain a reliable estimate of IQ without overloading the protocol. As Matrix reasoning is correlated at 0.62 and Vocabulary at 0.59 (Wechsler, 2016) with full scale intelligence quotient (FSIQ), these subtests were considered as a valid approximation of the FSIQ. Children had to meet one of the following criteria, to ensure that their intellectual efficiency was in the average range: (i) both scaled scores were between 7 and 13, or (ii) one of these scores was between 7 and 13 and the other between 5 and 13. Children with learning disabilities were not included in this group.

Other exclusion criteria applied to all applicants were genetic diseases; neurological or psychiatric conditions (traumatic brain injury, epilepsy, autism spectrum disorder, prematurity, etc.); elementary sensory, linguistic, or motor deficiencies; an insufficient command of French; and the use of psychotropic medication.

Materials

The subtests of two clinical scales were used to obtain performance-based measures: the Child Executive Functions – Battery (CEF-B; Roy, Fournet, Le Gall, & Roulin, 2021) and a developmental neuropsychological assessment (NEPSY-II; Korkman, Kirk, & Kemp, 2007). The daily life measures of EFs were obtained with the Behavior Rating Inventory of Executive Function, French version (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000; Roy, Fournet, Roulin, & Le Gall, 2013).

Performance-based measures.

Rey Osterrieth complex figure (CEF-B). This visuospatial test involves planning skills. It includes two conditions: formulation and execution. In the formulation condition, the examinee is asked to copy a complex figure as accurately as possible. A maximum score of 36 points may be awarded (C), according to the quality of the reproduction (accuracy and spatial localizations of items). In the execution condition, the children progressively copy the figure based on the successive presentation of the figure's parts drawn on five separate sheets of paper. Each part is presented in a different color. The program score (P) is based on the same scoring principles. A planning index (PI) is calculated as follows: $(P/C) \times 100$. The higher the PI, the more the page-by-page breakdown helps the child.

Eight mazes (CEF-B). This test evaluates planning ability. The child is asked to complete eight mazes of increasing difficulty, presented on letter (A4: 210 × 297 mm / 8.3 × 11.7") and ledger format (A3: 297 × 420 mm / 11.7 × 16.5") paper. A small dinosaur indicates the starting point. The child must draw the path leading out from this point to the exit point, avoiding dead-end paths. The time to complete each maze should not exceed 240 s to be considered as completed. The total time for the mazes completed (sum of completion time for each maze) and the total number of dead ends are recorded.

Stroop (CEF-B). The Stroop task is used to assess ability to inhibit a cognitive interference (reading). For each condition, 100 items are submitted to the participant. In the first condition, "Naming" (N), the child has to say the color of the rectangles. In the second condition, "Reading" (R), the child is asked to read written color names, all in black ink. In the third condition, "Interference" (I), the examinee is required to say the ink color of the words instead of reading the words (a color name). For each condition, the time of completion and number of correct and incorrect responses are recorded. An interference score for time and accuracy is obtained based on I and N conditions (I time – N time; I incorrect responses – N incorrect responses).

Cross-out joe (CEF-B). This test is designed to assess inhibitory control ability by the inhibition of distractors. The child is instructed to cross-out a character, "Joe," among a set of various distractors on two white sheets in ledger (A3) format (part A, part B). Each series comprises 240 items, with 48 identifiable targets. The child must cross-out the targets as quickly and as accurately as possible. Execution time is recorded (series A + B) and accuracy is measured by a total raw score of errors called "Imprecision" (false alarms and omissions in series A and B). The evolution of time and imprecision through the task is then calculated (time B – time A; imprecision B – imprecision A).

Kids card sorting test (CEF-B). This test is a shifting task. Four target cards are presented to the participant. The child is required to match 48 cards with target cards. The examinee is informed of the three combinations expected, according to the color, shape, and number of stimuli. The child must guess the combination rule, based on the psychologist's feedback ("yes" or "no"). After six correct answers, the combination rules are changed. Three scores are obtained: the time of completion (seconds), the number of perseverations (continuation of the classification type despite a "no" being given just before), the number of combination rules guessed by the child (maximum: 6 rules) and the number of drop outs (the child changes the combination rule unexpectedly).

Word generation subtest (NEPSY-II). This subtest assesses verbal fluency, involving spontaneous shifting. The child is given semantic and initial letter categories and asked to produce as many words as possible in 60 s. The total raw score (numbers of correct words) is converted to two standardized scores (norms from the manual), one for the semantic condition and the other for the initial letter condition.

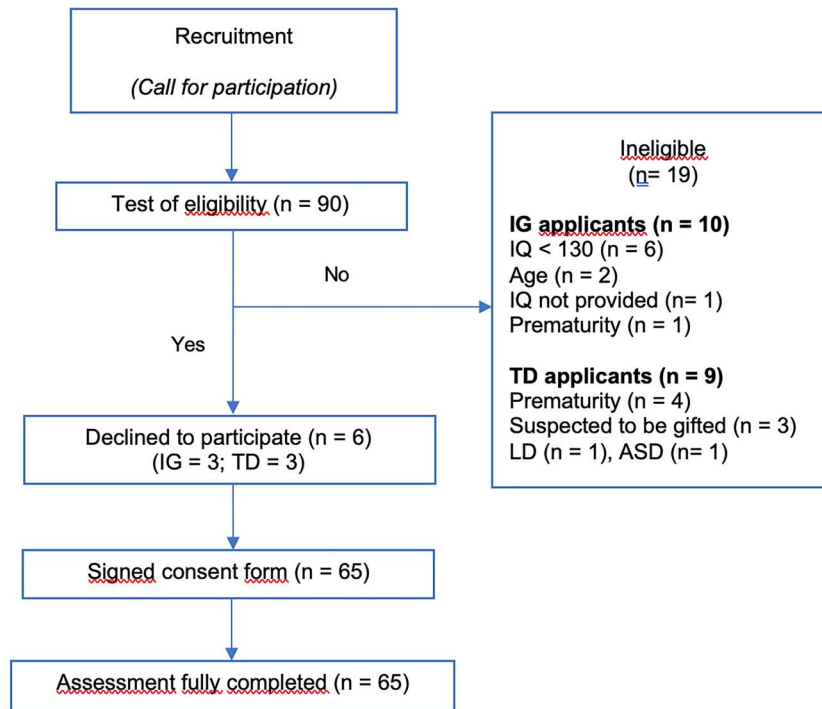


Fig. 1. Flow chart for inclusion and exclusion of the applicants. Note. ASD: autism spectrum disorder; IG: intellectually gifted; IQ: intelligence quotient; LD: learning disability; TD: typically developing.

Ratings measures by parents and teachers.

BRIEF. This is an 86-item questionnaire assessing EFs in daily life, given to parents and teachers (2 versions). Respondents are asked to rate the child's frequency of various behaviors associated with EFs. Each item is rated on a 3-point Likert scale, depending on the frequency of the child's behavior ("never": 1 point, "sometimes": 2 points, "often": 3 points). The BRIEF comprises eight clinical scales: Inhibit, Shift, Emotional control (combined to form the Behavioral Regulation Index, BRI), Initiate, WM, Plan/organize, Organization of materials, and Monitor (combined to form the Metacognition Index, MI). The Global Executive Composite (GEC) is derived from the combination of the two indexes. Two validity scales help to detect potential response biases (Inconsistency and Negativity scales). Raw scores can be converted into T-scores and percentiles. The significant clinical threshold is a T-score equal to or higher than 65.

Procedure. This research was registered at clinicaltrials.gov (identifier NCT03128125) and was approved by the Ethical Research Committee SUD EST IV (France) on March 16, 2017, and the National Agency for Medicine and Health Products Safety (ANSM). Recruitment of participants took place between April 2017 and August 2018.

Participants were recruited through a call for participation (newspaper and radio advertisements, schools, public places, library, sports associations, etc.) to avoid including only children from specialized services or gifted programs, as recommended by Gauvrit (2014) for the study of IGC. Families were free to contact the researchers by email or by telephone. All relevant information was sent to them at this time. For families interested in taking part in the research, all eligibility criteria were first checked before sending the information notice and the written consent forms to the participant and their family. An inclusion visit was arranged at the hospital, where the inclusion and exclusion criteria were double-checked by the child neurologist. Written consent forms were given to the medical investigator. Participation in this research included providing the child's a medical history and having a medical examination with the child neurologist (1 h). Then, the child carried out an EF assessment (1 h 30 min) as part of a larger neuropsychological examination. During the day, the parents were invited to fulfill the BRIEF. Participants were also free to submit the BRIEF to their teacher. A stamped self-addressed envelope was provided to facilitate the return of the questionnaire. Researchers were always available to answer parents' or teacher's questions on how to complete it.

Of the 90 children tested for eligibility to the study, 30 children were included in the IGC sample and 35 in the TDC sample (see Fig. 1). Participants of the two groups were Caucasian.

Table 1. Sample characteristics

	Intellectually gifted (<i>n</i> = 30)	Typically developing (<i>n</i> = 35)	Value	<i>p</i>
Age (months)	<i>M</i> = 126.3 (<i>SD</i> = 29.2)	<i>M</i> = 124.2 (<i>SD</i> = 28)	<i>t</i> = 0.30	0.763
PEL	<i>M</i> = 15.85 (<i>SD</i> = 2.26)	<i>M</i> = 14.99 (<i>SD</i> = 2.3)	<i>t</i> = 1.52	0.133
Sex				
Girls	12	16	$\chi^2 = 0.22$	0.643
Boys	18	19		
IQ	139.7 (<i>SD</i> = 7.2)	106.4 (<i>SD</i> = 9)	<i>t</i> = 16.29	<0.001

Note: *M*: mean; PEL: parental education level (mean education in years from grade 1, for both parents); *SD*: standard deviation

Table 2. Comparisons between (IGC) and (TDC) for EF performance-based measures

Tests	Measure	Min-Max	IGC <i>M</i> (<i>SD</i>)	TDC <i>M</i> (<i>SD</i>)	<i>U</i>	<i>p</i>	<i>r</i>
Stroop (CEF-B)	Time	0–∞	88.67 (40.3)	83.3 (51.2)	607.5	0.388	0.125
	Uncorrected errors	0–100	4 (12.9)	0.78 (1.6)	676	0.071	0.252
Cross-out Joe (CEF-B)	Execution time	0–∞	724.4 (265.4)	701.4 (196.8)	519.5	0.948	-0.10
	Imprecision	0–480	8.67 (5.9)	8.09 (5.1)	549	0.756	0.046
	Time evolution	– ∞: + ∞	12.23 (71.3)	–32.11 (58)	716.5	0.012	0.365
	Imprecision evolution	– 480 – 480	–0.53 (5.5)	–0.6 (4)	581.5	0.459	0.108
Kids Card Sorting Test (CEF-B)	Time	0–∞	181.5 (39.9)	199.5 (59.5)	426.5	0.278	-0.16
	Rules	0–7	4.8 (0.9)	4.31 (1.3)	623.5	0.182	0.188
	Perseverations	0–47	3.33 (2.7)	3.97 (4)	515.5	0.905	-0.018
	Drop out	0–16	1.57 (1.5)	1.63 (1.5)	504	0.781	-0.04
ROCF (CEF-B)	Formulation	0–36	28.6 (2.9)	28.35 (4)	532	0.931	0.013
	Planning	0–36	30.43 (3.1)	30.86 (3.3)	470.5	0.475	-0.104
	Planning index	– 36 – 36	1.9 (3.1)	2.52 (3.4)	437.5	0.346	-0.138
8 Mazes (CEF-B)	Total Time	0–∞	487.9 (201.9)	518.8 (219.3)	486.5	0.617	-0.073
	Impasses	0–∞	10.9 (10.5)	10.1 (8.1)	539.5	0.853	0.028
Word generation (NEPSY-II)	Semantic	0–∞	35 (10.2)	31.2 (9.2)	637.5	0.214	0.214
	Initial letter	0–∞	16 (7.1)	14.2 (6)	477.5	0.360	0.141

Note: CEF-B: Child Executive Functions – Battery; IGC: intellectually gifted children; TDC: typically developing children; *M*: mean; *SD*: standard deviation; *r*: rank biserial correlation; NEPSY-II: a developmental neuropsychological assessment.

Statistical analysis

Statistical analyses were performed using JASP 0.16.1.0. Nonparametric tests were used because much of the data did not follow a normal distribution. Mann–Whitney tests were used for group comparisons of performance-based and ratings measures (IGC, TDC). A correction for multiple tests comparisons was applied, which led us to choose a threshold of $p < 0.01$. Effect sizes were calculated using rank biserial correlation coefficients. Finally, partial correlations (correcting on age) were performed to study the relationships between performance-based and ratings measures of EF(s) and IQ measures (Matrix and Vocabulary, WISC-V) in each sample.

Results

Populations

IGC and TDC samples did not differ statistically in age, sex, or mean education level (see Table 1).

Performance-based measures

No significant differences were found between IGC and TDC for any of the EF performance-based measures, with a small effect size overall. Correction of the threshold (multiple comparisons) did not improve the significance of the imprecision evolution of Cross-out Joe (CEF-B) (see Table 2).

Table 3. Comparisons between IGC and TDC based on parent and teacher rating scores (T-score) from the BRIEF questionnaire

	IGC <i>M (SD)</i>	TDC <i>M (SD)</i>	U	<i>p</i>	<i>r_B</i>
BRIEF Parents	<i>n</i> = 29	<i>n</i> = 35			
BRI	65.8 (15.8)	46.2 (8.4)	862.5	< 0.001**	0.7
Inhibit	61.7 (16.3)	45.5 (8.6)	810.5	< 0.001**	0.597
Shift	58.9 (15)	47.7 (9.5)	734	0.002*	0.446
Emotional Control	66.6 (13.3)	47.1 (8.2)	890	< 0.001**	0.755
MI	59.3 (15.5)	48.8 (9.3)	686	0.007*	0.400
Initiate	55.9 (13)	47 (9.6)	715	0.005*	0.409
Working Memory	57.3 (16.2)	46.9 (7.8)	682	0.019	0.344
Plan/Organize	57.4 (14.3)	46.9 (10.6)	701	0.004*	0.431
Organization of materials	59.7 (10.7)	50 (9.9)	764	< 0.001**	0.505
Monitor	57.4 (12.2)	45.5 (8.1)	783	< 0.001**	0.543
GEC	62.9 (16.3)	45.9 (8.4)	794.5	< 0.001**	0.621
BRIEF Teacher	<i>n</i> = 25	<i>n</i> = 29			
BRI	57.1 (13.8)	49.7 (11.7)	388.5	0.017	0.408
Inhibit	56.8 (12.7)	51.1 (17.7)	459	0.024	0.366
Shift	52.9 (11.2)	47.1 (5.5)	362.5	0.066	0.313
Emotional Control	60 (17.6)	51.5 (10.4)	445.5	0.022	0.375
MI	53.7 (12.9)	47 (10.4)	398	0.021	0.392
Initiate	51.7 (12)	45.4 (7.8)	443.5	0.047	0.320
Working Memory	53.4 (11.2)	47.1 (9.7)	479	0.003*	0.488
Plan/Organize	52.5 (13.6)	47.3 (10.9)	370	0.082	0.294
Organization of materials	56 (14.3)	47.1 (9.2)	482	0.007*	0.435
Monitor	55.1 (13.8)	47.7 (11)	445	0.046	0.324
GEC	54.9 (12.9)	47.5 (11)	373	0.017	0.413

Note: BRIEF: Behavior Rating Inventory of Executive Function; *M*: mean T-score (mean = 50, *SD* = 10 in normative data); *SD*: standard deviation, *r_B*: effect size; BRI: Behavior Regulation Index; IGC: intellectually gifted children; TDC: typically developing children (intelligence in the mean range); MI: Metacognition Index; GEC: Global Executive Composite

In bold: significant *p* values less than 0.01* and 0.001**

Ratings measures

All parents from both samples completed the BRIEF. Out of the 30 IGC, 26 had teacher questionnaires returned and, out of the 35 TDC, 29 had teacher questionnaires returned. As the inconsistency score was significant for two IGC rating scales (1 completed by the parents, the other by a teacher), their results were not included in the analysis. Group comparison results are given in Table 3.

When rated by their parents, indicators of EFs in daily life were higher for the IGC than the TDC for most of the BRIEF clinical scales (5/8: Inhibit, Emotional Control, Plan/organize, Organization of materials, Monitor) and indexes (1/2: BRI), with medium to large effects. The difference for the GEC was also significant (large effect). Teachers also rated IGC higher on two clinical scales (WM and Organization of materials).

The relationships between EFs and intelligence were studied through partial correlational analyses within each sample, by controlling the age variable. Few significant correlations were found and only three of these remained significant after correction ($p < 0.01$) in the IGC sample (8-Mazes time and Word generation—semantic condition—with Vocabulary; Cross-out Joe time with Matrix). Only Matrix and the formulation condition of the Rey Osterrieth complex figure correlated significantly in the TDC sample. No significant correlation was found between the GEC and performance-based measures of EFs.

Discussion

The aim of this study was to investigate the executive functioning of IGC through a comprehensive assessment comprising performance-based and daily life measures.

Our study did not confirm the hypothesis of greatly superior EFs in IGC compared with TDC. Statistical tests did not allow us to differentiate our IGC and TDC samples based on any of the EF variables. Contrary to what had been expected (Hernández Finch et al., 2014), indicators of executive functioning in daily life were worse for IGC when rated by both teachers and parents. The IGC demonstrated higher scores than TDC on most of the BRIEF clinical scales (Inhibit, Emotional control, Plan/Organize, Organization of materials, Monitor), for BRI, MI, and GEC, when rated by their parents. The teacher's questionnaires also

revealed higher scores for two BRIEF clinical scales (WM and Organization of materials). These results demonstrated that people who knew these children well, especially their parents, had the impression that they had different executive functioning. As IGC obtained a higher rate of clinically elevated GEC score ($T \geq 65$), many of them seem to have similar behavior to those observed in executive dysfunction.

Should we, therefore, conclude that IGC suffer from executive dysfunction? A discrepancy between performance-based measures and ratings is not uncommon (Toplak, West, & Stanovich, 2013), as they are considered to reflect different aspects of the concept. It is worth noting that the BRIEF also covered some domains not assessed by laboratory tests, such as emotional functioning. The direction and the magnitude of the discrepancy (inferior EFs) in the context of higher intelligence are quite surprising; however, despite these clinically elevated scores, evidence may not support the hypothesis of executive dysfunction. First, few clinical scales scores of the teacher's rating scale were significantly different from those of TDC. Moreover, teachers rated very few children in the clinical range, which means that few of them demonstrated significant clinical signs in the classroom context. Moreover, our IGC sample does not seem to have encountered academic difficulties, since almost one in two are a year or more ahead in school. This is not consistent with the idea of executive dysfunction (Samuels, Tournaki, Blackman, & Zilinski, 2016).

We, therefore, need to ask how the clinician should treat such a discrepancy. Since the results of a questionnaire should correlate with cognitive tasks for which psychometric properties have been determined (de Vries et al., 2018), the inconsistency tends to disappoint clinicians (Ciesielski, 2020). Some authors have even suggested that EF problems experienced in home situations (evidenced by rating scale) do not necessarily derive from assumed underlying cognitive dysfunction as measured with EF tasks (de Vries et al., 2018).

Indeed, clinicians should keep in mind that the raters themselves play a large role in the results. Consequently, the score obtained by an individual is more likely to result from the subjective representation of the rater, rather than the "real" skill level of the individual. In our study, rater bias and implicit bias (ideas, attitudes, and stereotypes that subconsciously affect our understanding or action) may contribute to explaining the results, as giftedness is itself "a social construct" (Pfeiffer, 2015). Although empirical studies have demonstrated similar (or even healthier) psychological characteristics in gifted individuals compared with their nongifted peers, IGC are usually perceived as maladjusted and emotionally unstable (Baudson & Preckel, 2013; Preckel, Baudson, Krolak-Schwerdt, & Glock, 2015). The gifted label may also influence expectations about these children (Cuhe & Brasseur, 2017; Matheis, Kronborg, Schmitt, & Preckel, 2017) and, therefore, our way of interacting with them. It is interesting to note that these stereotypes about giftedness are also conveyed by the media and by books for parents and professionals. Looking for answers about their child's functioning, parent's concern may be increased by incorrect information about giftedness. As a result, they could then be more inclined to identify and/or misinterpret some behavior as associated with intellectual giftedness. As most of the IGC of our sample were in a year ahead of their age group at school, one can ask whether their parents and teachers had compared their abilities with those of children who were older. Complementary analyses showed, however, that the proportion of IGC with a clinically elevated score (rated by both parents and teachers) was similar between children who were a year ahead and those who were in the class corresponding to their age (data not shown).

Research on clinical populations generally provides evidence of higher discrepancies of results between parent ratings and performance-based measures, whereas teacher ratings and performance-based measures seem to be more convergent (de Vries et al., 2018; Modi et al., 2018). Parents usually tend to report more EF problems in daily life than teachers do (de Ruiter et al., 2016). Our results also found this pattern of response, which have several implications. In clinical practice, rating scales should not be used in isolation or instead of performance-based measures, as their convergence is limited. They should only be used in complement to the clinical interview and performance-based assessment, as they provide a measure of a child's difficulty as perceived by an adult. Indeed, the collection of everyday life indicators is subject to so many factors that these could lead to a clinically elevated score, not necessarily linked to a neuropsychological deficit. The use of an adaptive measure may be more appropriate in some cases, depending on the practitioner's clinical judgment.

At the theoretical level, the lack of convergence with the EF performance-based measures, also demonstrated here by correlation analysis, tends to support the hypothesis of a relative independence of EFs and intelligence, despite their overlapping definitions (Herrera-Pino & Castellanos, 2020). Indeed, higher intellectual level does not correspond to higher executive functioning. Moreover, very few measures of EFs significantly correlate with intellectual measures, regardless of intellectual level. This finding is in line with studies on neural networks that have revealed, aside from similar correlates, a more unique activation of EF, including ventral and anterior prefrontal cortices (Jurado & Rosselli, 2007). This may explain why some patients with frontal lobe lesions do not necessarily show decreased IQ even though they present executive dysfunction. As suggested by Duggan and Garcia-Barrera (2015), it may be more conceptually and practically beneficial to emphasize the differences between intelligence and executive functioning, rather than their similarities.

Some limitations of this study should be pointed out, such as the small sample sizes due to the scarcity of the IGC population and protocol constraints (length of the protocol, need to come to the hospital). Furthermore, the ecological validity of the

neuropsychological methods used here deserves to be documented. An assessment of WM would have been useful in addition to the EFs already tested in this study to appreciate all aspects of executive functioning, which was not possible here. The issue of EF assessment in IGC should also be considered. As these tests are designed with deficits in mind, it is doubtful whether they make it possible to differentiate children with very superior EFs from those within average range (the measures focus on errors rather than on successes).

Moreover, it has been suggested that children with intact (or superior) EFs may present a ceiling effect in neuropsychological measures, contrary to IQ tests (Mahone et al., 2002). Although our study did not reveal this phenomenon, some consider that new tests and/or appropriate measures based on a suitable methodology are needed in clinical practice to better identify high ability in IGC, such as tests from item response theory (IRT; Caroff, 2004). Based on an adaptive testing procedure, measures resulting from this theory offer advantages of statistical precision and power to detect effects (Kean & Reilly, 2014). Scales based on IRT are considered appropriate for measuring high cognitive abilities (Vock & Holling, 2008). This approach should be extended to all neuropsychological tests since it would help to detect superior ability equally well as deficit.

Despite the attention paid to recruitment in this study (by recruiting IGC who did not come from gifted programs or specialized services), a representativeness bias may also be questioned. In the country where this study took place (France), IQ assessment is the only valid way to identify gifted children. It implies consulting a psychologist to carry out an IQ assessment. To be included in this study, IGC should have been assessed prior to their enrollment by a psychologist not involved in the present research, resulting in a preselected sample. It can be suggested that children with certain behavioral features that make them stand out are more likely to consult a psychologist. So, our sample identified as gifted may present some clinical features that make it insufficiently representative of the IGC population as a whole. Finally, to limit the bias of rating with the BRIEF, a study including gifted children where parents and teachers are blinded to the children's status would be the best way to control this factor. This method would be difficult to achieve because of ethical concerns (to not inform the respondent of whether the child is classified as gifted or not) and would require the inclusion of a great number of participants, as only 2.2% of children have an IQ \geq 130.

In conclusion, IGC did not display superior scores on EF performance-based measures. Our results suggest that a very high intellectual level, as we assessed it, is not synonymous with very high EFs and, therefore, justifies that these two concepts should be distinguished. Nevertheless, efforts should be made to develop neuropsychological tests sensitive to high ability. Surprisingly, teachers' and parents' rating scales revealed more complaints about EFs of IGC than TDC in everyday functioning. As the data from the performance-based measures and academic achievement of these children did not support the idea of executive dysfunction, alternative assumptions should be explored. Further research is needed to better understand the reasons for this higher rating, especially to explore subjective beliefs about intellectual giftedness, expectations of adults (parents and teachers), and comparative elements (possibly with older children) relative to the behavioral rating of IGC.

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Conflicts of Interest

The authors have nothing to disclose.

Data availability statement

The data underlying this article will be shared on reasonable request to the corresponding author.

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References

Ardila, A. (2018). Is intelligence equivalent to executive functions? *Psicothema*, 30(2), 159–164. <https://doi.org/10.7334/psicothema2017.329>.

- Ardila, A., Pineda, D., & Rosselli, M. (2000). Correlation between intelligence test scores and executive function measures. *Archives of Clinical Neuropsychology*, *15*(1), 31–36. <https://doi.org/10.1093/arclin/15.1.31>.
- Arffa, S. (2007). The relationship of intelligence to executive function and non-executive function measures in a sample of average, above average, and gifted youth. *Archives of Clinical Neuropsychology*, *22*(8), 969–978. <https://doi.org/10.1016/j.acn.2007.08.001>.
- Arffa, S., Lovell, M., Podell, K., & Goldberg, E. (1998). Wisconsin card sorting test performance in above average and superior school children: Relationship to intelligence and age. *Archives of Clinical Neuropsychology*, *13*(8), 713–720. [https://doi.org/10.1016/S0887-6177\(98\)00007-9](https://doi.org/10.1016/S0887-6177(98)00007-9).
- Baudson, T. G., & Preckel, F. (2013). Teachers' implicit personality theories about the gifted: An experimental approach. *School Psychology Quarterly*, *28*(1), 37.
- Benedek, M., Jauk, E., Sommer, M., Arendasy, M., & Neubauer, A. C. (2014). Intelligence, creativity, and cognitive control: The common and differential involvement of executive functions in intelligence and creativity. *Intelligence*, *46*, 73–83. <https://doi.org/10.1016/j.intell.2014.05.007>.
- Bernes, G. A., Villodas, M., Coles, C. D., Kable, J. A., May, P. A., Kalberg, W. O., et al. (2021). Validity and reliability of executive function measures in children with heavy prenatal alcohol exposure: Correspondence between multiple Raters and laboratory measures. *Alcoholism: Clinical and Experimental Research*, *45*(3), 596–607.
- Blijd-Hoogewys, E. M. A., Bezemer, M. L., & van Geert, P. L. C. (2014). Executive functioning in children with ASD: An analysis of the BRIEF. *Journal of Autism and Developmental Disorders*, *44*(12), 3089–3100. <https://doi.org/10.1007/s10803-014-2176-9>.
- Brydges, C. R., Reid, C. L., Fox, A. M., & Anderson, M. (2012). A unitary executive function predicts intelligence in children. *Intelligence*, *40*(5), 458–469. <https://doi.org/10.1016/j.intell.2012.05.006>.
- Bucaille, A., Jarry, C., Brochard, S., Peudener, S., & Roy, A. (2022). Neuropsychological functioning of intellectually gifted children: A systematic review. *Journal of the International Neuropsychological Society*, *28*(4), 1–17.
- Calero, M. D., García-Martín, M. B., Jiménez, M. I., Kazén, M., & Araque, A. (2007). Self-regulation advantage for high-IQ children: Findings from a research study. *Learning and Individual Differences*, *17*(4), 328–343. <https://doi.org/10.1016/j.lindif.2007.03.012>.
- Carman, C. A. (2013). Comparing apples and oranges: Fifteen years of definitions of giftedness in research. *Journal of Advanced Academics*, *24*(1), 52–70. <https://doi.org/10.1177/1932202X12472602>.
- Caroff, X. (2004). L'identification des enfants à haut potentiel: Quelles perspectives pour l'approche psychométrique ? *Psychologie Française*, *49*(3), 233–251. <https://doi.org/10.1016/j.psfr.2004.06.001>.
- Cattell, R. B. (1963). Theory of fluid and crystallized intelligence: A critical experiment. *Journal of Educational Psychology*, *54*(1), 1–22. <https://doi.org/10.1037/h0046743>.
- Cattell, R. B. (1987). *Intelligence: Its structure, growth and action*. North-Holland: Elsevier.
- Ciesielski, E. J.M. (2020). *Examining assessment of executive function: Comparing performance-based measures and ratings in relation to academic achievement*. Doctoral dissertation, University of Cincinnati. OhioLINK Electronic Theses and Dissertations Center. http://rave.ohiolink.edu/etdc/view?acc_num=ucin1613744198164672
- Cornoldi, C. (2006). The contribution of cognitive psychology to the study of human intelligence. *European Journal of Cognitive Psychology*, *18*(1), 1–17. <https://doi.org/10.1080/09541440500215889>.
- Cuche, C., & Brasseur, S. (2017). *Le haut potentiel en questions*. Bruxelles: Mardaga.
- de Vries, M., de Ruiter, M. A., Oostrom, K. J., Schouten-Van Meeteren, A. Y. N., Maurice-Stam, H., Oosterlaan, J., et al. (2018). The association between the behavior rating inventory of executive functioning and cognitive testing in children diagnosed with a brain tumor. *Child Neuropsychology*, *24*(6), 844–858.
- Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. <https://doi.org/10.1146/annurev-psych-113011-143750>.
- Duan, X., Shi, J., Sun, S., Zhang, X., & Wu, J. (2009). Neural mechanisms of 1-back working memory in intellectually gifted children. Paper presented at the *3rd International Conference on Bioinformatics and Biomedical Engineering*, Tianjian, China, 14–16.
- Duan, X., Wei, S., Wang, G., & Shi, J. (2010). The relationship between executive functions and intelligence on 11- to 12-year-old children. *Psychological Test and Assessment eling*, *52*(4), 419–431.
- Duggan, E. C., & Garcia-Barrera, M. A. (2015). Executive functioning and intelligence. In S. Goldstein, D. Princiotta, & J. A. Naglieri (Eds.), *Handbook of intelligence: Evolutionary theory, historical perspective, and current concepts* (pp. 435–458). New York, NY: Springer Science. doi:https://doi.org/10.1007/978-1-4939-1562-0_27
- Duncan, J., Burgess, P., & Emslie, H. (1995). Fluid intelligence after frontal lobe lesions. *Neuropsychologia*, *33*(3), 261–268. [https://doi.org/10.1016/0028-3932\(94\)00124-8](https://doi.org/10.1016/0028-3932(94)00124-8).
- Friedman, N. P., Miyake, A., Corley, R. P., Young, S. E., DeFries, J. C., & Hewitt, J. K. (2006). Not all executive functions are related to intelligence. *Psychological Science*, *17*(2), 172–179. <https://doi.org/10.1111/j.1467-9280.2006.01681.x>.
- Gauvrit, N. (2014). Précocité intellectuelle: Un champ de recherches miné. *Approche Neuropsychologique Des Apprentissages Chez l'Enfant*, *132*(133), 1–6.
- Gilbert, S. J., & Burgess, P. W. (2008). Executive function. *Current Biology*, *18*(3), R110–R114. <https://doi.org/10.1016/j.cub.2007.12.014>.
- Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). Behavior rating inventory of executive function. *Child Neuropsychology*, *6*(3), 235–238. <https://doi.org/10.1076/chin.6.3.235.3152>.
- Gottfredson, L. S. (1997). Mainstream science on intelligence: An editorial with 52 signatories, history, and bibliography. *Intelligence*, *24*(1), 13–23. [https://doi.org/10.1016/S0160-2896\(97\)90011-8](https://doi.org/10.1016/S0160-2896(97)90011-8).
- Guerra, A., Hazin, I., Guerra, Y., Roulin, J.-L., Le Gall, D., & Roy, A. (2020). Developmental profile of executive functioning in school-age children from Northeast Brazil. *Frontiers in Psychology*, *11*, 596075. <https://doi.org/10.3389/fpsyg.2020.596075>.
- Guez, A., Peyre, H., Le Cam, M., Gauvrit, N., & Ramus, F. (2018). Are high-IQ students more at risk of school failure? *Intelligence*, *71*, 32–40. <https://doi.org/10.1016/j.intell.2018.09.003>.
- Hampshire, A., Highfield, R. R., Parkin, B. L., & Owen, A. M. (2012). Fractionating human intelligence. *Neuron*, *76*(6), 1225–1237. <https://doi.org/10.1016/j.neuron.2012.06.022>.
- Hartung, J., Engelhardt, L. E., Thibodeaux, M. L., Harden, K. P., & Tucker-Drob, E. M. (2020). Developmental transformations in the structure of executive functions. *Journal of Experimental Child Psychology*, *189*, 104681. <https://doi.org/10.1016/j.jecp.2019.104681>.
- Hernández Finch, M. E., Speirs Neumeister, K. L., Burney, V. H., & Cook, A. L. (2014). The relationship of cognitive and executive functioning with achievement in gifted kindergarten children. *Gifted Child Quarterly*, *58*(3), 167–182. <https://doi.org/10.1177/0016986214534889>.

- Herrera-Pino, J. A., & Castellanos, C. E. (2020). The relationship between intelligence and executive functions in Hispanic patients with mild traumatic brain injury. *Psychology, 11(1)*, 137–145. <https://doi.org/10.4236/psych.2020.111009>.
- Johnson, J., Im-Bolter, N., & Pascual-Leone, J. (2003). Development of mental attention in gifted and mainstream children: The role of mental capacity, inhibition, and speed of processing. *Child Development, 74(6)*, 1594–1614. <https://doi.org/10.1046/j.1467-8624.2003.00626.x>.
- Johnson, W., Nijenhuis, J. T., & Bouchard, T. J. (2008). Still just 1 g: Consistent results from five test batteries. *Intelligence, 36(1)*, 81–95. <https://doi.org/10.1016/j.intell.2007.06.001>.
- Jurado, M. B., & Rosselli, M. (2007). The elusive nature of executive functions: A review of our current understanding. *Neuropsychology Review, 17(3)*, 213–233. <https://doi.org/10.1007/s11065-007-9040-z>.
- Kean, J., & Reilly, J. (2014). Item response theory. In F. Hammond, J. Malec, & R. Buschbacher (Eds.), *Handbook for clinical research: Design, statistics and implementation* (pp. 195–198). New York: Springer Publishing Company. <https://connect.springerpub.com/content/book/978-1-6170-5099-2/part/part02/chapter/ch49>
- Korkman, M., Kirk, U., & Kemp, S. (2007). *NEPSY-II: A developmental neuropsychological assessment* (2nd ed.). San Antonio, TX: Harcourt Assessment.
- Kuwajima, M., & Sawaguchi, T. (2010). Similar prefrontal cortical activities between general fluid intelligence and visuospatial working memory tasks in preschool children as revealed by optical topography. *Experimental Brain Research, 206(4)*, 381–397. <https://doi.org/10.1007/s00221-010-2415-z>.
- Leikin, M., Paz-Baruch, N., & Leikin, R. (2013). Memory abilities in generally gifted and excelling-in-mathematics adolescents. *Intelligence, 41(5)*, 566–578. <https://doi.org/10.1016/j.intell.2013.07.018>.
- Mahone, E. M., Hagedorn, K. M., Cutting, L. E., Schuerholz, L. J., Pelletier, S. F., Rawlins, C., et al. (2002). Effects of IQ on executive function measures in children with ADHD. *Child Neuropsychology, 8(1)*, 52–65. <https://doi.org/10.1076/chin.8.1.52.8719>.
- Maricle, D. E., & Avirett, E. K. (2018). The role of cognitive and intelligence tests in the assessment of executive functions. In *Contemporary intellectual assessment: Theories, tests, and issues* (4th ed., pp. 973–992). New York, NY: The Guilford Press.
- Matheis, S., Kronborg, L., Schmitt, M., & Preckel, F. (2017). Threat or challenge? Teacher beliefs about gifted students and their relationship to teacher motivation. *Gifted and Talented International, 32(2)*, 134–160. <https://doi.org/10.1080/15332276.2018.1537685>.
- McBee, M. T., & Makel, M. C. (2019). The quantitative implications of definitions of giftedness. *AERA Open, 5(1)*, 2332858419831007. <https://doi.org/10.1177/2332858419831007>.
- McGrew, K. S. (1997). Analysis of the major intelligence batteries according to a proposed comprehensive Gf-Gc framework. In Flanagan, D. P., Genshaft, J. L., & Harrison, P. L. (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (, pp. 151–119). New York, NY: The Guilford Press.
- Miller, D. C., & Maricle, D. E. (2018). The emergence of neuropsychological constructs into tests of intelligence and cognitive abilities. In *Contemporary intellectual assessment: Theories, tests, and issues* (4th ed., pp. 912–931). New York, NY: The Guilford Press.
- Miranda, A., Colomer, C., Mercader, J., Fernández, M. I., & Presentación, M. J. (2015). Performance-based tests versus behavioral ratings in the assessment of executive functioning in preschoolers: Associations with ADHD symptoms and reading achievement. *Frontiers in Psychology, 6*, 545.
- Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 21(1)*, 8–14. <https://doi.org/10.1177/0963721411429458>.
- Modi, A. C., Vannest, J., Combs, A., Turnier, L., & Wade, S. L. (2018). Pattern of executive functioning in adolescents with epilepsy: A multimethod measurement approach. *Epilepsy & Behavior, 80*, 5–10.
- Montoya-Arenas, D. A., Aguirre-Acevedo, D. C., Díaz Soto, C. M., & Pineda Salazar, D. A. (2018). Executive functions and high intellectual capacity in school-age: Completely overlap? *International Journal of Psychological Research, 11(1)*, 19–32. <https://doi.org/10.21500/20112084.3239>.
- Nikolašević, Ž., Smederevac, S., Bugarski Ignjatović, V., Kodžopeljić, J., Milovanović, I., Prinz, M., et al. (2020). Executive functions and intelligence- are there genetic difference? *Intelligence, 82*, 101480. <https://doi.org/10.1016/j.intell.2020.101480>.
- O’Meagher, S., Norris, K., Kemp, N., & Anderson, P. (2019). Examining the relationship between performance-based and questionnaire assessments of executive function in young preterm children: Implications for clinical practice. *Child Neuropsychology, 25(7)*, 899–913.
- Pang, W., Esping, A., & Plucker, J. A. (2017). Confucian conceptions of human intelligence. *Review of General Psychology, 21(2)*, 161–169. <https://doi.org/10.1037/gpr0000103>.
- Pfeiffer, S. I. (2015). *Essentials of gifted assessment*. New Jersey, NJ: John Wiley & Sons.
- Preckel, F., Baudson, T. G., Krolak-Schwerdt, S., & Glock, S. (2015). Gifted and maladjusted? Implicit attitudes and automatic associations related to gifted children. *American Educational Research Journal, 52(6)*, 1160–1184.
- Roca, M., Parr, A., Thompson, R., Woolgar, A., Torralva, T., Antoun, N., et al. (2010). Executive function and fluid intelligence after frontal lobe lesions. *Brain, 133(1)*, 234–247. <https://doi.org/10.1093/brain/awp269>.
- Roy, A., Fournet, N., Le Gall, D., & Roulin, J.-L. (2021). *Batterie FÉE: Batterie d’évaluation des fonctions exécutives chez l’enfant*. Paris, France: Hogrefe France Edition.
- Roy, A., Fournet, N., Roulin, J.-L., & Le Gall, D. (2013). *BRIEF-inventaire d’évaluation comportementale des fonctions exécutives, adaptation française [behavior rating inventory of executive]*. Paris, France: Hogrefe France Edition.
- Roy, A., Kefi, M.-Z., Bellaj, T., Fournet, N., Le Gall, D., & Roulin, J.-L. (2016). The Stroop test: A developmental study in a French children sample aged 7 to 12 years. *Psychologie Française, 63(2)*, 129–143. <https://doi.org/10.1016/j.psfr.2016.08.001>.
- Roy, A., Roulin, J.-L., Fournet, N., Le Gall, D., Krasny-Pacini, A., & Chevignard, M. (2020). Les troubles des fonctions exécutives. In Majerus, S., Jambaqué, I., Mottron, L., Van der Linden, M., & Poncelet, M. (Eds.), *Traité de neuropsychologie de l’enfant, 2ème édition* (, pp. 219–241). Paris, France: De Boeck Supérieur.
- de Ruitter, M. A., Schouten-van Meeteren, A. Y. N., van Vuurden, D. G., Maurice-Stam, H., Gidding, C., Beek, L. R., et al. (2016). Psychosocial profile of pediatric brain tumor survivors with neurocognitive complaints. *Quality of Life Research, 25(2)*, 435–446.
- Samuels, W. E., Tournaki, N., Blackman, S., & Zilinski, C. (2016). Executive functioning predicts academic achievement in middle school: A four-year longitudinal study. *The Journal of Educational Research, 109(5)*, 478–490. <https://doi.org/10.1080/00220671.2014.979913>.
- Schweizer, K., & Moosbrugger, H. (2004). Attention and working memory as predictors of intelligence. *Intelligence, 32(4)*, 329–347. <https://doi.org/10.1016/j.intell.2004.06.006>.
- Soriano-Ferrer, M., Félix-Mateo, V., & Begeny, J. C. (2014). Executive function domains among children with ADHD: Do they differ between parents and teachers ratings? *Procedia-Social and Behavioral Sciences, 132*, 80–86.

- Spearman, C. (1904). "General intelligence," objectively determined and measured. *The American Journal of Psychology*, 15(2), 201–292. [JSTOR. https://doi.org/10.2307/1412107](https://doi.org/10.2307/1412107).
- Sternberg, R. J., & Gardner, M. K. (1982). A componential interpretation of the general factor in human intelligence. In H. J. Eysenck (Ed.), *A model for intelligence* (pp. 231–254). New York, NY: Springer. doi:https://doi.org/10.1007/978-3-642-68664-1_8
- Sternberg, R. J., & Kaufman, J. C. (1998). Human abilities. *Annual Review of Psychology*, 49(1), 479–502. <https://doi.org/10.1146/annurev.psych.49.1.479>.
- Tanabe, M. K., Whitaker, A. M., O'Callaghan, E. T., Murray, J., & Houskamp, B. M. (2014). Intellectual ability as a predictor of performance on the Wisconsin card-sorting test. *Applied Neuropsychology: Child*, 3(4), 275–283. [psych. https://doi.org/10.1080/21622965.2012.757700](https://doi.org/10.1080/21622965.2012.757700).
- Thompson, A., & Steinbeis, N. (2020). Sensitive periods in executive function development. *Current Opinion in Behavioral Sciences*, 36, 98–105.
- Thorndike, E. L. (1921). Intelligence and its measurement: A symposium–I. *Journal of Educational Psychology*, 12(3), 124–127. <https://doi.org/10.1037/h0064596>.
- Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? Performance-based and rating measures of EF. *Journal of Child Psychology and Psychiatry*, 54(2), 131–143. <https://doi.org/10.1111/jcpp.12001>.
- van Aken, L., van der Heijden, P. T., Oomens, W., Kessels, R. P. C., & Egger, J. I. M. (2019). Predictive value of traditional measures of executive function on broad abilities of the Cattell–horn–Carroll theory of cognitive abilities. *Assessment*, 26(7), 1375–1385. <https://doi.org/10.1177/1073191117731814>.
- Viana-Sáenz, L., Sastre-Riba, S., Urraca-Martínez, M. L., & Botella, J. (2020). Measurement of executive functioning and high intellectual ability in childhood: A comparative meta-analysis. *Sustainability*, 12(11), 1–12.
- Vock, M., & Holling, H. (2008). The measurement of visuo-spatial and verbal-numerical working memory: Development of IRT-based scales. *Intelligence*, 36(2), 161–182. <https://doi.org/10.1016/j.intell.2007.02.004>.
- Vogelaar, B., Bakker, M., Hoogeveen, L., & Resing, W. C. (2017). Dynamic testing of gifted and average-ability children's analogy problem solving: Does executive functioning play a role? *Psychology in the Schools*, 54(8), 837–851.
- Wechsler, D. (2016). *WISC-V : Manuel d'interprétation*. Paris, France: Pearson - Edition du Centre de Psychologie Appliquée.
- Whitaker, A. M., O'Callaghan, E. T., & Houskamp, B. M. (2013). Executive functioning in intellectually gifted children and adolescents. *Cognitive Sciences*, 8(2), 161–188.