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Thirty years of ADHD and WISC in scientific research: A systematic review of cognitive profile and index discrepancies

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Abstract

Several decades have passed since the initial exploration of the cognitive profile of ADHD using the WISC. Since then, the scientific evidence on the topic has grown and evolved, at times being contradictory. Therefore, it is considered valuable to collect, analyze, compare, and synthesize the findings from the past 30 years. A systematic review was conducted following the PRISMA guidelines. The sources of information included the WoS, Scopus, PsycInfo, and MedLine databases, and the search terms applied were: (ADHD OR 'attention deficit' OR hyperactive*) AND (WISC*). Some of the inclusion criteria were: Participants were males and/or females aged between 6 and 16 years, formally diagnosed with ADHD, and assessed using the WISC-IV and/or the WISC-III. A total of 27 high-quality studies, with 6,486 participants across them, published up to September 2024, were analyzed. The systematic review, supported by a simple complementary statistical approach, suggests a cognitive profile characterized by higher scores on VC and PR/PO and lower scores on WM/FFD and PS. The index discrepancies that arise from comparing VC and PR/PO scores with WM/FFD and PS scores range from five to ten points. For the assessment of ADHD, as a complementary tool to the observation scales, it could be useful to use the WISC, examine the cognitive profile and index discrepancies, always with careful interpretation by an experienced professional in the field of psychology, psychopedagogy, psychiatry or neuropsychology.

Keywords: ADHD; Attention Deficit; Hyperactivity; WISC-III; WISC-IV; Cognitive Profile.

Resumen

Treinta años de TDAH y WISC en investigación científica: Una revisión sistemática del perfil cognitivo y discrepancias entre índices. Han pasado varias décadas desde la exploración inicial del perfil cognitivo del TDAH utilizando el WISC. Desde entonces, la evidencia científica sobre el tema ha crecido y evolucionado, siendo en ocasiones contradictoria. Por ello, se considera valioso recopilar, analizar, comparar y sintetizar los hallazgos de los últimos 30 años. Se llevó a cabo una revisión sistemática siguiendo las directrices PRISMA. Las fuentes de información incluyeron las bases de datos de WoS, Scopus, PsycInfo y MedLine, y los términos de búsqueda aplicados fueron: (ADHD OR 'attention deficit' OR hyperactive*) AND (WISC*). Algunos de los criterios de inclusión fueron: Participantes de sexo masculino y/o femenino con edades entre 6 y 16 años, diagnosticados formalmente con TDAH y evaluados mediante el WISC-IV y/o WISC-III. Se analizaron un total de 27 estudios de calidad, con 6,486 participantes en total, publicados hasta septiembre de 2024. La revisión sistemática, respaldada por un enfoque estadístico complementario simple, sugiere un perfil cognitivo caracterizado por puntuaciones más altas en CV y RP/OP, y puntuaciones más bajas en MT/ID y VP. Las discrepancias entre índices que surgen al comparar las puntuaciones de CV y RP/OP con las de MT/ID y VP oscilan entre cinco y diez puntos. Para la evaluación del TDAH, como herramienta complementaria a las escalas de observación, podría ser útil utilizar el WISC, examinar el perfil cognitivo y las discrepancias entre índices, siempre con una interpretación cuidadosa por parte de un profesional experimentado del ámbito de la psicología, psicopedagogía, psiquiatría o neuropsicología.

Palabras clave: TDAH; Déficit de Atención; Hiperactividad; WISC-III; WISC-IV; Perfil cognitivo.

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Highlights

- A characteristic cognitive profile in ADHD was identified, marked by higher scores in Verbal Comprehension and Perceptual Reasoning/Perceptual Organization, and lower scores in Working Memory/Freedom from Distractibility and Processing Speed.
- Index discrepancies suggest their diagnostic utility when carefully interpreted by trained professionals.
- Subtypes of ADHD showed minor differences in Verbal Comprehension and Perceptual Reasoning/Organization scores, but PS emerged as a differentiating factor among them.
- The WISC-IV data revealed more pronounced cognitive patterns compared to The WISC-III, reinforcing its relevance in ADHD assessment.
- The WISC remains a valuable complementary tool for ADHD assessment, supporting differential diagnosis when used alongside behavioral scales and expert clinical judgment.

Puntos clave

- Se identificó un perfil cognitivo característico en TDAH, con puntuaciones más altas en Comprensión Verbal y Razonamiento Perceptivo/Organización Perceptual, y más bajas en Memoria de Trabajo y Velocidad de Procesamiento.
- Las discrepancias entre índices sugieren su utilidad diagnóstica si son interpretadas cuidadosamente por profesionales cualificados.
- Los subtipos de TDAH mostraron pocas diferencias en Comprensión Verbal y Razonamiento perceptivo, pero la Velocidad de Procesamiento destacó como factor diferenciador entre ellos.
- Los datos del WISC-IV mostraron patrones cognitivos más acentuados en comparación con el WISC-III, reforzando su relevancia en la evaluación del TDAH.
- El WISC sigue siendo una herramienta complementaria valiosa para la evaluación del TDAH, apoyando el diagnóstico diferencial cuando se utiliza junto a escalas conductuales y juicio clínico experto.

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders in children and adolescents (Polanczyk et al., 2014; Thomas et al., 2015). Its primary symptoms typically manifest between the ages of 6 and 12 years (APA, 2013). Therefore, early detection is crucial to initiate intervention and prevent further deterioration (Rappaport et al., 1998; Sonuga-Barke et al., 2011; Hamed et al., 2015; Miller et al., 2018; Hare et al., 2021; Kajka & Kulik, 2021). To diagnose ADHD, it is necessary to confirm the presence of a persistent pattern of inattention, hyperactivity, and impulsivity that significantly interferes with individual, social, academic, or occupational functioning (APA, 2013; Bélanger et al., 2018). However, its assessment is a complex process, hindered by, among other factors, the lack of biological markers and the existence of assessment tools that, at times, only seem to provide approximate information (Navarro-Soria et al., 2020).

An important part of ADHD assessment is based on the use of observational scales (Collett et al., 2003; Snyder et al., 2006; Mulraney et al., 2021; Moncivais et al., 2022), i.e., systematic recordings of behaviors perceived by different observers, such as the first update of the Child and Adolescent Behavior Inventory (CABI 1.1.; Burns et al., 2018), the fourth edition of the Conners Comprehensive Behavior Rating Scales (CONNERS 4; Conners, 2022), or the Barkley Deficits in Executive Functioning Scale - Children and Adolescents (BDEFS-CA; Barkley, 2012). However, for the sake of completeness, it is recommended to directly assess the individual through the application of psychometric tests (Reid & Maag, 1994; Isquith et al., 2013; Krieger & Amador-Campos, 2018; Marshall et al., 2021), i.e., standardized tests such as the fifth edition of the Stanford-Binet Intelligence Scales (SB-5; Roid, 2003), the fourth edition of the Woodcock-Johnson Tests of Cognitive Abilities (WJ-IV; Schrank, 2014), the Neuropsychological Assessment of Executive Functions in Children (ENFEN; Portellano et al., 2009), or the Wechsler Intelligence Scale for Children (WISC), one of the most widely used psychometric tests of cognitive abilities internationally (Oakland & Hu, 1992; Oakland et al., 2013; Oakland et al., 2016; Benson et al., 2019; Muñiz et al., 2020).

It is believed that the first attempt to identify specific cognitive traits through the WISC was made by Bannatyne (1968). Shortly thereafter, the need for a cognitive study of ADHD was postulated by Prifitera and Dersh (1993). Since then, the WISC has been used by a variety of professionals to aid in the assessment and diagnosis of ADHD. Over time, repeated use of the WISC with numerous individuals diagnosed with ADHD has led to the hypothesis of a distinct cognitive profile, i.e., a pattern of responses with similar characteristics. For example, with the third edition of the Wechsler Intelligence Scale for Children (WISC-III; 1991), a greater impairment of individuals with ADHD was identified in the Digit Span and Arithmetic subtests, which are part of the Freedom from Distractibility Index (FFD; Anastopoulos et al., 1994; Hesapcioglu et al., 2016); in Digit Span, Arithmetic, and Coding in the Spatial Skills Cluster (Prifitera & Dersh, 1993; Hesapcioglu et al., 2016); in Digit Span, Arithmetic, Coding, and Symbol Search in the SCAD Profile (Kaufman, 1994; Mayes & Calhoun, 2006); and in Digit Span, Arithmetic, Coding, and Information in the ACID Profile (Prifitera & Dersh, 1993; Filippatou & Livaniou, 2005).

With the arrival of the fourth edition of the *Wechsler Intelligence Scale for Children* (WISC-IV, 2003), these subtests were reorganized around other subscales. Although most of the psychometric test characteristics remained stable, some subtests disappeared and some subscales shifted, improving reliability and validity. However, despite these changes, individuals with ADHD continued to show higher levels of impairment on the Arithmetic, Digit Span, and Letters-Number Sequencing subtests of the Working Memory Index (WM), as well as on Symbol Search, Coding, and Cancellation in the Processing Speed Index (PS). The scores obtained on other indexes, such as Verbal Comprehension (VC) and Perceptual Reasoning (PR), contrast with the deficits found in WM and PS. Thus, a cognitive profile characterized by higher scores in VC and PR, and lower scores in WM and PS, was established (Arribas et al., 2011; Barkley et al., 2001; Bustillo & Servera, 2015; Corral et al., 2013; Mayes & Calhoun, 2006; Toffalini et al., 2022),

revealing discrepancies between the indexes and drawing, on the composite score graph, a line chart with a sharp drop, a downward slope, or, as some authors have referred to it, a "cognitive step" (Fenollar-Cortés et al., 2015; Navarro-Soria et al., 2017; Navarro-Soria et al., 2020). The hypothesis that the main impairment in ADHD is rooted in significant deficits in WM and PS is increasingly relevant (Cheung et al., 2014; Fosco et al., 2020; Kibby et al., 2019; Kubo et al., 2018; Moura et al., 2019; Yang et al., 2017).

Several decades have passed since the initial exploration of the cognitive profile of ADHD using the WISC. Since then, scientific evidence on the topic has grown and evolved, at times being contradictory. Therefore, the main objective of the research presented is to conduct a systematic review to collect, analyze, compare, and synthesize the findings from the past 30 years. Additionally, the aim is to create a "meta-cognitive profile" and examine the index discrepancies, in order to facilitate the assessment and diagnosis of ADHD. Finally, possible differences between groups will be explored, depending on variations in symptom predominance and the different editions of the WISC.

Method

Protocol and registration

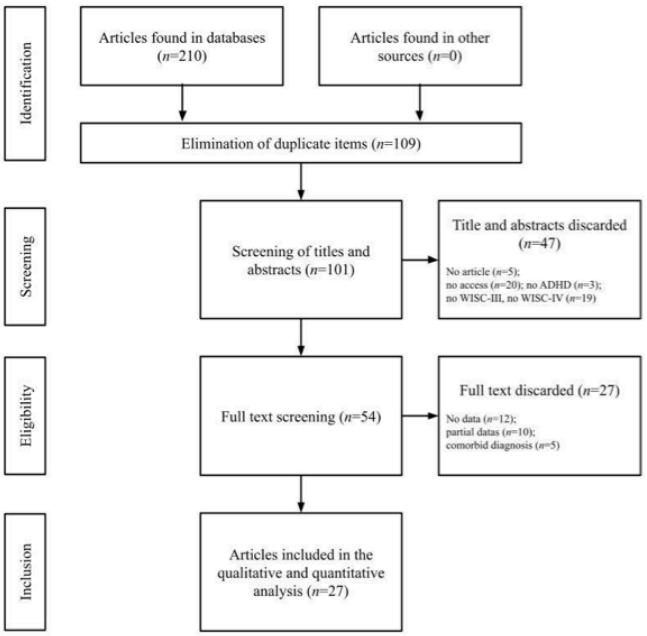
The protocol for the systematic review was registered in the *International Prospective Register of Systematic Reviews* (PROSPERO, https://www.crd.york.ac.uk/prospero; Protocol Number: CRD42022339096) and followed the guidelines of the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA; Moher et al., 2009).

Eligibility criteria, sources of information and search for articles

With partial reliance on the guidelines of the *Population-Intervention-Comparison-Outcome* (PICO; Richardson et al., 1995), the inclusion and exclusion criteria determined for the articles included in the systematic review were as follows: (1) participants were males and/or females between the ages of 6 and 16 years of age; (2) participants were formally diagnosed with ADHD; (3) participants had no comorbidities with other Neurodevelopmental Disorders such as Autism Spectrum Disorder (ASD) or Specific Language Impairment (SLI); (4) the assessment instrument implemented was the WISC-III and/or the WISC-IV; (5) the outcomes recorded were, at a minimum, the score from the VC, PR/Perceptual Organization (PO), WM/FFD and PS subscales; (6) the study was written in English or Spanish; (7) the study was published in a high-impact journal. Therefore, research on: (1) comparative studies between neurotypical (NT) sample, ADHD sample and other neurodevelopmental disorders; and (2) validation studies with the aforementioned instruments in ADHD population were included in the present study.

The collection of publications was carried out independently by two authors. The main sources of information used were the Web of Science (WoS) and Scopus databases, in order to favour the quality of the articles by ensuring their indexation in the Journal Citation Reports (JCR) and the SCImago Journal Rank (SJR). Other complementary sources of information used were the PsycInfo and MedLine databases. The terms applied to the search for articles were the following: (ADHD OR "attention deficit" OR hyperactive*) AND (WISC*). The time interval for publication of studies was from outset up until September 2024. The details of the article search are recorded in the PRISMA flow chart (Figure 1).

Figure 1. Flow chart



Study selection and data extraction

The selection of studies for the systematic review was carried out independently by two authors. After removing duplicate articles, the remaining papers were screened based on the eligibility criteria. The titles and abstracts of the articles were used as a first approximation, but the final decision to include studies was made on the basis of the full text of the papers.

A protocol was developed to extract the characteristics of the studies. The following characteristics were extracted: Sample size of the ADHD and NT control groups, female-male percentage in ADHD and NT control groups, mean age of ADHD and NT participants, ADHD subtype, treatment, pharmacological and/or therapeutic, comorbidity, method of assessment using standardized tests, the WISC edition and specifically the score obtained in the VC, PR/OP, WM/FFD and PS subscales, reporting bias, continent and year of publication. In addition, the methodological quality of the included studies was assessed using 8 items of the Newcastle-Ottawa Scale (NOS) for case-control studies (Wells et al., 2015). This scale uses a "star system" to judge on the basis of three dimensions: Selection, comparability, and exposure for case-control studies. The NOS consists of 8 items and the maximum total quality score is 10 stars. Data extraction and assessment of the articles was performed independently by two authors with expertise in bias analysis. Any disagreement was resolved by a third reviewer.

Complementary analysis

In addition to the qualitative analysis inherent to the methodology of this type of research, the present systematic

review also includes a simple quantitative analysis, based on the frequency and percentage of the number of articles or subjects involved, as well as the calculation of basic measures of centralization and dispersion, i.e., means (M) and standard deviations (SD) weighted by the sample of each study. These operations were performed using *Statistical Package for the Social Sciences* (v.25.0).

Results

Study characteristics

After eliminating duplicate papers and applying the eligibility criteria, the non-relevant articles were discarded. Ultimately, a total of 27 articles were included (Figure 1). The total number of participants was 6,486, of whom 80.67 % (*N* = 5,231) were formally diagnosed with ADHD, 3.22 % (*n* = 209) belong to the control group and 16.12 % (*n* = 1,046) were diagnosed with other disorders. In terms of sex, 75.34 % (*n* = 3,941) were male and 23.71 % (*n* = 1,240) were female. The sex of 0.95 % (*n* = 50) was not recorded. Regarding age, most articles set their range between 6 and 16 years (*M* = 9.62; *SD* = 0.86). Regarding ADHD subtype, 42.29 % (*n* = 2212) were diagnosed as combined type (ADHD-C), 30.47 % (*n* = 1594) as predominantly inattentive (ADHD-I), 4.40% (*n* = 230) as predominantly hyperactivity and impulsivity (ADHD-HI) and 0.44% (*n* = 23) with unspecified ADHD. The subtype of 14.17 % (*n* = 773) was not recorded.

In terms of pharmacological treatment, a total of 12 out of 27 papers reported that participants were not taking specific medication for ADHD at the time of the research. However, some papers acknowledged that a high percentage of the sample were receiving pharmacological treatment. Despite this, several authors stated that they recorded no differences between medicated and non-medicated participants. On the other hand, several studies stated that they did not know whether subjects were receiving medication, and other studies did not report this information. With regard to psychoeducational treatment, 25 articles did not refer to the presence or absence of psychoeducational therapy. Data on comorbidity were inconsistent, with 13 articles reporting that participants had no other disorders and several authors reporting between 20 %, 60 % and 90 % of ADHD cases were comorbid with behavioral, emotional, learning or language disorders. Other studies did not report information regarding the presence or absence of comorbidity.

The 27 selected papers analyzed a total of 6,486 participants, with 5,231 pertaining to ADHD groups (range: 6-16 year old) and 209 to the control groups (range: 6-16 year old). Seventeen studies (62.9 %) showed a medium-high quality on the NOS scale (Supplementary Table S1). Likewise, 100 % of the studies analyzed had an adequate definition of the sample characteristics according to DSM-5 or DSM-IV-TR criteria. On the other hand, 85.1 % of the studies reported the origin or a defined area of influence (e.g., a defined hospital or clinic, group of hospitals), and the obtaining of the sample (e.g., random sample). However, 37 % of the papers had comparative groups (clinical and neurotypical) had the same socio-demographic characteristics, including sex. Furthermore, 29.6 % of the studies correctly define the control group (e.g., scores obtained on intelligence scales and ADHD scales, clinical history, etc.) are reported. In this sense, 62.9 % of the studies included in their analysis a comparison between the control group and the clinical group. However, only 18.5 % of the articles select the participants' membership in a control group with a blind and randomized strategy. On the other hand, 44.4 % of the studies use the same selective method, the same diagnostic tools are applied, etc. Specifically, 70.3 % of the studies report the non-response rate in the tests applied (e.g., the same type of score is applied to both groups analyzed). Finally, 48.1 % of the studies have a balance in the total number of participants between the clinical and neurotypical sample.

Data synthesis

Sequencing of the four subscales: description of a "cognitive meta-profile"

Although the results of a total of 27 articles were analyzed in the systematic review, two distinct blocks of independent data were extracted from the same article. Therefore, a total of 28 studies will be referred to, instead of 27 articles. In a total of 27 of 28 studies, or 96.43 % (*n* = 5,171), either VC or PR/PO was the superior subscale. In 20 studies, 71.43 % (*n* = 3,874), VC was the highest scoring variable; and in 14 studies, 50 % (*n* = 3,517), PR/PO was the highest scoring factor. At the other extreme, in 26 studies, 92.86 % (*n* = 5,115), either PS or WM/FFD was the lowest subscale. In 14 studies, 50 % (*n* = 2,931), PS was the variable with the smallest numbers; and in 19 studies, 67.86 % (*n* = 4,457), WM/FFD was the lowest scoring factor. It should be noted that PS only ranked first in a single study, while WM/FFD did not rank first in any of the cases (Tables 1, 2, 3 and 4).

From another perspective, a total of 21 out of the 28 studies, i.e., 75 % (n = 4,680), reported a cognitive pattern characterized by a higher score in VC and PR/PO and a lower score in WM/FFD and PS (Table 5). The most repeated cognitive pattern was [VC > PR/PO > PS > WM/FFD], present in 6 studies (*n* = 998). Other projects also presented identical profiles such as [PR > VC > WM = PS], [VC = PR/OP > PS > WM/FFD] and [VC = PR > WM > PS], each repeated in 3 articles (*n* = 1,163; *n* = 824; *n* = 537). Other relatively frequent data were [VC = PR/PO], present in 8 studies (*n* = 2,264), and [WM/FFD = PS], present in 7 studies (*n* = 2,282). It should be noted that the cognitive pattern of [VC = PR > PS = WM] was extracted from the study with the largest sample size (*n* = 859).

However, a total of 7 out of 28 studies, i.e., 25% (*n* = 551), reported discordant profiles (Table 6), which differed from the previously observed cognitive pattern, in that they were not characterised by higher VC and PR/PO scores and lower WM/FFD and PS scores.

Ultimately, the pattern characterized by higher VC (*M* = 101.53; *SD* = 6.7) and PR/PO (*M* = 101.33; *SD* = 5.11) and lower WM/FFD (*M* = 92.6; *SD* = 3.09) and PS (*M* = 93.98; *SD* = 4.12) scores, stood out as it was supported by a significant proportion of the study sample and found support in other articles (Figure 2). However, the discordant profiles, characterised by not scoring higher on VC (*M* = 96.03; *SD* = 5.37) and PR/PO (*M* = 93.89; *SD* = 4.31) and scoring lower on WM/FFD (*M* = 89.73; *SD* = 9.34) and PS (*M* = 94.43; *SD* = 5.17), contrasted by not concentrating a substantial amount of the study sample and by presenting in isolation, i.e., not finding support in any of the research reviewed (Figure 3). In general, the global cognitive

Supplementary Table S1. Review of author judgments on quality assessment for each included study

Item Newcastle - Ottawa quality assessment scale case control studies	Parracho et al. (2005)	Finegold et al. (2010)	Adams et al. (2011)	Williams et al. (2011)	Wang et al. (2011)	Williams et al. (2012)	Wang et al. (2013)	De Angelis et al. (2013)	Kang et al. (2013)	Inoue et al. (2016)	Iovene et al. (2017)	Finegold et al. (2017)	Kang et al. (2018)	Coretti et al. (2018)	Zhang et al. (2018)	Ma et al. (2019)	Plaza-Díaz et al. (2019)	Niu et al. (2019)
Definition adequate	-	-	-	★	★	★	-	★	-	★	★	-	-	★	★	★	★	★
Representativeness of the cases	-	★	★	-	-	-	-	★	-	-	★	-	-	★	★	★	★	★
Selection of controls	-	-	-	★	´-	-	-	-	★	-	★	-	-	-	-	★	★	-
Definition of controls	-	-	-	-	-	-	-	-	-	-	★	-	-	★	★	-	★	★
Comparability of cases and controls on the basis of the design or analysis	★	-	★	-	★	-	-	★	★	-	-	-	★	★	★	★	★	-
Ascertainment of exposure	★	★	★	-	-	-	-	★	★	★	★	★	★	★	★	★	★	★
Same method of ascertainment for cases and controls	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
Non-Response rate	★	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	5	3	5	3	3	2	1	5	5	3	6	2	4	7	7	7	8	5
Balance between the sample sizes of the groups.	-	-	1	1	1	1	1	-	1	1	1	-	1	1	-	1	1	-
Reporting bias	1	1	1	1	-	1	-	1	1	1	1	-	1	1	-	1	1	1

Note. - = not adequately assessed; 1 = not reporting bias; high quality (9-8 stars total); moderate quality (7-5 stars total); low quality (> 4 stars total)

Table 1. Sociodemographic data of the included studies

N°	Research	ADHD (*N*)	Age			Sex (*n*)		Subtipe (*n*)				Treatment (%)		Comorbidity
			Range (Years)	*M*	*SD*	Men	Women	ADHD -C	ADHD -I	ADHD -HI	ADHD Not specified	Pharmacological	Therapeutic	
1[a]	Mayes & Calhoun (2006)	118	Jun-16	9	2.7	76	42	n.d.	n.d.	-	-	No	n.d.	n.d.
2	Bustillo & Servera (2015)	74	6-Dec	8.41	1.61	56	18	24	27	-	23	n.d.	n.d.	n.d.
3	Ünal et al. (2021)	154	6-Dec	9.18	2.51	116	38	106	39	7	-	No	n.d.	No
4	Dinçer et al. (2022)	60	Jun-13	8.6	1.66	50	10	42	14	4	-	No	n.d.	Yes (66.7%) behavioral (+50%) and language
5	Styck & Watkins (2017)	233	Jun-16	10.5	2.6	163	70	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Yes (17.5%) learning, emotional and language
6	Navarro-Soria et al. (2020)	95	Jun-14	9.6	2.4	68	27	48	47	-	-	Yes (68.4%)	n.d.	No
7	Molavi et al. (2020)	139	Jun-15	8.2	2.5	112	27	33	35	71	-	No	n.d.	No
8	Matsuura et al. (2014)	15	Oct-15	10.8	1.8	13	2	n.d.	n.d.	n.d.	n.d.	Yes (86.7%)	Yes	No

N°	Research	ADHD (*N*)	Age			Sex (*n*)		Subtipe (*n*)				Treatment (%)		Comorbidity
			Range (Years)	*M*	*SD*	Men	Women	ADHD -C	ADHD -I	ADHD -HI	ADHD Not specified	Pharmacological	Therapeutic	
9	Gomez et al. (2016)	812	Jun-16	11.03	3.08	616	196	522	227	63	-	No	n.d.	Yes (+90%) behavioral and emotional
10	Thaler et al. (2015)	314	Jun-16	10.3	2.8	219	95	113	201	-	-	n.d.	n.d.	Yes (+95%) behavioral y learning
11	Parke et al. (2020)	178	Jun-16	10.4	2.8	123	55	78	100	-	-	n.d.	n.d.	No
12	Fenollar-Cortés et al. (2015)	86	Jun-14	9.6	2.4	61	25	44	42	-	-	Yes (86.6%)	n.d.	n.d.
13	Walg et al. (2017)	50	Jul-16	10.2	2	n.d.	n.d.	29	21	-	-	No	n.d.	No
14	Fernández-Jaén et al. (2012)	170	6-Dec	8.4	2.02	129	41	94	74	2	-	No	No	Yes (67.4%) behavioral and emotional
15	Calub et al. (2019)	28	8-Dec	9.76	1.29	28	-	28	-	-	-	n.d.	n.d.	Yes (7.14%) behavioral
16	Wanderer et al. (2021)	45	Jun-16	9.3	2.2	39	6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	No
17	Fenollar-Cortés et al. (2019)	859	Jun-16	9.6	2.81	681	178	365	494	-	-	No	n.d.	No
18	Jiang et al. (2015)	78	Jun-14	10.03	2.53	78	-	23	46	9	-	n.d.	n.d.	No
19	Kim & Song (2020)	44	6-Nov	7.8	1.41	44	-	n.d.	n.d.	n.d.	n.d.	No	n.d.	No
1[b]	Mayes & Calhoun (2006)	586	Jun-16	9	2.4	434	152	n.d.	n.d.	-	-	No	n.d.	n.d.
20	Ulla et al. (2007)	42	10-Nov	n.d.	n.d.	32	10	n.d.	n.d.	-	-	n.d.	n.d.	n.d
21	Egeland et al. (2006)	48	n.d.	10.6	2.4	30	18	48	-	-	-	n.d.	n.d.	No
22	Moura et al. (2019)	98	6-Dec	8.55	1.92	75	23	26	36	36	-	No	n.d.	No
23	Mayes & Calhoun (2004)	630	Jun-16	9	3	466	164	495	135	-	-	No	n.d.	Yes (21.4%) behavioral
24	Koyama et al. (2006)	27	n.d.	8.7	2.1	23	4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
25	Krane & Tannock (2001)	188	Jun-18	8.7	1.72	158	30	94	56	38	-	No	n.d.	Yes (+78%) behavioral
26	Snow & Sapp (2000)	35	Jun-16	10.9	2.8	30	5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
27	Naglieri et al. (2003)	25	Jun-16	10.3	2.5	21	4	n.d.	-	n.d.	-	n.d.	n.d.	No

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed, n.d. = No Data

Table 2. Subscale scores for the subscales of the included studies

Nº	Research	WISC (Ed)	Subescales								FSIQ	
			VC		PR/PO		WM/FFD		PS			
			M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1[a]	Mayes & Calhoun (2006)	IV	114	13	117	13	93	13	93	12	108	13
2	Bustillo & Servera (2015)	IV	102.62	13.23	100.89	9.4	88.76	12.42	92.07	13.02	95.03	8.82
3	Ünal, D et al. (2021)	IV	96.75	11.29	91.79	12.94	89.99	12.75	91.66	13.17	90.91	11.76
4	Dinçer, M et al. (2022)	IV	90.6	13.25	93.03	12.12	85.85	12.42	95.63	13.56	88.61	12.68
5	Styck & Watkins (2017)	IV	96.35	12.56	98.78	14.19	92.42	12.47	92.9	14.53	94.47	13.51
6	Navarro-Soria et al. (2020)	IV	106.4	14.9	104.1	15.5	96.9	15.5	98.1	16.3	101.9	15.5
7	Molavi et al. (2020)	IV	93.91	17.52	90.52	14.59	77.91	16.87	92.27	16.72	85.61	16.17
8	Matsuura et al. (2014)	IV	103.1	12.4	104.9	13.1	101.2	21.7	99.3	11.3	103.8	14.9
9	Gomez et al. (2016)	IV	89.25	15.31	93	15.29	87.7	15.24	87.4	14.95	87.56	15.08
10	Thaler et al. (2015)	IV	101.8	14.4	100.8	13	95.6	13.6	93.4	13.4	98.4	12.8
11	Parke et al. (2020)	IV	105.5	13.5	104.9	12	99.1	12.4	97.6	13.4	n.d.	n.d.
12	Fenollar-Cortés et al. (2015)	IV	106.4	14.9	104.4	15.5	96.9	15.5	98.1	16.3	101.9	15.5
13	Walg et al. (2017)	IV	105.24	1.95	104.68	1.56	92.54	1.71	99.72	1.52	101.32	1.49
14	Fernández-Jaén et al. (2012)	IV	107	17.7	104	16.5	94	14.4	95	15.4	103	16.7
15	Calub et al. (2019)	IV	108.1	10.02	106.61	13.1	100.64	10.43	96.64	10.73	105.21	10.33
16	Wanderer et al. (2021)	IV	103	13.1	102	14.8	96	11.6	94	10.9	99	11.9
17	Fenollar-Cortés et al. (2019)	IV	101.45	12.81	100.64	13.21	92	13.06	92.14	13	95.43	12.18
18	Jiang et al. (2015)	IV	111.23	13.7	103.49	9.62	91.84	9.76	94.55	13.05	101.92	9.86
19	Kim & Song (2020)	IV	100.43	11	101.16	16.24	90.45	11.03	88.61	13.91	94	12.26
1[b]	Mayes & Calhoun (2006)	III	107	14	106	13	94	14	99	15	104	14
20	Ulla et al. (2007)	III	91.5	14.9	89.7	18.1	84.3	14.7	84.3	16.2	86.5	16.5
21	Egeland et al. (2006)	III	88	17	90	22	87	16	86	19	85	22
22	Moura et al. (2019)	III	105.2	10.46	100.9	10.01	105.15	9.93	104.01	13.76	103.89	8.5
23	Mayes & Calhoun (2004)	III	107	n.d.	105	n.d.	93	n.d.	98	n.d.	104	n.d.
24	Koyama et al. (2006)	III	89.9	16.6	101.9	13.1	98.4	19.4	98	13.5	94.9	12.9
25	Krane & Tannock (2001)	III	100.12	14.27	99.64	14.86	95.7	12.53	97.56	15.92	99.99	13.59
26	Snow & Sapp (2000)	III	100.4	n.d.	98.2	n.d.	92.7	n.d.	95.1	n.d.	97.8	n.d.
27	Naglieri et al. (2003)	III	102.5	15.2	99	13.9	98.5	16.1	95.4	18.9	102.3	13.9

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed, FSIQ = Full Scale Intelligence Quotient

Table 3. Differences between the subscales of the included studies

Nº	Research	WISC (Ed)	Sequencing of the four subscales	Difference between two subscales					
				VC-PR/OP	WM/FFD-PS	VC-WM/FFD	VC-PS	PR/PO-WM/FFD	PR/PO-PS
1a	Mayes & Calhoun (2006)	IV	PR > VC > WM = PS	3	0	21	21	24	24
2	Bustillo & Servera (2015)	IV	VC > PR > PS > WM	1.73	3.31	13.86	10.55	12.13	8.82
3	Ünal, D et al. (2021)	IV	VC > PR = PS > WM	4.96	1.67	6.76	05.09	1.8	0.13
4	Dinçer, M et al. (2022)	IV	PS > PR > CV > WM	2.43	9.78	4.75	5.03	7.18	2.6
5	Styck & Watkins (2017)	IV	PS > VC > WM = PS	2.43	0.48	3.93	3.45	6.36	5.88
6	Navarro-Soria et al. (2020)	IV	VC > PR > PS > WM	2.3	1.2	9.5	8.3	7.2	6
7	Molavi et al. (2020)	IV	VC > PS > PR > WM	3.39	14.36	16	1.64	12.61	1.75
8	Matsuura et al. (2014)	IV	PR > VC > WM > PS	1.8	1.9	1.9	3.8	3.7	5.6
9	Gomez et al. (2016)	IV	PR > VC > WM = PS	3.75	0.3	1.55	1.85	5.3	5.6
10	Thaler et al. (2015)	IV	VC = PR > WM > PS	1	2.2	6.2	8.4	5.2	7.4
11	Parke et al. (2020)	IV	VC = PR > WM > PS	0.6	1.5	6.4	7.9	5.8	7.3
12	Fenollar-Cortés et al. (2015)	IV	VC > PR > PS > WM	2	1.2	9.5	8.3	7.5	6.3
13	Walg et al. (2017)	IV	VC = PR > PS > WM	0.56	7.18	12.7	5.52	12.14	4.96
14	Fernández-Jaén et al. (2012)	IV	VC > PR > PS = WM	3	1	13	12	10	9
15	Calub et al. (2019)	IV	VC > PR > WM > PS	1.49	4	7.46	11.46	5.97	9.97
16	Wanderer et al. (2021)	IV	VC = PR > WM > PS	1	2	7	9	6	8

Nº	Research	WISC (Ed)	Sequencing of the four subscales	Difference between two subscales					
				VC-PR/OP	WM/FFD-PS	VC-WM/FFD	VC-PS	PR/PO-WM/FFD	PR/PO-PS
17	Fenollar-Cortés et al. (2019)	IV	VC = PR > PS = WM	0.81	0.14	9.45	9.31	8.64	8.5
18	Jiang et al. (2015)	IV	VC > PR > PS > WM	7.74	2.71	19.39	16.68	11.65	8.94
19	Kim & Song (2020)	IV	PR = VC > WM > PS	0.73	1.84	9.98	11.82	10.71	12.55
1b	Mayes & Calhoun (2006)	III	VC = PO > PS > FFD	1	5	13	8	12	7
20	Ulla et al. (2007)	III	VC > PO > FFD = PS	1.8	0	7.2	7.2	5.4	5.4
21	Egeland et al. (2006)	III	PO > VC = FFD = PS	2	1	1	2	3	4
22	Moura et al. (2019)	III	VC = FFD > PS > PO	4.3	1.14	0.05	1.19	4.25	3.11
23	Mayes & Calhoun (2004)	III	VC > PO > PS > FFD	2	5	14	9	12	7
24	Koyama et al. (2006)	III	PO > FFD = PS > VC	12	0.4	8.5	8.1	3.5	3.9
25	Krane & Tannock (2001)	III	VC = PO > PS > FFD	0.48	1.86	4.42	2.56	3.94	2.08
26	Snow & Sapp (2000)	III	VC > PO > PS > FFD	2.2	2.4	7.7	5.3	5.5	3.1
27	Naglieri et al. (2003)	III	VC > PO = FFD > PS	3.5	3.1	4	7.1	0.5	3.6

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed

Table 4. Subscale scores of the included studies by diagnostic subtype

Nº	Research	WISC (Ed)	Subtipe	Subescale								FSIQ	
				VC		PR/PO		WM/FFD		PS			
				M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
6	Navarro-Soria et al. (2020)	IV	ADHD-C	105.3	12.9	105.5	15.1	91.1	11.9	105.1	18	102.5	16.2
			ADHD-I	106.2	16	104.2	12.3	100.6	17.9	89.2	12	100.2	14.5
7	Molavi et al. (2020)	IV	ADHD-C	96.06	16.58	91.42	14.08	79.18	15.57	93.9	17.35	87.06	15.63
			ADHD-I	85.74	17.72	85.25	20.47	72.37	16.44	83.28	16.98	77.77	17.77
			ADHD-HI	99.94	18.27	94.9	9.22	82.19	18.59	99.64	15.83	92	15.12
12	Fenollar-Cortés et al. (2015)	IV	ADHD-C	106.2	13.9	105.7	15.7	91.8	13.2	104.9	17.2	103	16.7
			ADHD-I	106.1	15.7	104.1	12.1	102.4	16	90.4	12.4	101.1	13.5
17	Fenollar-Cortés et al. (2019)	IV	ADHD-C	101.76	12.85	101.85	13.17	92.37	12.82	93.31	13.67	96.47	12.74
			ADHD-I	101.21	12.78	99.74	13.18	91.73	13.24	91.27	12.43	94.66	11.71
18	Jiang et al. (2015)	IV	ADHD-C	110.36	13.29	102.09	10.33	91.36	10.54	96.64	13.6	102.26	11.32
			ADHD-I	111.15	14.01	103.85	9.84	91.76	9.51	93.26	11.63	101.3	09.07
			ADHD-HI	113.78	14.33	105.11	6.72	93.44	10.05	96	19	104.22	10.6
25	Krane & Tannock (2001)	III	ADHD-C	100.3	14.08	100.07	14.13	94.93	13.39	97.6	16.03	98.87	13.34
			ADHD-I	99.72	13.45	97.64	15.62	96.02	9.84	95.61	14.9	97.7	12.45
			ADHD-HI	100.28	16.11	101.44	15.52	97.06	13.95	100.29	17.12	101.18	15.75

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed, FSIQ = Full Scale Intelligence Quotient

Table 5. Studies with a cognitive pattern of higher scores in VC and PR/PO and lower scores in WM/FFD and PS

Subjects (*N*)	Papers (*N*)	Cognitive profile	Research
1163	3	PR > VC > WM = PS	Mayes & Calhoun (2006); Styck & Watkins (2017); Gomez et al. (2016)
998	6	VC > PR/PO > PS > WM/FFD	Bustillo & Servera (2015); Navarro-Soria et al. (2020); Fenollar-Cortés et al. (2015); Jiang et al. (2015); Mayes & Calhoun (2004); Snow & Sapp (2000)
859	1	VC = PR > PS = WM	Fenollar-Cortés et al. (2019)
824	3	VC = PR/PO > PS > WM/FFD	Walg et al. (2017); Mayes & Calhoun (2006); Krane & Tannock (2001)
537	3	VC = PR > WM > PS	Thaler et al. (2015); Parke et al. (2020); Wanderer et al. (2021)
170	1	VC > PR > PS = WM	Fernández-Jaén et al. (2012)
44	1	PR = VC > WM > PS	Kim & Song (2020)
42	1	VC > PO > FFD = PS	Ulla et al. (2007)
28	1	VC > PR > WM > PS	Calub et al. (2019)
15	1	PR > VC > WM > PS	Matsuura et al. (2014)

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed

Table 6. Studies without cognitive pattern of higher scores in VC and PR/PO and lower scores in WM/FFD and PS

Subjects (*N*)	Papers (*N*)	Cognitive profile	Research
154	1	VC > PR = PS > WM	Ünal et al. (2021)
139	1	VC > PS > PR > WM	Molavi et al. (2020)
98	1	VC = FFD > PS > PO	Moura et al. (2019)
60	1	PS > PR > VC > WM	Dinçer et al. (2022)
48	1	PO > VC = FFD = PS	Egeland et al. (2006)
27	1	PO > FFD = PS > VC	Koyama et al. (2006)
25	1	VC > PO = FFD > PS	Naglieri et al. (2003)

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed

Figure 2. Cognitive profile characterized by higher scores in VC and PR/PO and lower scores in WM/FFD and PS.

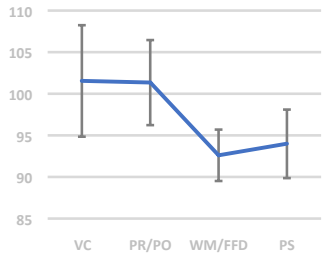


Figure 3. Discordant profile not characterized by a higher score in VC and PR/OP and a lower score in WM/FFD and PS.

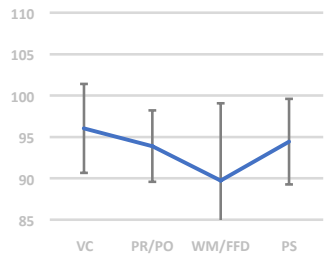
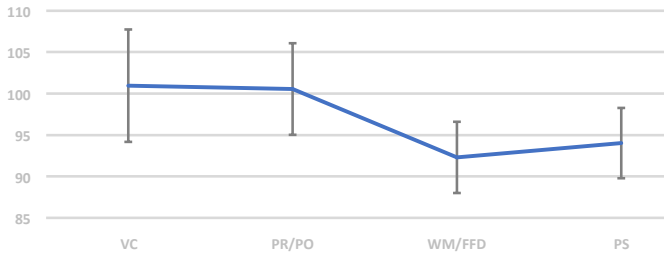


Figure 4. Global cognitive profile elaborated from all the studies analyzed.



profile derived from all the studies analyzed was also characterized by a higher score in VC (*M* = 100.95; *SD* = 6.78) and PR/PO (*M* = 100.55; *SD* = 5.52) and a lower score in WM/FFD (*M* = 92.3; *SD* = 4.3) and PS (*M* = 94.02; *SD* = 4.24), which is consistent with a large part of the scientific literature (Figure 4).

Differences between two subscales: analysis of the index discrepancies

In a total of 26 out of 28 studies, that is 92.86% (*n* = 5,126), the difference between VC and PR/OP did not exceed five points. Similarly, in 25 studies, 89.29% (*n* = 4,982), the difference between WM/FFD and PS did not exceed five points. However, when comparing VC with WM/FFD and PS, the difference exceeded five points in 20 studies, 71.43% (*n* = 3,752), and in 21 studies, 75% (*n* = 3,698), and exceeded ten points in 8 studies, 28.57% (*n* = 1,845), and in 6 studies, 21.43% (*n* = 512). Similarly, when comparing PR/PO with WM/FFD and PS, the difference exceeded five points in 21 studies, 75% (*n* = 4,676), and in 18 studies, 64.29% (*n* = 4,407), and exceeded ten points in 8 studies, 28.57% (*n* = 1,719), and in 2 studies, 7.17% (*n* = 162).

Thus, in general, the difference between VC and PR/PO (*M* = 2.16; *SD* = 1.60) and WM/FFD and PS (*M* = 2.4; *SD* = 2.89) did not exceed 5 points with few exceptions, whereas the difference between VC and WM/FFD (*M* = 8. 74; *SD* = 5.09), VC and PS (*M* = 7.13; *SD* = 4), PR/PO and WM/FFD (*M* = 8.41; *SD* = 3.93) and PR/PO and PS (*M* = 6.8; *SD* = 3.41) frequently exceeded that figure.

Comparison by ADHD subtype

A total of 17 of 27 articles collected sufficient information to make a comparison by ADHD subtype; however, 6 studies found no differences and 5 studies did not provide data. Finally, a total of 6 articles were included in the following analysis. The sum of the participants involved amounted to a total of 1,688 subjects, of whom 85.6 % (*N* = 1,445) were formally diagnosed with ADHD. Among these, in terms of sex, 80.14 % (*n* = 1,158) were male and 19.86 % (*n* = 287) were female. Regarding age, most of the articles set their range between 6 and 16 years (*M* = 9.37; *SD* = 0.5). In regards to ADHD subtype, 42.01 % (*n* = 607) were diagnosed with ADHD-C, 49.83 % (*n* = 720) with ADHD-I, 8.17 % (*n* = 118) with ADHD-HI.

All articles examined distinctions between ADHD-C and ADHD-I and, among these, 3 studies, that is 11.11 % (*n* = 118), also considered ADHD-HI (Table 7). Although the results were relatively uneven, the data estimated that ADHD-C was characterised by a cognitive pattern of [PS > WM/FFD], found in 5 articles, 83.33 % (*n* = 561); ADHD-I presented a cognitive pattern of [WM/FFD ≥ PS], observed in 4 articles, 66.67 % (*n* = 621); while ADHD-HI was characterised by a PS well above WM in 2 articles, 33.33 % (*n* = 109).

Thus, the comparison of the overall cognitive profiles by ADHD subtype did not seem to reveal major differences in terms of VC or PR/PO, rather the main differences were concentrated in WM/FFD and PS (Table 8; Figure 5). Although ADHD-HI showed lower scores than ADHD-I and ADHD-C on WM/FFD, the fundamental difference between the ADHD subtypes seems to focus on the degree of impairment of the PS.

Finally, it is important to examine the consequences of the analysis by ADHD subtype on the index discrepancies (Table 9). It should be noted that the greatest imbalance in ADHD-C subscale scores was found when comparing WM/FFD with VC and PR/PO. ADHD-I appeared to show similar inequalities when WM/FFD and PS were compared with VC and PR/PO. Both ADHD-C and ADHD-I revealed few differences both when comparing VC with PR/PO and when comparing WM/FFD with PS. Quite different was the contrasting scores of the

Figure 5. Cognitive patterns according to ADHD subtyp

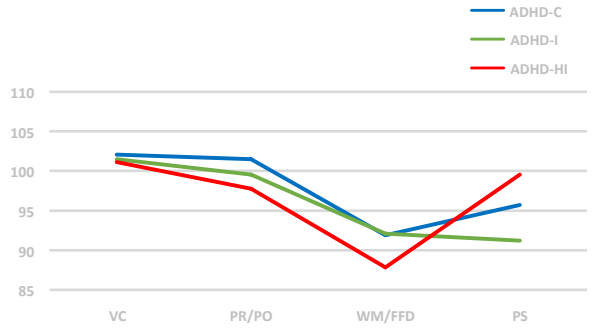


Figure 6. Cognitive patterns according to WISC edition.

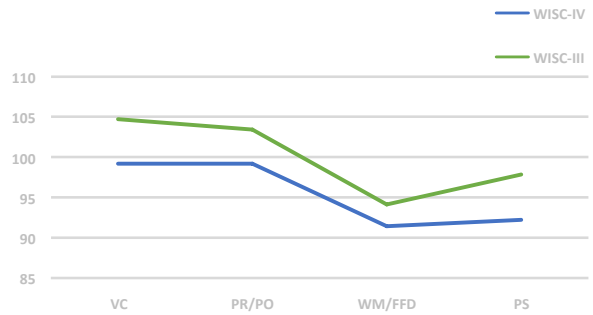


Table 7. Cognitive patterns according to ADHD subtype

Subtipe	Subjects (*N*)	Papers (*N*)	Cognitive profile	Research
ADHD-C	365	1	VC = PR > PS > WM	Fenollar-Cortés et al. (2019)
	94	1	PO = VC > PS > FFD	Krane & Tannock (2001)
	79	2	VC = PR = PS > WM	Navarro-Soria et al. (2020); Fenollar-Cortés et al. (2015)
	33	1	VC > PS > PR > WM	Molavi et al. (2020)
	23	1	VC > PR > PS > WM	Jiang et al. (2015)
ADHD-I	550	2	VC > PR/PO > WM/FFD = PS	Krane & Tannock (2001); Fenollar-Cortés et al. (2019)
	71	2	VC > PR > WM > PS	Navarro-Soria et al. (2020); Fenollar-Cortés et al. (2015)
	46	1	VC > PR > PS > WM	Jiang et al. (2015)
	35	1	VC = PR > PS > WM	Molavi et al. (2020)
ADHD-HI	71	1	VC = PS > PS > WM	Molavi et al. (2020)
	38	1	PR > PS = VC > WM	Krane & Tannock (2001)
	9	1	VC > PR > PS > WM	Jiang et al. (2015)

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed

Table 8. M and SD for each subscale by ADHD subtype

Subtipe	Subescale							
	VC		PR/PO		WM/FFD		PS	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
ADHD-C	102,08	2,67	101,5	2,88	91,89	3,26	95,7	3,97
ADHD-I	101,47	4,58	99,56	3,72	92,11	5,49	91,21	2,27
ADHD-HI	101,11	3,66	97,78	3,68	87,84	7,03	99,57	1,07

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed, M = Mean, SD = Standard Deviation

Table 9. M and SD of differences between subscales by ADHD subtype

Subtipe	Subescale											
	VC-PR/PO		WM/FFD-PS		VC-WM/FFD		VC-PS		PR/PO-WM/FFD		PR/PO-PS	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
ADHD-C	0.72	1.84	3.82	4.95	10.2	3.44	6.38	3.47	9.61	2.52	6.07	3.24
ADHD-I	1.91	1.47	2.19	3.93	9.36	3.53	10.26	3.69	7.45	2.9	8.35	3.02
ADHD-HI	4.07	2.22	11.74	7.06	13.27	6.99	1.54	4.69	9.95	3.86	3.92	2.23

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed, M = Mean, SD = Standard Deviation

Table 10. Cognitive patterns according to ADHD subtype

WISC (Ed)	Subjects (*N*)	Papers (*N*)	Cognitive profile	Research
IV	1163	3	PR > VC > WM = PS	Mayes & Calhoun (2006); Styck & Watkins (2017); Gomez et al. (2016)
	859	1	VC = PR > PS = WM	Fenollar-Cortés et al. (2019)
	537	3	VC = PR > WM > PS	Thaler et al. (2015); Parke et al. (2020); Wanderer et al. (2021)
	333	4	VC > PR > PS > WM	Bustillo & Servera (2015); Navarro-Soria et al. (2020); Fenollar-Cortés et al. (2015) Jiang et al. (2015)
	170	1	VC > PR > PS = WM	Fernández-Jaén et al. (2012)
	154	1	VC > PR = PS > WM	Ünal et al. (2021)
	139	1	VC > PS > PR > WM	Molavi et al. (2020)
	60	1	PS > PR > VC > WM	Dinçer et al. (2022)
	50	1	VC = PR > PS > WM	Walg et al. (2017)
	44	1	PR = VC > WM > PS	Kim & Song (2020).
	28	1	VC > PR > WM > PS	Calub et al. (2019)
	15	1	PR > VC > WM > PS	Matsuura et al. (2014)
III	774	2	VC = PO > PS > FFD	Mayes & Calhoun (2006) Krane & Tannock (2001)
	665	2	VC > PR > PS > FFD	Mayes & Calhoun (2004) Snow & Sapp (2000).
	98	1	VC = FFD > PS > PO	Moura et al. (2019)
	48	1	PO > VC = FFD = PS	Egeland et al. (2006)
	42	1	VC > PO > FFD = PS	Ulla et al. (2007)
	27	1	PO > FFD = PS > VC	Koyama et al. (2006)
	25	1	VC > PO = FFD > PS	Naglieri et al. (2003)

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed

Table 11. M and SD for each subscale by WISC edition

WISC (Ed)	Subescale							
	VC		PR/OP		WM/FFD		PS	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
IV	99.17	6.87	99.19	5.63	91.43	4.36	92.21	3.28
III	104.71	4.75	103.42	4	94.13	3.51	97.87	3.4

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed, M = Mean, SD = Standard Deviation

Table 12. M and SD of the differences between subscales by WISC edition

WISC (Ed)	Subescale											
	VC-PR/PO		WM/FFD-PS		VC-WM/FFD		VC-PS		PR/PO-WM/FFD		PR/PO-PS	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
IV	2.33	1.57	1.63	3.03	7.74	5.02	7.13	4.52	7.76	3.9	7.21	3.88
III	1.8	1.59	4.03	1.63	10.85	4.57	7.11	2.61	9.78	3.64	5.91	1.84

Note. VC = Verbal Comprehension, PR = Perceptual Reasoning, PO = Perceptual Organization, WM = Working Memory, FFD = Freedom from Distractibility, PS = Processing Speed, M = Mean, SD = Standard Deviation

ADHD-HI subscales, as one of their top imbalances was when comparing WM with PS, and their main affinity was when comparing PS with VC.

Comparison by edition of WISC

A total of 18 out of 27 articles, that is 66.6 7% (n = 3,434), used WISC-IV; 8 articles, 29.63 % (n = 1,093), used WISC-III; and 1 article, 3.7 % (n = 704), applied both WISC-IV and WISC-III. A similar proportion of the study sample from studies that implemented both WISC-IV and WISC-II, 94.4 % (n = 3,353) and 92.56 % (n = 1,554) respectively, revealed a cognitive pattern that was characterized in some way by higher scores on VC and PR/PO and lower scores on WM/FFD and PS (Table 10). However, the two editions of the WISC differed in some respects. While 61.71 % (n = 2,192) of the subjects assessed with WISC-IV were defined by [WM = PS], 85.71 % (n = 1,439) of the subjects assessed with WISC-III were distinguished by [PS > FFD].

Thus, comparison of the overall cognitive profiles by WISC edition did not seem to reveal major differences (Table 11; Figure 6). The greatest disparity between WISC editions seems to focus on PS.

Again, it is important to examine the consequences of the analysis by WISC edition on the index discrepancies (Table 12). First, the studies that used WISC-IV revealed a similar imbalance in subscale scores when comparing WM and PS with VC and PR. However, in the case of the WISC-III, the difference between these subscales was irregular. This situation seems to be mainly due to the fact that the discrepancy between WM and PS was smaller in WISC-IV than in WISC-III.

Discussion

The main objective of the systematic review was to descriptively analyze the scientific studies and synthesize the large amount of empirical evidence surrounding ADHD and WISC. As previously indicated, the "cognitive meta-profile" has been characterized by higher scores on VC and PR/PO and lower scores on WM/FFD and PS. Similarly, the index discrepancies that has originated from pitting VC and PR/PO scores against WM/FFD and PS scores has ranged from five, eight and ten points, sometimes even exceeding the latter (Bustillo & Servera, 2015; Calub et al., 2019; Fenollar-Cortés et al., 2015; Fenollar-Cortés et al., 2019; Fernández-Jaén et al., 2012; Gomez et al., 2016; Jiang et al., 2015; Kim & Song, 2020; Krane & Tannock, 2001; Matsuura et al., 2014; Mayes & Calhoun, 2004; Mayes & Calhoun, 2006; Navarro-Soria et al., 2020; Parke et al., 2020; Snow & Sapp, 2000; Styck & Watkins, 2017; Thaler et al., 2015; Ulla et al., 2007; Walg et al., 2017; Wanderer et al., 2021). One of the most recent studies of the ADHD cognitive profile in WISC found a response pattern identical to that of the present systematic review in a further 1,000 affected subjects (Toffalini et al., 2022).

Undoubtedly, WM is one of the main impaired psychological processes in ADHD (Karalunas et al. 2017; Kofler et al. 2017; Hawk et al. 2018; Simone et al., 2018). A recent meta-analysis, which examined the Digit Span subtest of the WM index of the WISC, in 50 studies, observed that the ADHD group presented a greater deficit than the control group (Ramos et al., 2020). Such reality has not only been reflected in WISC, but in other psychometric tests (Fried et al., 2015; Manassis et al., 2007; Mariani & Barkley, 1997). Although not all articles have obtained the aforementioned results (Kasper et al., 2012; Nigg et al., 2005), a recent meta-meta-analysis, considering 34 meta-analyses, confirmed the accentuated shortcomings of WM in ADHD (Pievsky & McGrath, 2018).

However, the empirical evidence surrounding the impairment of PS in ADHD is variable (Kibby et al., 2019). While some research that has assessed PS has found that the ADHD group scored lower than the control group (Bridgett & Walker, 2006; Jacobson et al., 2011; Shanahan et al., 2006); other projects have been inconclusive (Johnson et al., 2001; Nikolas & Nigg, 2013; Seidman, 2006). There is some meta-analytic evidence that the response speed of the ADHD group does not show many differences in relation to the control group; however, such results may be due to the fact that ADHD individuals are characterized by a shorter reaction time when their generally erroneous impulsive response is taken into account (Huang-Pollock et al., 2012; Kofler et al., 2013), which seems to bias the overall estimates (Kofler et al., 2020). However, studies that have assessed both response speed and test performance have also found that the ADHD group scored lower than the control group (Fosco et al., 2017; Karalunas et al., 2014).

In any case, PS appears to be a variable more closely related to ADHD subtypes. In the present systematic review, PS was the key factor in differentiating both the "meta-cognitive profile" and the index discrepancies of ADHD-C, ADHD-I and ADHD-HI. Studies have been characterized by higher PS scores in ADHD-C than in ADHD-I, sometimes by with a difference of only a few points (Fenollar-Cortés et al., 2019; Krane & Tannock, 2001; Jiang et al., 2015), and sometimes with ten or more points of contrast (Fenollar-Cortés et al., 2015; Molavi et al., 2020; Navarro-Soria et al., 2020). Where ADHD-HI comes into play, it has been defined by a higher score in PS than in ADHD-C and ADHD-I, between three, five and up to ten points apart (Krane & Tannock, 2001; Molavi et al., 2020), probably motivated by sample size and age.

Thus, PS has been a critical factor in multiple studies that have sought to examine differences between ADHD subtypes, with PS also falling below in ADHD-I (Calhoun & Mayes, 2005; Dovis et al., 2015a, 2015b; Goth-Owens et al, 2010; Klenberg et al., 2017; Riccio et al., 2006; Solanto et al., 2007; Thaler et al., 2013), both ADHD-C (Mayes et al., 2009), and ADHD-HI (Hellwig-Brida et al., 2010). However, other articles have not obtained the aforementioned results (Chhabildas et al., 2001; Lemiere et al., 2010; Skogli et al., 2014), including a recent meta-analysis that found no differences in PS between ADHD subtypes (LeRoy et al., 2019). Some current studies continue to search for differences between ADHD subtypes, finding evidence that PS impairment is a hallmark of ADHD-I (Rostami et al., 2022; Wu et al., 2022).

Regarding WM between ADHD subtypes, the mean data of the present systematic review has suggested similar scores between ADHD-C and ADHD-I, whereas such values in ADHD-HI seem to be somewhat lower (Fenollar-Cortés et al., 2015; Fenollar-Cortés et al., 2019; Jiang et al., 2015; Krane & Tannock, 2001; Molavi et al., 2020; Navarro-Soria et al., 2020). WM, could also be considered, albeit with less relevance, as a discriminating variable between ADHD subtypes. Although most studies have not found discrepancies in WM between ADHD-C and ADHD-I (Adams et al., 2010; Martel et al., 2007; Mullane et al., 2011; Shuai et al., 2011), the same meta-analysis, mentioned above, has identified greater WM impairment in ADHD-HI (LeRoy et al., 2019).

Finally, in the present systematic review, both the "meta-cognitive profile" and the index discrepancies in WISC-IV and WISC-III showed several similar characteristics, with the fourth edition of this test showing a more pronounced response pattern. The only article in the present systematic review that compared the two editions of the WISC reported similar conclusions, indicating that the WISC-IV may be more effective than WISC-III in the diagnostic assessment of ADHD (Mayes & Calhoun, 2006). Although we are not aware of a large number of studies comparing both editions of the WISC in this way, one investigation that analyzed the cognitive profile of ASD stated that the response pattern was more accentuated in WISC-IV than in WISC-III (Nader et al., 2015).

Risk of bias can be an important variable when comparing results between studies. Thus, comparative studies between the ADHD group and the neurotypical group are lacking. Furthermore, in some cases the comparison groups are clinical or mixed (Unal et al., 2021). This may be due to the fact that the selection of articles included (1) comparative studies

between ADHD and clinical samples (For example: ASD); (2) comparative studies between ADHD and neurotypical sample; and (3) psychometric validation studies with an ADHD sample only. Although the quality of the studies was generally good, reporting bias was found in almost half of the studies analyzed. Therefore, the methodological rigor of future studies must be improved.

Conclusions

The WISC, especially its third and fourth editions, is an assessment instrument that, based on the pattern of responses generated in individuals with ADHD, has been proven after the study of 27 studies, to aid in the assessment of ADHD, due to the index discrepancies found between, on the one hand, VC and PR/PO and, WM/FFD and PS on the other. In relation to the different manifestations of the disorder, scores have also been found that help in the differential diagnosis by comparing the PS variable between the three types of ADHD manifestation. As a complement in the assessment of ADHD, it is advisable to use the WISC as a complementary tool to observation scales, always accompanied by the careful interpretation by an experienced professional in the field of psychology, psychopedagogy, psychiatry and/or neuropediatrics.

As future lines of research, it is considered necessary to analyze the cognitive profile of ADHD in the fifth edition of the Wechsler Intelligence Scale for Children (WISC-V, 2014), in order to confirm the existence of the patterns found in the present research also in the latest version of the WISC.

Conflict of interest

The authors report no conflicts of interest.

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