FAMILY NEUROPSYCHOLOGICAL APPROACH TO ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD): AN EXPLORATORY STUDY

ENFOQUE NEUROPSICOLÓGICO FAMILIAR PARA EL TRASTORNO POR DÉFICIT DE ATENCIÓN CON HIPERACTIVIDAD (TDAH): UN ESTUDIO EXPLORATORIO

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Abstract

Attention Deficit Hyperactivity Disorder (ADHD) is a highly heritable disorder, often parents of children with ADHD also present psychiatric conditions. Literature reports that executive functions deficits (EFD) are frequently present in these parents, leading to negative influences on the children´s executive functions (EF) development. Most of these studies have been conducted with self-report scales, research with formal neuropsychological tests is lacking. Objective: To explore the presence and the relationship between the executive functions deficits (EFD) and the psychiatric diagnosis in family trios: mother, father, and their male son with

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ADHD-diagnosis. Method: Participants: 20 family trios: parental couples (mother and father) and their male son with ADHD diagnosis, living all together. The evaluation was performed with a wide-range EF battery (eleven subtests), and with psychiatrist evaluation structured interview (MINI-Kid/MINI-PLUS). Logistic binary regression was used to determinate which EFD identified each individual group (mothers, fathers, children), and each combined group (all parents, all males, males with ADHD). IQ was controlled. Results: 50% of mothers presented depression, and 30% anxiety, while 45% of fathers presented ADHD. Diverse clinical and subclinical EFD were identified. Three EF were mainly affected: working memory, attentional performance, and semantic categorization. Particularly the former two were affected in children and in the father´s group with ADHD. Conclusions: Parents' clinical and cognitive characteristics impose developmental challenges in children with ADHD. A developmental neuropsychological family -systemic- approach for ADHD is advisable, to avoid considering the child as the only member with a clinical condition.

Keywords: Family; Neuropsychology; Parenting; Male Son.

Resumen

El Trastorno por Déficit de Atención con Hiperactividad (TDAH) es un trastorno altamente hereditario, a menudo los padres de niños con TDAH también presentan afecciones psiquiátricas. La literatura informa que los déficits de las funciones ejecutivas (DFE) están frecuentemente presentes en estos padres, lo que lleva a influencias negativas en el desarrollo de las funciones ejecutivas (FE) de los niños. La mayoría de estos estudios se han realizado con escalas de autoinforme, faltando investigación con pruebas neuropsicológicas formales. Explorar la presencia y la relación entre los déficits de funciones ejecutivas (DFE) y el diagnóstico psiquiátrico, en tríos familiares: madre, padre y su hijo varón con diagnóstico de TDAH. Se incluyeron 20 parejas parentales (madres y padre) con un hijo varón con diagnóstico de TDAH, viviendo en la misma casa. La evaluación se realizó con una batería de FE de amplio rango (once subpruebas) y una entrevista psiquiátrica estructurada (MINI-Kid/MINI-PLUS). Se utilizó regresión binaria logística para identificar las DFE en cada grupo de participantes. Se controló el coeficiente intelectual. El 50% de las madres presentaron depresión, y 30% ansiedad, 45% de los padres presentaron TDAH. Se presentaron diversas DFE tanto clínicas como subclínicas. Tres FE fueron las principalmente afectadas: memoria de trabajo, rendimiento atencional y categorización semántica; específicamente las últimas dos se afectaron en el grupo de niños y en el de padres (hombres) con TDAH. Conclusión: las características clínicas y cognitivas de los padres imponen desafíos para el óptimo desarrollo para los niños con TDAH. Un enfoque de desarrollo neuropsicológico familiar -sistémico- para el TDAH es recomendable, evitando considerar al niño como el único miembro con de la familia con una condición clínica.

Palabras clave: familia; TDAH; parentalidad: hijos varones.

Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a highly heritable disorder (Franke et al., 2012; Solberg et al., 2021), with a high possibility that any (or both) parents of a child with ADHD present the same diagnosis (Auerbach et al., 2017; Smalley et al., 2000). For example, Stark et al. (2016) studied the presence of ADHD in 75 mothers and 49 fathers of children with ADHD, finding that 41 % of mothers and 51 % of fathers presented enough criteria to be diagnosed with ADHD. Therefore, several authors outline the importance of considering the family as a system in which children with ADHD develop (Deater-Deckard, 2017).

Executive functions deficits (EFD) in ADHD have been widely described in both children and adults (Pievsky & Macgrath, 2018), but with some controversies (Duff & Sulla, 2015): not all people diagnosed with ADHD exhibit EFD (Doyle, 2006; Luo et al., 2019). It is to notice that the majority of studies aimed to explore EFD in ADHD have included less than three EF per study (Pievsky & Macgrath, 2018; Willcutt et al., 2005;), leading to

an insufficient coverage of the variety-complexity of the EF (Burgess & Stuss, 2017; Testa et al., 2012). Meta-analysis using factorial-reduced –three or less– EF (psychometric) models, have shown insufficient validation-replication (Karr et al., 2018). Administering less than four EF measures significantly increases the risk of discriminant errors (Holmes et al., 2010).

Executive functions (EF) are key cognitive capacities to organize, plan and regulate cognition and behavior; the adequate development of EF represents one of the pillars for a successful psychological development (Diamond, 2013). Several EF have been described (Anderson, 2001) of which the most frequently studied in general population are: inhibitory control, working memory, planning, and mental flexibility (Duff & Sulla, 2015; Nyongesa et al. 2019).

Family studies in EF-ADHD. Most ADHD family studies have been performed using self-report scales or questionnaires as the main EF-instrument (Andrews et al., 2021). The most frequent scales are BRIEFs -Behavior Rating Inventory of Executive Function- (Gioia et al., 2000), and BACS-2 Behavior Assessment System for Children (Kampaus & Reynolds, 2007). Meta-analysis of studies with young-adult samples (20-29 years old) reports weak to moderate correlations between self-estimated cognitive abilities and formal testing –cognitive/neuropsychological tests– (Freund & Kasten, 2012; Herreen & Zajac, 2017). Buchanan (2016) and Soto et al. (2020) obtained similar results for the relation of self-reported EF versus (scales) formal cognitive testing. Williams et al. (2016), found that the self-report of attentional control in a large sample of 315 young adults is not related to the performance in attentional or executive functions tests, but to emotional adjustment, neuroticism, and conscientiousness. The most frequent formal EF tests are presented in Table 1, according to Flores et al. (2014) and Nyongesa et al. (2019).

Table 1.

Executive functions and tests at BANFE-2.

Executive Function	Test(s)
Inhibitory control	Stroop paradigm
Risk-benefit	Iowa-type test
Working memory	
Visual identification	Visual identification task
Visual sequential	Visual sequential task
Verbal	Verbal working memory tasks
Inverted sequencing	Self-ordered pointing task
Figure sequences	Figure sequences task
Alphabetic ordering	Alphabetic ordering task
Consecutive subtraction	Consecutive subtraction task
Mental flexibility	WCST-type test
Visuospatial planning	Maze tests
Sequential planning	Hanoi tower-type test
Abstract classification	Semantic classification task
Fluency	Verbs fluency task

There are few studies in this field using formal cognitive-neuropsychological testing; for example, Goos et al. (2009) studied the motor-inhibitory control (Stop signal task) in seventy-five families, that included their child with an ADHD diagnosis (mean age 8.7 years old), the parents and one non-ADHD sibling. Results indicate that parents of children with ADHD presented lower performance (poorer inhibitory control) than the comparison adults (families with non-ADHD Children).

The most important finding was that the parents' inhibitory control ability (particularly fathers) significantly predicted the performance of their children, regardless of symptom severity or diagnosis. Authors identified an inhibitory control deficit in children and their parents as independent of symptom severity in both generations. Thissen et al (2014) studied three EF: motor inhibition (Stop signal task), verbal and visual working memory, in 238 participants between 5 and 19 years old (average of 17.3 years old) and 147 parents. Their results show that ADHD and EF did correlate between parents and offspring and did not cross-correlated in adolescent siblings. Authors consider that the correlations found in childhood are

no longer present in adolescence, due to developmental changes.

Parenting is an important factor in executive function development for example, He et al. (2012) studied a sample of 533 participants (54 % females) from 17 to 27 years old (mean of 20.47 years, *SD*: 51.01) and a positive protective effect of parental warming on the (better) cognitive performance on Iowa-paradigm (risk-benefit) testing (Bechara et al., 2000).

In contrast, parents with ADHD and EFD present deficits in organization and planning, provide fewer effective solutions to daily problem-solving, and present inappropriate supervision of the child everyday activities (Murray & Johnston, 2006). Contrary to professional descriptions and studies, parents with the highest ADHD features report "the best" present parenting practices. Experts interpret this type of report as an overestimation of their low metacognitive consciousness (Butzbach et al., 2021; Lui et al., 2013). These parents are hard to conscientize to promote behavioral change. In particular, parents with reinforcement/motivation deficits exhibit parenting deficits in the promotion of the children persistence (positive motivation to future rewards/goals; Sagvolden et al., 2005).

Deater-Deckard et al. (2010) studied the role of working memory in observed reactive parenting in 216 mothers interacting with their children, who were videotaped while they completed two frustrating cooperation tasks. The interactions were coded using the Parent–Child Interaction System (PARCHISY; Deater-Deckard, 2000)

After a home visit, two different research assistants coded each mother-child dyad using the Parent–Child Interaction System (PARCHISY; Deater-Deckard, 2000). Cognitive testing included the Vocabulary (verbal), Block Design (spatial) and Digit Span (working memory) subtests of the Wechsler Adult Intelligence Scale -Third Edition- (Wechsler, 1997). Mothers with working memory deficits tended to react negatively (harsh reactive parenting) to (experimental) frustrated cooperation tasks with their child. Working memory deficits have been closely related to inadequate organization and planning in daily home activities (household chaos), they also present direct and indirect (negative) effects on the EF development across childhood (Andrews et al., 2021). Working memory permits to deal with different task at the same time and to efficiently perform one task after another in a short period of time, also allows to efficiently update ongoing cognitive (real-time) information to respond-adapt to new contingencies (Huang-Pollock et al., 2017).

A recent study of family functioning by Bhide et al. (2024) compared 179 families with a child with ADHD (group 1) and 86 families with a child with subthreshold ADHD (group 2), versus 212 families with children without ADHD (group 3). Baseline measures of diverse family functioning domains resulted in (groups 1 and 2) higher psychological distress, less parenting self-efficacy, less parenting consistency, more stressful life events, poorer quality of life and greater parenting anger. The follow up (18-month and 36- months) revealed (groups 1 and 2) less parent-partner support and parenting warmth, with worsen quality of life.

Systematic reviews have found that EF studies on family trios (mother, father, and ADHD-child) are scarce. Most genetics studies have been developed in sibling twins, and most "family" studies include "parents" but do not indicate if they are part of the parental couple (e.g., Ragadran et al., 2023), also a significant proportion of these studies includes mainly mothers (over representing mothers versus fathers); main results indicate different influences between mothers versus fathers over ADHD-children's symptoms and treatment outcomes (Chronis-Tuscano et al., 2017; Deater-Deckard, 2017).

Family trios represent one of the main paradigms in current psychiatry (Liu et al., 2011). In particular, EF represents one of the main cognitive paradigms for the study of familiar (heritability) effects on cognitive performance in psychiatry (Chang, et al., 2020). However, this heritability range has been calculated –only– from 20 to 40 % (Blokland et al, 2017); meaning that the neuropsychological family (trio) studies should not be reduced only to heritability effects, but also to comprehend the family ecosystem in the children´s EF development (Andrews et al., 2021; Deater-Deckard, 2017).

Male-female ADHD phenotypes. The lack of clinical female-ADHD consensus produces women to be underdi-

agnosed and undertreated unlike men (Anker et al., 2018, Young et al., 2020). Male-female differences in the clinical and behavioral criteria for ADHD have not yet been properly established, despite sufficient evidence in literature for example, higher levels of emotional difficulties in women (Solberg et al., 2018). In general, girls present a later age of onset and more subtle clinical manifestation, so girls are diagnosed three to four times less often than boys (O´Brien et al., 2010). Differences have also been found in white matter -mainly in the prefrontal cortex- (Jacobson et al., 2015). Also, girls show an overall reduction in total prefrontal cortex volume (surface area), while boys show particular reduction in the right anterior cingulate, left-medial prefrontal cortex and in the premotor cortex (Dirlikov et al., 2014). The neuropsychological evidence indicates differences in verbal fluency (Wodka et al., 2008); one longitudinal study found differences in reward-risk-benefit (Iowa-type test performance), interestingly only the girl's performance deteriorates in the transition from childhood to adolescence (Skogli et al., 2017). Due to this type of evidence, in the last decade, an important emphasis for not mixing male-female samples in ADHD studies has been stated.

The knowledge of the EFD by a wide range approach in family trios with control for the parental psychiatric conditions, is still an insufficient explored field. In the present study, family trios: mothers and fathers in parental couple, and their male-children with ADHD diagnosis (all living together in the same house), were evaluated with a wide range EF battery, and by a psychiatric structured interview. The main objective was to explore the mental health and the EF parental eco-system in which children with ADHD develop. Our main hypothesis was that at least 50% of mothers and 50% of fathers of children with ADHD will present psychiatric conditions and EFD.

Method

Participants

20 trios: the mother, the father and their male child with an ADHD diagnosis. The total sample consisted of 60 participants. Mothers group with an average of 37.23 years old (*S.D.* = 7.09), and 10.75 (*S.D.* = 1.29) years of schooling. The father's group had an average of 41.87 years old (*S.D.* = 7.83) and 11.14 (*S.D.* = 2.02) years of schooling. The male-children (n = 20) with 8.70 years old in average (*S.D.* = 1.17) and 2.59 (*S.D.* = 1.03) years of school. Families were classified (hospital´s social work department) as middle or middle-low-income families.

Inclusion criteria: 1.- families living together since childbirth (in the same home). 2.- Children with an ADHD-diagnosis (psychiatrist structure interview, DSM-V criteria, and Mini-Kid-Lecrubier et al., 1997-), age range: between 7-10 years old, non-previously medicated for psychiatric conditions, non-previously treated by neuropsychological intervention. I.Q. equal to 80 or higher (Shipley et al., 2014).

Parents: biological parents (according to mother information), age range: 25-55 years, a minimum of 9 years of regular school, I.Q. equal to 80 or higher.

Exclusion criteria: Parents: I.Q. lower than 80, neurological conditions (epilepsy, brain injuries), lack of agreement of the parents to participate in the study. Children: I.Q. less than 80, developmental dysphasia, epilepsy or other neurological conditions.

Instruments

BANFE-2. It is a wide range executive neuropsychological battery that evaluates 11 EF (see Table 1), and two additional processes (proverbs and metamemory). The battery was constructed after the adaptation of the most used-validated test of EF. The battery presents population norms for more than 400 normative participants from 7 to 80 years old, with different years of academic studies. The cognitive profiles are organized in scale points (Flores et al., 2012). The instrument is sensitive to different age-developmental stages (different test and test-parameters are particularly sensitive to age from childhood to youth: Flores-Lázaro et al., 2014), and to school years (Flores et al., 2011), psychometrics parameters are similar to gold standard tests (Flores-Lázaro et al., 2017). Some tests are particularly sensitive to child/ADHD (Medrano et al., 2024), and to adolescent-ADHD (Medrano et al., 2018).

MINI-PLUS (Sheehan et al., 1999) and Mini-kid (Lecrubier et al., 1997). The MINI-international neuropsychiatric interview. It is a structured psychiatric interview instrument that assesses the presence of several DSM-IV disorders (ADHD, anxiety, mood, substance use, psychotic, eating, conduct, antisocial, etc.).

ASRS-V1.1 (Kessler et al., 2005). Adult ADHD Self Report Scale. Symptom checklist base on DSM-IV-TR criteria (Mexican validation and norms by Reyes Zamorano et al., 2013).

Shipley-2. Brief Intelligence Scale (Shipley, et al., 2014). Validation and Mexican norms by Manual Moderno.

Procedure

The Identification and diagnosis of ADHD in children was performed as part of the hospital clinical services. Sampling was obtained by quote: six parents-families decided not to participate. Parents and children were invited to participate, receiving the explanation about the objectives of the study, a written consent agreement was signed. The project was approved by both the research and the ethics research committees of the hospital. Full anonymity was guaranteed. Children gave written informed consent after proper oral explanation, (the younger children only oral informed consent). This research was conducted and finished previously to the beginning of the social restriction by the Covid-19 pandemic declaration.

Participants were evaluated by a group of psychiatrists (MINI-PLUS: Sheehan et al., 1999; MINI-Kid: Lecrubier et al., 1997) and neuropsychologists (BANFE-2: Flores et al., 2014; Shipley-2: Shipley et al., 2014) and fulfilled complimentary scales. For each participant, the full evaluation was performed in two to three sessions of 40 minutes (on average) each.

Data Analysis

Correlational and regression analysis were performed to identify if the number of school years and the I.Q. level had influenced on the EF performance. A binary logistic regression was performed to statistically determine which EF properly identified each group (neuropsychological phenotypes). We analyzed two types of groups: individual groups (children, mothers, and fathers), and combined groups (all parents n = 40, all-males n = 40, all males with ADHD n = 29).

Table 2.

Demographics and descriptives results.

	Demographics			Psychiatric diagnosis				
	Age	**School years**	**I.Q.**	**ADHD**	**Mood disorders**	**Anxiety disorders**	**Behavioral disorders**	**No disorder**
Mothers	37.23(7.09)	10.75(1.29)	97.45 (5.32)	15%	50%	30%	0%	50%
Fathers	41.87(7.83)	11.14(2.02)	99.20 (7.87)	45%	15%	15%	0%	35%
Children	8.70 (1.17)	2.59 (1.03)	112.25(15.33)	100%	5%	15%	60%	0%
Type 1 family (n=8)	34.45(5.79)	11.77(1.47)	96.62 (6.36)	68%	62%	75%		Dx per parent 2.25 (1.29)
Type 2 family (n= 7)	39.07(8.57)	13.41(2.53)	113.71(8.05)	21%	28%	21%		0.83 (1.40)
Type 3 family (n= 5)	44.66(8.88)	12.53(1.78)	103.56(12.23)	0%	0%	0%		

Note: Dx = number of psychiatric diagnoses.

Results

Demographics characteristics and psychiatric diagnosis are presented in Table 2. On average the sample included young parents with non-university studies, this situation is according to average worldwide countries (OCDE, 2019). Only the age was statistically different between the parents (-2.657, p = .018). 50 % of mothers presented diagnosis for depression/mood disorder, 30 % for anxiety; while 45% of fathers presented ADHD diagnosis, and 15 % anxiety. 60 % of children presented behavioral disorders (mainly oppositional defiant disorder). In ASRS-V1.1 scale, the group of mothers presented 21. 87 (*S.D.* = 12.61) points and the group of fathers 25.47 (*S.D.* = 11.92) points; with non-significant results between groups (*t*-test).

Five parental couples (25 %) presented cero psychiatric diagnosis, in seven parental couples (35 %) only one of the parents presented a psychiatric diagnosis, and in eight parental couples (40 %) both parents presented a psychiatric diagnosis. The age of parental couples indicates that the younger the parents the higher the percentage of psychiatric diagnosis. According to these results, three types of families were identified (see Table 2), type-1 families present the highest number of psychiatric conditions (mainly anxiety and ADHD disorders); type-2 families present mainly mood disorders.

The number of clinical traits reported by the parents (ASRSV1.1 scale), only correlated in the male group with the time to perform the Stroop test measure (r^2 = .480, p = .050). However, in both mothers and fathers the higher ADHD-symptoms predicted the time to perform the Stroop test.

All children presented the hyperactive-impulsive combination (80 %). The main comorbidity was oppositional defiant disorder (60 %).

Clinical profiles. Due that BANFE-2´s profiles are organized in scalar points (age-schooling years), additional to individual groups (children, mothers, and fathers), the performance of combined groups was obtained: All sample (n = 60), parents (mothers and fathers, n = 40), all males (n = 40), males with ADHD diagnosis (n = 29). Clinical scores for each group are presented at Table 3. Due that BANFE-2 has 35 measures per profile, only clinical and subclinical scores are presented. The male's group, the children's group and the fathers' groups presented the higher number of clinical and subclinical EFD. Coincidences between these groups were present at verbal WM deficits, verbal fluency, Stroop total score (inhibitory plus attentional errors) and semantic categorization. The four more frequent clinical EFD were coincident in the groups of children and males (mainly by clinical scores).

Table 3.

Clinical and subclinical scores according to BANFE-2´s profiles.*

Performance	Verbal WM	WM SOPT	Semantic categ.	Verbal fluency	Stroop score	R-B score	Inhibitory Control	Visual WM	Stroop time	Total
Males	Clin	Sub	Clin	Clin	Clin	Sub	Sub	Sub	Sub	4-5
Children	Clin		Clin	Sub	Clin	Sub	Sub	Sub		3-4
Fathers	Clin	Sub	Sub	Clin		Sub	Sub			2-4
Parents	Sub	Clin	Sub	Sub						1-3
Mothers	Sub	Clin								1-1
All sample	Sub	Sub	Sub			Sub			Sub	0-5
M-ADHD		Sub				Sub	Sub	Sub		0-4
Total	3-3	2-4	2-3	2-2	2-0	0-5	0-4	0-3	0-2	

Note: *Scalar scores: a score of 6 points or less indicates clinical performance (Clin), a score of 7 points indicates subclinical performance (Sub). WM (Working Memory); SOPT (Self Ordered Pointing Task); R-B (Risk-Benefit); Inhibitory Control (Stroop errors); Stroop score (all type of errors); Semantic categ. (Semantic Categorization); Individual groups: Children (n = 20), Mothers (n = 20), Fathers (n = 20). Combined groups: AS = all sample (n = 60), Males = all males (n = 40), M-ADHD = males with ADHD (n = 29). Parents = mothers and fathers (n = 40).

While the seven more frequent (clinical and subclinical) EFD were coincident in the groups of children, males and fathers. In contrast the mother's group was far less affected.

To explore the effect of the I.Q. on the EF performance in the children's group, correlations and linear regressions were applied. In the group of children (n = 20) two (high) correlations were found in verbal WM (r = .522, p = .018) and the WCST-type test total score (r = .596, p = .006). Predictions were significant for verbal WM (r^2 = .543, p = .002), WCST-type test total score (r^2 = .379, p = .009), and visual WM (SOPT) score (r^2 = .575, p = .042).

In both parents' groups (n = 20 for each group), the bivariate correlations and (single) linear regression analysis included I.Q., schooling years, and ADHD symptoms (ASRSV1.1 scale). Few significant results were found (see Table 3), for example the influence of I.Q. measures only correlated moderately (in both mothers and fathers) with one dimension of EF performance.

Table 4.

Significant correlations and predictions for I.Q., school years and ADHD symptoms in the parents.

		Mothers		Fathers	
	Executive functions	**Mean**	**Correlation**	**Mean**	**Correlation**
Correlations ASRS	Stroop time	10.6 (2.47)	r = .054, p = .836	8.11 (3.14)	r = .506, p = .038*
I.Q.	Card classification score	9.4 (4.21)	r = .464, p = .045*	8.18 (4.67)	r = .478, p = .047*
School years	Differed perseverations	9.36 (3.37)	r = .473, p = .041*	9.27 (2.90)	r = .020, p = .938
	Card classification time	9.94 (2.30)	r = -.238, p = .358	11.23 (2.77)	r =.504, p = .039*
	Verb fluency	8.12 (3.73)	r = -.386, p = .103	6.76 (1.29)	r = .567, p = .014*
	Risk selection	9.73 (2.55)	r = .193, p = .427	8.38 (2.53)	r = -.628, p = .005*
Predictions ASRS					
	Stroop time		r^2 = .836, p = .003*		r^2= .256, p = .038*
I.Q.					
	Card classification score		r^2 = .215, p = .045*		r^2= .238, p = .047*
School years					
	Card classification time		r^2= .238, p = .358		r^2=.254, p = .039*
	Verb fluency		r^2= .149, p = .103		r^2= .321, p = .014*
	Risk selections		r^2= .037, p = .427		r^2=.395, p = .005*

Note: predictions by single linear regression. All Durbin Watson values ranged from 1.098 to 2.496. Significance is signaled by an asterisk: *

On the contrary, the schooling years correlated with four measures of EF performance (from low to moderate), in both negative and positive directions. In fathers three high correlations were found (risk selection ability correlated in negative direction).

Neuropsychological phenotypes. Due that the average group performance presented in Table 3 is based in mean´s scores, for example 9 participants may present scores of 4 and 5 points (highly clinical) while 11 participants present a score of 8 (normal-low), the average score for that group is 6 (clinical). To further specify if the real number (proportion) of the clinical score reflects a particular EF-phenotype for each group, a binary logistic regression was performed (see Table 5). Due to the low number of participants per group, this type of analysis is performed only to reveal finding trends.

The analysis was performed based on scalar points (adjusted for age and schooling years). three EFD were confirmed in the children's group: verbal working memory (WM), semantic classification, and attentional-inhibitory control (Stroop total score); two in the all –males groups, and two in the males– ADHD group.

In the parent´s group the three executive functions confirmed in the children's groups were identified (finding trends) but not confirmed by the OR´s. Overall results highlight three EFD: verbal working memory, semantic classification and inhibitory control (Stroop) performance as possible family-ADHD markers.

Table 5.

Identification-confirmation of executive functions affected by group. Finding trends by binary logistic regression.

	Working memory (verbal)	Semantic classification	Stroop Total score	Verbal Fluency
Children	X^2= 3.713, p = .054	X^2= 4.985, p = .026	X^2 = 6.267, p = .012	X^2 = .276, p = .599
OR	3.34*	3.93*	4.39*	0.74
Intervals	0.98 – 11.44	1.18 – 13.11	1.37 – 13.97	0.24 – 2.24
Males-ADHD	X^2 = 3.611, p = .057	X^2 = 4.026, p = .045	X^2 = 5.105, p = .024	X^2 = .492, p = .483
OR	3.12	2.99*	3.50*	1.46
Intervals	0.94 – 10.28	1.01 – 8.84	1.15 – 10.57	0.50 – 4-24
All males	X^2 = 7.080, p = .008	X^2 = 5.976, p = .015	X^2 = 2.915, p = .098	X^2 = 3.645, p = .056
OR	6.41*	4.16*	2.80	2.97
Intervals	1.49 – 27.64	1.28 – 13.51	0.84 – 9.32	0.95 – 9.30
Fathers	X^2 = 0.294, p = .588	X^2 = 0.015, p = .904	X^2 = .668, p = .414	X^2 = 5.487, p = .019
OR	.156	1.07	0.58	5.26*
Intervals	0.03 – 0.67	0.34 – 3.29	0.18 – 1.87	1.31 – 12.21
Mothers	X^2 = 6.224, p = .013	X^2 = 1.017, p = 1.000	X^2= 2.814, p = .093	X^2 = .043, p = .835
OR	1.41	0.24	0.35	0.33
Intervals	0.40 – 4.99	0.07 – 0.77	0.10 – 1.18	0.10 – 1.04
Parents	X^2 = 3.915, p = .050	X^2 = 5.278, p = .022	X^2 = 6.625, p = .010	X^2 = 0.277, p = .599
OR	0.29	0.25	0.22	1.34
Intervals	0.87 – 1.021	0.76 – 0.84	0.07 – 0.72	0.44 – 4.05

Note: OR´s significance is signaled by an asterisk: *

Discussion

To our knowledge, this is the first family neuropsychological study with balanced parental couples and their male children with ADHD that includes both a wide range EF battery and a structured psychiatric interview, for all participants.

In the present exploration study a relevant percentage of psychiatric diagnosis were found in the mothers and the fathers' group. The younger the parental couples, the higher the percentage of psychiatric diagnosis. The negative effect of younger maternal-paternal ages has already been reported in literature: a higher social precarity is associated to younger pregnancy, but also less psychological-personal development and less economic sufficiency (Aitken et al., 2016). By these criteria three types of ADHD families were found: high presence of psychiatric conditions, low presence of psychiatric conditions, and without psychiatric conditions.

At the cognitive performance level, the higher number of EFD (clinical and subclinical) were present in the children, males, and fathers' groups. The identification of the clinical and subclinical scores as relevant markers in mental health represents recent clinical criteria (Korman et al., 2019), reflecting a higher clinical sensibility to the already recognized symptomatic persistence (sub-clinical ADHD) in youth and adulthood (Faraone, 2006; Song et al., 2021).

A possible family clinical EF ecosystem was identified (mean profile performance) with several clinical and subclinical performances. These findings were partially confirmed for the all-males and the males-ADHD group. These confirmations coincide with the three EFD confirmed in the children's group (working memory, attentional-inhibitory control, and semantic categorization).

Verbal fluency was the only EFD confirmed in the father's group. In the parents' group (mothers and fathers) significant trends in the same EFD than children were identified, but not confirmed by OR´s. It is important to notice that logistic regression as well as Chi-square models are based on the expected-observed frequencies. As the fathers´ group presented ADHD in 45 %, while the mothers´ group had clinical depression in 50 %. Also, three different parental couples with different percentages of psychiatric diagnosis integrated this sample.

We believe this situation precluded more significant results. Based on the combined analysis of the data from Tables 3 and 5, we support this argument in three types of results: 1. In the children´s group, 100 % of participants present ADHD, three out of three EFD were confirmed. 2. In the all-male group, 55 % of fathers no dot presented ADHD, only two of four EFD were confirmed. 3. Without the influence of the most phenotypical group (the children´s group) in the father´s group only one EFD was confirmed. This three different aggrupation decrease the percentage of ADHD diagnosis (100 % at children; 72 % at all-males, and 45 % at fathers): the less clinical-phenotypic a group is, then a progressive decrement in OR´s confirmation is observed.

These results suggest that future research with ADHD-families should include clinical-phenotypic parents: mothers and fathers with and without psychiatry diagnosis (similar clinical/non-clinical neuropsychological phenotypes).

The evidence of WM deficits in different clinical conditions –e.g. ADHD, learning disabilities, depression, bipolar disorder, schizophrenia– (Caspi et al., 2014), have led to some authors to state the notion that WM may represent the cognitive-transdiagnostic risk factor for psychopathology (Huang-Pollock et al., 2017). The results presented here indicate that verbal WM deficits may also be a characteristic in families of children with ADHD (but large parental couples are required to confirm these findings). A deficit in working memory in mothers produces low efficiency in the behavioral regulation of the child and increases the reactive negativity (Harsh reactive parenting) to the child behavior (Deater-Deckard, 2010). As a process, WM is required to support learning of new academic information, representing a cognitive system that supports the access to factual knowledge (Cragg & Gillmore, 2014) and the implementation of cognitive strategies (Cragg et al., 2017; Norwalk et al., 2009).

In children WM deficits in ADHD are related to extended networks alterations (decreased structural connectivity) in right precentral and poscentral gyrus, right supe-

rior parietal gyrus, left paracentral lobule, right superior parietal gyrus, right cerebellum, and left hippocampus (Lienag et al., 2023). While in adults, working memory depends mainly on frontoparietal networks (Zhang et al., 2024), which is positively associated with efficient functional connectivity in the postcentral gyrus and negatively correlated with ADHD clinical symptoms (Hong et al., 2024).

Mothers presented a high presence of mood disorders, maternal depression is the main predictor of mothers' parenting stress (Zsép et al., 2021). This clinical situation combined with the maternal WM deficiency leads to harsh reactive parenting (Deater-Deckard et al., 2010) and disorganization and instability within home –household chaos– (Andrews et al., 2021).

In this child sample, the specific measure of inhibitory control (interference effect) was not impaired. Meta-analysis on inhibitory control deficits (measured by Stroop tests) present mixed results (Homack & Riccio, 2004; Lansbergen et al., 2007). Liu et al (2011) studied a sample of 1253 participants, family trios of children with ADHD mainly males (father/ADHD-child/male-brother) and found no association (shared heritability) for the inhibitory performance at the Stroop test performance. Due that in an ADHD-adolescent sample, the inhibitory control was one of the EF described as deficient (Medrano, et al., 2018), we do not consider that our Stroop version to lack sensibility. The total number of errors (word-reading plus color-word reading -interference-) was confirmed as a clinical feature, mainly in the different male groups. Liu et al. (2011) did find significant results for the inhibitory factor of the BRIEFs scale, but we consider that the significant component of attentional control reported here, represents a more general attentional performance than an inhibitory performance (Stroop effect). Also, the correlation found in the male parent group (overall time to perform the test/number of ADHD symptoms), is similar to the higher time to perform a go-no-go task reported in adults-ADHD males versus adults-ADHD females (Stibbe et al., 2020). By the P300 paradigm (electrophysiological response) diverse research groups have found that the time involved in the response, depends mainly in the post stimulus evaluation (Rosenfled & Skogsberger, 2006; Zurrón et al., 2009), a complex neurocognitive process not only reduced to conflict (color-word) resolution (Di Russo & Bianco, 2023). It is important to notice that BANFE-2 includes 10 measures of time performance across 10 different subtests. Interestingly only the time to perform the Stroop test correlated with clinical ADHD symptoms in fathers.

The capacity to perform semantic analysis and categorization optimally requires significant brain areas interaction (Binder et al., 2009). A particular left lateralized fronto-temporal network has been outlined (Davey et al., 2016; Zeithamova et al., 2019). In children activity in cortical areas like the left frontal inferior gyrus has been associated with the search for semantic associations, and inferior parietal activations are associated with the integration of highly related semantic features (Chou et al., 2006; Moore-Parks et al., 2010). Categorization is a slow developmental process across childhood (Bjorklund et al., 2009; Jarrold et al., 2009). Semantic processing is fundamental to academic learning, the deficit in these processes leads to suboptimal analysis of information (Miller, 2000).

The implications of these findings cover two main areas: general psychological- development and cognitive-neuropsychological development. Systematic reviews and metanalysis on child-ADHD show that clinical treatment is focused on the children, with additional group-based parental psychoeducation about the child's clinical condition (Daley et al., 2018; Ogundele et al., 2023). In contrast, most children in our sample have at least one parent with a psychiatric diagnosis. Depression and WM deficits in mothers produce harsh parenting interactions, mainly frustration in cooperation tasks. If parents present reinforcement/motivation deficits, a negative influence is posed in children development of persistence: the positive motivation to future rewards/goals (Sagvolden et al., 2005). Parents with the highest ADHD symptoms report "the best" parenting practices (Butzbach et al., 2021; Lui et al., 2013), these metacognition deficits (cognitive bias) are resistant to psychological treatment, because these types of parents are more difficult to conscientize to promote behavioral change.

Parental scaffolding is a crucial factor in the children´s EF development (Bibok et al., 2009). EFD in parents produces inadequate organization and planning in daily home

activities (household chaos), insufficient supervision of everyday activities of the child, and less efficiency to provide solutions to daily problem-solving (Murray & Johnston, 2006). All these conditions have negative influence on the EF development across childhood (Andrews et al., 2021). In this sample of children academic learning and cognitive development dimensions are compromised (EFD in semantic categorization, verb fluency, and WM). In addition, the EFD in the parents (WM and verbal fluency). It suggests the need for neuropsychological intervention at these cognitive dimensions.

Conclusions

In this exploratory study, the sample of balanced parents couples included here indicates three probable types of ADHD-families: high presence, low presence and absent psychiatric conditions, been the younger age-parents the more affected. As a group the parents present several clinical and subclinical EFD. At 75 % of the families studied, psychiatric conditions and clinical/subclinical EFD represent the parental ecosystem of their male son with ADHD.

These preliminary data suggest that the characterization of the family neuropsychological and psychological ecosystem of the children with ADHD should become a normal clinical procedure. To confirm-expand the finding trends in this exploratory study, larger samples of families are required. The confirmation for specific EFD at each parental group requires further variable control in the number-type of psychiatric diagnosis (psychiatric similar phenotypes at mothers and fathers), but also families with parents without any psychiatric condition.

A systemic approach is required in neuropsychology, to provide clinical treatment (when needed) to mothers and fathers of children with ADHD, and not only psychological counseling to the parents about “the child's disorder”.

Limitations and future challenges. Larger samples are required to further confirm/specify these findings, not only to determine replicability, but also to include two groups of parents: with and without psychiatric conditions, conforming clinically homogeneous parent samples. Also, specific variables regarding child-ADHD: gender, type/presentation, medication, interventions-therapy, and different age ranges, were not controlled in this study.

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