Executive Functions in Preschoolers with ADHD, ODD, and Comorbid ADHD-ODD: Evidence from Ecological and Performance-based measures

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Abstract

Executive functioning in 3-year old preschoolers with attention deficit hyperactivity disorder (ADHD), oppositional defiant disorder (ODD), comorbid ADHD+ODD, and children without any of these conditions (control group) is examined. A community sample including 622 children was diagnosed using a diagnostic interview following DSM-IV criteria, and assessed using the Behavior Rating Inventory of Executive Function Preschool version (BRIEF-P) and the Kiddie-Conners' Continuous Performance Test. The children diagnosed with ADHD showed the poorest executive function (EF) profile in comparison to controls, and were closely followed in this respect by the comorbid ADHD+ODD children. The ADHD and comorbid groups presented similar executive difficulties. The ODD group obtained mean scores statistically equal to those of controls in EF. These findings suggest that, in preschoolers, executive functioning deficits assessed with a performance-based measure or with behavioral descriptions are specific to children with ADHD, in comparison to those with ODD. This study contributes knowledge about executive functions in two prevalent and comorbid disorders in preschool children, ADHD and ODD, knowledge that can help our understanding of specific deficits and the design of specific early intervention initiatives.

Key words: Attention deficit hyperactivity disorder; BRIEF-P; executive functions; K-CPT; oppositional defiant disorder.

Executive Functions in Preschoolers with ADHD, ODD, and Comorbid ADHD-ODD: Evidence from Ecological and Performance-based measures.

Attention deficit-Hyperactivity disorder (ADHD) and oppositional defiant disorder (ODD) are common disorders in childhood starting early in life. Among preschoolers, ADHD prevalence ranges between 2% and 3.7%, and that of ODD between 6.9% and 9.4% (Bufferd, Dougherty, Carlson, & Klein, 2011; Egger, et al., 2006; Ezpeleta, Osa, & Doménech, in press). ADHD and ODD tend to co-occur and, in about 40-60% of ADHD cases, ODD is also present (Biederman, et al., 2007) – this comorbidity having been identified from preschool age (Bufferd, et al., 2011; Ezpeleta, Osa, et al., in press). It has been proposed that the two disorders have a common genetic liability that increases the risk of suffering from both of them (Tuvblad, Zheng, Raine, & Baker, 2009), and which could be associated with dopaminergic and serotoninergic circuits of reward and inhibition. Executive functioning may be a shared deficit in ADHD and ODD (Kochanska, Murray, & Harlan, 2000). Executive functions (EF) are defined as "those self-directed actions needed to choose goals and to create, enact, and sustain actions toward those goals" (Barkley, 2012, p.60). Processes such as inhibition, planning and organizing, working memory, flexibility or emotional control are included in executive functioning. Deficits in executive control may compromise behavioral regulation in emotional and cognitive areas in ADHD and in ODD.

ADHD has been conceptualized as a disorder with primary behavioral inhibition deficits that alters the development and effective performance of EF and the self-regulation they permit (Barkley, 2006). Response inhibition, working memory and flexibility assessed by neuropsychological procedures have been consistently associated with ADHD in the preschool period (Pauli-Pott & Becker, 2011) and school-age children (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Willcutt, Doyle, Nigg,

Faraone, & Pennington, 2005). In disruptive behavior disorders (DBD), which include ODD and conduct disorder (CD), Matthys, Vanderschuren, Schutter, and Lochman (2012) proposed that impaired neurocognitive deficits in the interrelated areas of punishment processing, reward processing and cognitive control affect social learning processes and disrupt the ability to refrain from inappropiate behaviors. A recent meta-analysis in the preschool population showed that inhibition, working memory and cognitive flexibility are also affected in DBD (Schoemaker, Mulder, Dekovic, & Matthys, 2013). Effect sizes of association of EF were similar for ADHD and DBD. Therefore, considered together, EF are impaired in externalizing disorders. It has been suggested that the nature of EF deficits in ODD/CD might be more related to "hot" reward-related executive functions than to "cool" abstract-cognitive executive functions, compared to the case of ADHD (Hobson, Scott, & Rubia, 2011). In this group of disorders, it is necessary to separate the effects of ODD and CD, given that these disorders are different, have a different developmental pathway, and most children with ODD do not progress to CD (Rowe, Costello, Angold, Copeland, & Maughan, 2010). Few studies have separated ODD from CD to examine EF, and few have compared ADHD, ODD, and ADHD+ODD comorbidity. Thus, it is important to identify the neuropsychological profile of these disorders, when present alone or in association, early in life, with a view to identifying treatment targets and to designing appropriate interventions.

Part of the previous work with preschoolers in the general population has considered ODD/CD jointly. Results comparing performance-based EF in ADHD and ODD/CD indicate that the response inhibition difficulties were specific to ADHD (Berlin & Bohlin, 2002). When a comorbid and a control group were included, executive functioning performance of the comorbid and the ADHD groups was similar, and in both cases poorer than for the control and ODD/CD groups (Kalff, et al., 2002). Similar results were found in clinically-referred preschoolers by Schoemaker, et al. (2012), who reported that ADHD and ADHD+ODD/CD groups presented similar inhibition deficits. The comorbid group was

similar to the ADHD-only group in terms of severity, but similar to the DBD-only group in terms of pattern of inhibition (reward involvement). No working memory deficits were identified.

Other studies have compared EF, assessed with neuropsychological procedures, in preschoolers from the general population with ADHD and ODD, reporting that difficulties in EF (inhibition, working memory [WM] and verbal fluency) were associated with ADHD but not with ODD (Brocki, Nyberg, Thorell, & Bohlin, 2007; Martel, Roberts, & Gremillion, 2013; Thorell & Wåhlstedt, 2006); comorbidity was not studied. Finally, Youngwirth, Harvey, Gates, Hashim, and Friedman-Weieneth (2007) compared four groups (ADHD, ODD, ADHD+ODD, control) and found that the comorbid group, followed by the ADHD group, obtained poorer scores on EF than the ODD or control groups; these latter groups did not differ.

Summarizing, studies in preschoolers have found that: 1) EF difficulties seem to be specific to ADHD; 2) the comorbid group performs the same as or more poorly than the ADHD-only group; and 3) the DBD/ODD group does not differ from the control group.

All previous studies have used performance-based EF measures, which may be difficult to administer to preschool children and do not fully reflect real executive performance in children's daily life. There is a general concern about the deficient association between performance-based executive functioning measures and standardized questionnaires. It has been argued that they assess different aspects of the same construct, that performance tests measure ability while questionnaires capture the application of those abilities in a specific context, and that the conditions in which performance tests are applied – a quiet and structured environment – result in a lack of ecological validity (McAuley, Chen, Goos, Schachar, & Crosbie). Given that performance-based measures of executive functioning at preschool age present some limitations (Sherman & Brooks, 2010), the use of questionnaires describing

how children behave when they are required to apply executive control is a promising assessment alternative (Gioia, Espy, & Isquith, 2003).

An important limitation of current literature is that little attention has been paid to differentitating EF deficits in ADHD and ODD. In the above review, only the study by Youngwirth, et al. (2007) compared these conditions in four groups (ADHD, ODD, ADHD+ODD, control). The study of EF during the preschool period, when EFs are emerging and maturing, separately for ADHD, ODD, and the comorbidity between the two, needs further study. The aim of this study was to explore differential executive functioning in a broad sample of 3-year-olds from the general population with ADHD, ODD, and comorbid ADHD+ODD, and children without these disorders, using an ecological measure to try to clarify the nature of executive dysfunction when these disorders are present in the real preschool environment, as well as a performance-based measure. We hypothesized that poorer executive function would be associated with ADHD and ADHD+ODD, and that the ODD group would exhibit subtle or no impairment compared to the control group.

Method

Participants

Participants were part of a longitudinal study of risk factors in developmental psychopathology starting at the age of 3 with a double-phase design. A cross-sectional two-phase design began with a selection of a random sample of 2,283 children from the census of preschoolers in grade P3 (age 3) at 54 schools in Barcelona (Spain). A total of 1,341 families (58.7%) agreed to participate in the first phase, and children were screened for behavioral problems through the Strengths and Difficulties Questionnaire (SDQ^{3-4}; Goodman, 2001), enriched with four symptoms of DSM-IV oppositional defiant disorders (the principal disorder of interest in the original study) not included in the original questionnaire. In the

second phase of the study, all children with a positive score in the screening (raw score of at least 4 points in the conduct problems scale, percentile 90 in community samples, or a response option of 2 [certainly true] in any of the eight DSM-IV oppositional defiant symptoms) and a random sample including 30% of negative screen scores were invited to continue. Children with pervasive developmental disorders or intellectual disability, and those with difficulties understanding the Catalan or Spanish language were excluded. A total of 622 children and their parents agreed to participate (rate of participation in the second phase was 89.4%). No statistical differences emerged comparing participants and refusals in the second phase on the basis of sex (p=.82) or type of school (p=.85).

The children participating in the present study correspond to the first year of assessment, when they were aged 3. Performance measures of IQ and executive functioning (K-CPT) administration rules indicate that these measures can be applied from age 4; therefore, these score correspond to the second follow-up, when the children were aged 4. A total of 94 teachers from 54 schools reported on the children. Participating teachers had known the children for a mean of 7.6 months (SD = 2.2).

Table 1 shows descriptive data for total sample (n=622). The (weighted) prevalences of the disorders considered in the study were: 3.6% ADHD, 6.9% ODD, 1.4% conduct disorder, 0.4% depression, 2.1% separation anxiety, 3.6% specific phobia and 1.9% social phobia. Sixty-three children (7.9%, weighted) presented comorbidities other than ADHD or ODD.

Measures

The *Diagnostic Interview for Children and Adolescents for Parents of Preschool and Young Children* (DICA-PPYC; Ezpeleta, de la Osa, Granero, Domènech, & Reich, 2011) is a semi-structured diagnostic interview designed to assess the most common psychological disorders at ages 3-7 years according to the DSM-IV-TR criteria (American Psychiatric Association, 2000). Parents were

interviewed about the presence of symptoms when the children were 3 years old. The interview was used to form the groups of analysis and for evaluating comorbidity other than that for the different disorders of interest (conduct disorder, depression, separation anxiety, and social and specific phobias)

The *Behavior Rating Inventory of Executive Function preschool version* (BRIEF-P; Gioia, et al., 2003) is a standardized rating scale that assesses behaviors reflecting the executive functions in preschool children aged 2 to 5 years. The teachers' form was employed to measure behavioral manifestations of EF in daily life in a preschool environment in the last 6 months. The instrument consists of 63 items on a 3-point ordered scale (1 = *Never*, 2 = *Sometimes*, and 3 = *Often*) that measure 5 clinical dimensions of executive functioning: Inhibit (I), Emotional Control (EM), Shift (S), Working Memory (WM) and Plan/Organize (PO). Those scales form 3 broad indexes: Inhibitory Self-Control Index (ISCI), composed of Inhibition and Shift; Flexibility Index (FI), composed of Shift and Emotional Control; and Emergent Metacognition Index (EMI), made up of Working Memory and Plan/Organize. There is also a composite score called Global Executive Composite (GEC), which indicates general executive performance. The higher the score, the higher the difficulty in the construct. Evidence of internal consistency for the BRIEF-P-P scales was very high in the sample (Cronbach's alphas ranged from .87 in the Shift scale to .97 in GEC) (Ezpeleta, Granero, Penelo, Osa, & Doménech, in press). Teachers answered the questionnaire when the children were 3 years old.

The Kaufman Brief Intelligence Test (K-Bit; (Kaufman & Kaufman, 2000) is a brief test for individuals aged 4 to 90 that takes 10–30 minutes to administer and provides an estimate of intelligence quotient (IQ). Two subtests were applied. The Vocabulary Subtest (Verbal) includes expressive vocabulary and definitions that assess knowledge of words and their meanings. The Matrix Subtest (Nonverbal) assesses the ability to solve new problems through the perception of relationships and the

completion of analogies between concepts. Children were tested when they were aged 4, the minimum permitted age for administering this instrument.

The *Strengths and Difficulties Questionnaire* (SDQ^{3-4}; Goodman, 1997) for parents and teachers of 3 to 4-year-old children was used as a dimensional measure of psychopathology. It is made up of 25 items with 3 response options (0: *not true*; 1: *somewhat true*; 2: *certainly true*) on five scales: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behavior. Higher scores indicate greater problems. Parents and teachers answered the SDQ when children were aged 3. The Cronbach's alpha reliability in the present sample for conduct and hyperactivity scales were .59 and .74, respectively, in the case of parents, and .73 and .85 in that of teachers.

The *Kiddie-Continuous Performance Test* (K-CPT; Conners, 2006) is a performance-based measure of attention function and response inhibition for children aged 4-5. The software presents stimuli consisting of familiar pictures for very young children (doll, truck, ball, etc.), and response/no response is required depending on the picture that appears. The program provides 12 variables related to attention: *omission* means lack of a required response (high score indicates the child is not orienting and responding to the stimulus); *commission* is a response after a stimulus that requires none (high score indicates high responses to nontarget); *hit reaction time* is the mean response time over all 5 time blocks (high scores reflect slow response times); *hit reaction time standard error* is a measure of erratic responding (high score indicates erratic responding, often related to inattentiveness); *variability of standard errors* is the response time consistency within respondent (high score reflects high inconsistency in speed of response); *attentiveness (d')* denotes how well the individual discriminates between targets and nontargets (high score indicates poor ability to discriminate); *perseverations* is a response that occurs less than 100ms following a stimulus (high score indicates anticipatory

responding); and the remaining variables are measures of reaction time. The K-CPT was administered when the children were 4 years old (n = 612) (as stipulated in the questionnaire manual).

Procedure

The study was approved by the Ethics Review Committee at the authors' institution. Schools and parents were informed about the objectives, benefits and research implications of the study, and parents were asked to give permission for their children to participate in it. The children's teachers were asked to fill in the SDQ and the BRIEF-P, after consent had been obtained from the parents and confidentiality was guaranteed. Specialists in child psychopathology, previously trained in the use of the diagnostic interview, interviewed parents at the school. Other psychologists, trained in the administration of the K-Bit and K-CPT, administered the test to the children during school hours.

Statistical analysis

The SPSS20 for Windows was used. First, differences in socio-economic variables were compared between diagnostic subtypes with chi-square tests (for categorical features) and analysis of variance (ANOVA) procedures (for quantitative variables). Subsequently, General Linear Models (GLM) implemented within a Complex Sample System (creating a sampling project based on a weighted variable with values inverse to the probability of random selection in the second phase of the design) compared the mean of the EF scores between diagnostic groups; these models were adjusted for the covariates gender, IQ score and the presence of any comorbidity other than ADHD+ODD. The Holm-Bonferroni method (Holm, 1979) was used to control for increase in type-I errors due to multiple comparisons.

Results

Description of the groups in symptomatology

According to the diagnostic interview, the sample was classified into four groups: ODD group (*N* = 51; 5.9% weighted), ADHD group (*N* = 23; 2.6% weighted), comorbid group (children who met criteria for both ODD and ADHD) (*N* = 10; 1% weighted) and a control group (children without any of the aforementioned pathologies) (*N* = 538; 90.5%) (Table 1). No differences between diagnostic groups emerged for sex, ethnicity, type of family (single parent vs two parents) or age, but differences were statistically relevant for socioeconomic status: low socioeconomic status was more prevalent in the ADHD and comorbid groups.

Regarding symptomatology, the comorbid and ADHD groups scored significantly higher in the SDQ conduct and ADHD scales as reported by parents and teachers. Mean scores for the IQ measure were also statistically different, the lowest scores being found for the comorbid ADHD+ODD children, followed by the ADHD children.

Executive functioning

Supporting information: Table A shows the descriptive data (mean and standard deviation) for EF measures (stratified by sex) in each group. On the whole, the poorest results in EF scores were obtained by children diagnosed with ADHD, followed by comorbid ADHD+ODD.

Table 2 shows the descriptive data for EF for each group and the GLM results (adjusted for the covariates comorbidities other than ADHD-ODD and IQ) comparing the mean scores between diagnostic groups. First, the interaction between the group (control, ODD, ADHD or comorbid) and sex was assessed, to evaluate the potential moderator effect of gender in the association between diagnosis

and EF. Since no interaction achieved significant results, this parameter was excluded from the models and the main effects for the factor disorder were estimated.

Means of EF for the ODD group were statistically equal to the means for controls. ADHD, compared to controls, yielded poorer results (higher scores) in the BRIEF-P scales, indicating difficulties in inhibition, emotional control, working memory, plan-organize, inhibitory self-control indexes, emergent metacognition and global executive composite, and in the K-CPT commissions (high impulsivity), Hit RT (fast reaction time), Hit RT Std Error (inconsistent reaction time), Var Std Error (inconsistent speed of response), Hit RT ISI change (slowing of reaction time as the time between targets increases) and Hit SE ISI change (more erratic reaction time as the time between targets increases). Comorbid ADHD+ODD children: a) compared to controls obtained poorer mean values in the BRIEF-P inhibit scale and in K-CPT Hit RT Std Error (inconsistent reaction time), Var Std Error (inconsistent speed of response), lower Beta (response style characterized by responding freely to most of the targets without worrying about mistakenly responding to a nontarget) and higher Hit RT block change (slowing reaction time over the different blocks), Hit SE block change (less consistent reaction as the test progresses) and Hit SE ISI change (slowing of reaction time as the time between targets increases); b) compared to ODD these comborbid children obtained poorer mean values in the BRIEF-P inhibit scale and higher mean values in K-CPT Hit RT Std Error (inconsistent reaction time) and Var Std Error (inconsistent speed of response), lower means in Beta (unconcerned response style) and higher means in Hit SE block change (less consistent reaction as the test progresses); and c) compared to the ADHD group, the comorbid participants obtained lower means in K-CPT Beta (unconcerned response style). Finally, the ADHD group, compared to the ODD group, obtained poorer EF results in almost all the BRIEF-P scales (except for shift, emotional control and FI index) and in K-CPT Hit RT (slow reaction time), Hit RT Std Error (inconsistent reaction time) and Var Std Error (inconsistent speed of

response), Hit RT ISI change (slowing of reaction time as the time between targets increases) and Hit SE ISI change (more erratic reaction time as the time between targets increases).

Discussion

The goal of the study was to ascertain whether there were differences in executive functioning between ADHD, ODD and both conditions in preschool children. The diagnostic condition with the poorest indicators in EF (assessed with the BRIEF-P and K-CPT questionnaires) is ADHD, followed by the comorbid ADHD+ODD children. The ADHD and ADHD+ODD groups were similar in executive functioning, and the ODD group was similar in executive functioning to the control group. Therefore, as a result of evaluating EF with different instrument (performance-based and behavioral descriptions), it emerges that the deficits in executive functioning appear to be specifically associated with ADHD in preschoolers from the general population. These results are in line with previous research in preschoolers and school-age children (Clark, Prior, & Kinsella, 2000; Oosterlaan, Scheres, & Sergeant, 2005; Qian, Shuai, Cao, Chan, & Wang, 2010). The contributions of the present study are: 1) separating ODD from conduct disorders; 2) using mixed tecniques for assessing EF and incorporating a standardized questionnaire of executive functioning; 3) including a comorbid group and a control group; and 4) extending the sample size of previous studies.

Inhibition, as assessed by Inhibit in the BRIEF-P, is an executive function that discriminates consistently among externalizing groups and between externalizing and control groups. According to this questionnaire, inhibition is significantly more impaired when ADHD is present (ADHD and ADHD+ODD groups) than when it is absent (ODD and control). The groups with the ADHD diagnosis showed greater behavioral difficulties that imply inhibition problems. However, the K-CPT identified as

having greater inhibition problems the group with ADHD only (commissions, Hit RT). Executive functions, specifically those inhibiting behavior, are a core problem in ADHD (Barkley, 2006).

In our study we did not find executive problems in the ODD group, as this group did not differ from the controls. ODD has recently been conceptualized as a multidimensional disorder (Stringaris & Goodman, 2009) from preschool age (Ezpeleta, Granero, Osa, Penelo, & Doménech, 2012), and negative affectivity, more than poor cognitive control, seems to be a part of it (Martel, Roberts, & Gremillion, 2013). Alternatively, deficits in executive functioning in ODD may be related more to "hot" than to "cool" EF (Hobson, et al., 2011).

The comorbid group was similar in EF to the ADHD group, as in the studies by Kalff, et al. (2002) and Schoemaker, et al. (2012). However, we found a particularity of the the comorbid group: it differed from ODD, from ADHD and from controls in the Beta response style indicator of K-CPT, insofar as it obtained significantly poorer values. Children in the comorbid group were not cautious, and responded very often to K-CPT; they did not try to avoid commission errors, tending to be unconcerned about mistakenly responding to a nontarget. Such beta value results could be related to low effortful control, which has been proposed as being associated with the personality trait "conscientiousness" (Martel, et al., 2013) and is involved in ODD. The child's capacity to inhibit a prepotent response is altered in disruptive behavior disorders (ODD and CD) through deficient levels of effortful control, a general executive factor of temperament (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). Thus, a specific feature of the comorbid group would be their marked lack of interest in doing a task well, and this should be taken into account in treatment plans.

There was no agreement between the standardized and performance measures in the identification of inhibition difficulties in the groups. Behavioral descriptions provided by the teachers differentiated more markedly between the groups than the performance measure. According to the

BRIEF-P, a quick and easy-to-administer questionnaire, other deficiencies in executive functioning (WM, planning-organize) emerged in the ADHD-only group in comparison to the ODD and control groups. For their part, the K-CPT scores that best differentiated the externalizing groups were inattention measures (Hit RT Std Error, Var Std Error), which reflected slow reaction time and erratic response style often related to deficits in sustained attention. A combination of techniques is useful during the diagnostic assessment process for obtaining better knowledge about the executive functioning of each group. Espy, Sheffield, Wiebe, Clark, and Moehr, 2011) suggested the the BRIEF-P should be used as a broad indicator of problem behavior, and not as a substitute for assessing performance-based executive skills. Thus, while the BRIEF-P was able to identify gross behavioral difficulties in inhibition, the K-CPT specifically identifies mostly difficulties related to reaction time, to consistency of execution, and to inattention. Different levels of detail in diagnostic assessment may be helpful for planning intervention.

The present results should be interpreted considering some limitations. First, the EF questionnaire was obtained from teachers only, and not from parents. Teachers, however, do have the opportunity to observe and compare behaviors in a normative group of children of the same age, which add some value to the ratings. Second, the sample size for the comorbid ADHD+ODD group was low, limiting the statistical power of comparison for this group versus the other diagnostic conditions. Third, the study of EF in preschoolers entails some difficulties. The structure of EF in preschoolers needs further study, some studies suggesting a single general factor of executive functioning (Wiebe, et al., 2011), these functions becoming more differentiated with age (Hughes, 2011), and others proposing two (inhibition, WM) (Schoemaker, et al., 2012), three (inhibitory self-control, flexibility, emergent metacognition) (Ezpeleta, Granero, et al., in press) or four (hyperactive behaviors, attention problems, dishinhibition behaviors, emotional regulation behaviors) (Espy, et al., 2011). Also, the relationships

between EF and ADHD or ODD might be less sound during the preschool years because these functions are developing during this period. Schoemaker, et al. (2013), in a meta-analysis in preschoolers, found larger effect sizes of executive functioning in older (4.7 to 6-year-old) versus younger (3 to 4.6-year-old) children. Thus, it may be that at age 3 only a few associations emerged. Finally, the diagnoses were derived through a semi-structured diagnostic interview carried out with the parents. Following DSM-IV criteria it was established whether there was impairment in several contexts. We also obtained the SDQ scores for ADHD from parents and teachers to provide more evidence of the level of symptomatology. In the context of this research it was not possible to apply the optimal form of reaching an ADHD diagnosis, pooling information from multiple sources (parent interview, teacher and parent ratings using standardized scales) and arriving at a consensus of experts.

In conclusion, our findings suggest that EF difficulties at age 3 are specific to children with ADHD. Children with comorbid ODD and ADHD must be treated in relation to EF difficulties in the same way as children with ADHD only. Our findings contribute to the understanding of the neuropsychological characteristics of ODD alone and in association with ADHD. They also highlight the need for early identification of EF difficulties in preschoolers, especially those with ADHD, and for starting early in children's development to stimulate the areas with deficits, particularly inhibition skills. The differential pattern of executive functions obtained in this study for the diagnostic groups supports the suggestion that ADHD and ODD have different profiles of executive dysfunction at preschool age.

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Table 1. Descriptive data for the sample.

		Total (N=622)	Control (N=538)	ODD (N=51)	ADHD (N=23)	ODD+ADHD (N=10)	[1]χ^2 or F	p-value
Gender. *N; %*	Male	310; 49.8%	260; 48.3%	29; 56.9%	17; 73.9%	4; 40.0%	χ^2 =7.22;	.062
Ethnicity. *N; %*	Caucasian	554; 89.1%	482; 89.6%	44; 86.3%	21; 91.3%	7; 70.0%	χ^2 =8.42;	.568
	Hispanic	40; 6.4%	31; 5.8%	5; 9.8%	2; 8.7%	2; 20.0%		
	Oriental	6; 1.0%	5; 0.9%	1; 2.0%	0; 0%	0; 0%		
	Other	22; 3.6%	20; 3.7%	1; 2.0%	0; 0%	1; 10.0%		
Socioeconomic level. *N; %*	High	205; 33.0%	184; 34.2%	19; 37.3%	2; 8.7%	0; 0%	χ^2 =23.90;	.001
	Middle-High and Medium	283; 45.5%	249; 46.39%	20; 39.2%	10; 43.5%	4; 40.0%		
	Middle-Low and Low	134; 21.5%	105; 19.5%	12; 23.5%	11; 47.8%	6; 60.0%		
Single parent. *N; %*	Yes	30; 4.8%	24; 4.5%	3; 5.9%	1; 4.3%	2; 20.0%	χ^2 =5.31;	.129
	Mean; SD							
Child's age (years-old)		3.77; 0.33	3.76; 0.33	3.87; 0.30	3.74; 0.33	3.69; 0.31	F=2.03;	.109
Intelligence (K-BIT score)		99.2; 15.9	99.8; 15.4	98.0; 16.4	91.9; 21.0	88.5; 16.6	F=3.51;	.015
SDQ: conduct; Parents		3.23; 1.87	2.99; 1.76	4.61; 1.73	4.83; 1.87	5.60; 2.17	F=25.9;	<.001
SDQ: ADHD; Parents		4.22; 2.53	3.93; 2.37	4.98; 2.66	7.74; 2.00	7.30; 2.21	F=26.6;	<.001
SDQ: conduct; Teachers		1.98; 2.14	1.81; 2.03	2.78; 2.56	3.91; 2.27	2.90; 2.56	F=10.9;	<.001
SDQ: ADHD; Teachers		3.37; 2.84	3.19; 2.78	3.31; 2.47	6.74; 2.65	5.90; 2.60	F=15.2;	<.001

Note. SD: standard deviation. K-BIT: Kaufman Brief Intelligence test. SDQ: Strengths and Difficulties Questionnaire

Comparison based on chi-square test for categorical variables and ANOVA for quantitative variables.

Table 2. Association between diagnostic subtype and executive functions in the executive functions measures (BRIEF-P and K-CPT scores).

	Control		ODD		ADHD		Comorbid (COM)		Interaction		Factor		GLM (adjusted for other comorbidity and IQ): mean differences (ϕ) and p-value									
	(*n*=538)		(*n*=51)		(*n*=23)		(*n*=10)		Group×sex		Group		ODD vs		ADHD vs		COM		ODD vs		ADHD vs		ODD vs	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	*p*	F	*p*	Control		Control		Control		COM		COM		ADHD	
BRIEF-P scales																								
Inhibit (I)	22.78	6.71	22.96	7.27	32.30	6.79	28.10	8.89	1.939	.733	13.82	<.001	0.27	.812	**8.77***	<.001	**5.80***	.019	**-5.53***	.037	2.97	.289	**-8.50***	<.001
Shift (S)	13.15	3.51	13.10	3.76	13.77	3.41	13.10	3.99	1.629	.908	0.219	.884	-0.33	.611	0.29	.719	-0.59	.620	0.26	.842	0.88	.527	-0.62	.537
Emotional Cont. (EC)	11.97	3.40	12.76	3.75	14.96	4.12	13.30	6.42	2.472	.520	2.695	.058	0.74	.211	**2.89***	.009	1.23	.511	-0.50	.797	1.66	.439	-2.16	.076
Working Mem. (WM)	22.35	6.60	22.36	6.23	29.26	9.59	26.50	8.48	0.653	.998	3.620	.027	-0.45	.633	**5.55***	.003	2.83	.223	-3.28	.173	2.72	.348	**-6.00***	.003
Plan-Organize (PO)	13.29	3.74	13.52	3.82	16.87	4.70	15.20	4.17	1.043	.998	3.315	.029	-0.02	.965	**2.89***	.003	1.39	.228	-1.42	.251	1.50	.309	**-2.92***	.008
ISCI (I+S)	34.75	8.91	35.72	10.13	47.26	9.81	41.40	14.19	2.510	.520	9.196	<.001	1.01	.524	**11.7***	<.001	7.04	.079	-6.03	.152	4.63	.307	**-10.7***	<.001
FI (S+EC)	25.12	6.13	25.86	6.36	28.80	6.83	26.40	9.64	2.507	.520	1.153	.360	0.42	.690	3.27	.066	0.66	.818	-0.24	.937	2.62	.427	-2.85	.155
EMI (WM+PO)	35.65	10.07	35.88	9.67	46.13	13.82	41.70	12.40	0.813	.998	3.687	.027	-0.48	.741	**8.44***	.002	4.23	.213	-4.71	.185	4.21	.322	**-8.92***	.003
GEC; Total	83.54	19.19	84.70	18.67	107.27	21.81	96.30	22.60	0.548	.998	8.823	<.001	0.21	.944	**20.5***	<.001	10.8	.075	-10.6	.101	9.73	.174	**-20.3***	<.001
K-CPT scales (T-scores)																								
Omissions	48.49	9.22	48.29	9.34	50.75	8.19	49.45	9.18	1.057	.766	0.516	.671	0.01	.996	2.59	.216	0.13	.966	-0.12	.970	2.46	.495	-2.58	.271
Commissions	52.35	9.75	51.91	10.04	49.40	7.23	57.09	11.49	0.602	.791	2.918	.071	-1.15	.418	**-4.42***	.005	2.41	.506	-3.57	.351	-6.83	.078	3.27	.100
Hit RT	50.21	9.30	48.79	7.56	52.78	7.47	48.59	11.64	1.265	.766	1.839	.216	-0.76	.532	**3.78***	.034	-0.54	.882	-0.23	.950	4.32	.266	**-4.54***	.022
Hit RT Std Error	50.47	7.23	49.42	7.54	54.42	6.00	54.75	4.53	0.670	.791	4.911	.014	-0.81	.490	**3.91***	.004	**3.94***	.015	**-4.75***	.011	-0.03	.987	**-4.72***	.005
Var Std Error	50.65	7.79	49.85	8.01	54.35	7.15	55.92	4.67	0.211	.926	4.834	.014	-0.48	.691	**3.75***	.018	**5.24***	.003	**-5.72***	.004	-1.49	.507	**-4.23***	.026
d'	51.08	9.29	50.22	7.69	49.65	7.30	53.14	9.29	0.196	.926	1.071	.411	-1.56	.205	-2.21	.158	-0.50	.866	-1.06	.733	-1.71	.600	0.65	.728
Perseverations	51.89	13.93	50.72	11.10	52.97	15.20	64.10	28.48	0.454	.837	0.856	.491	-1.44	.405	-0.69	.805	10.68	.207	-12.12	.152	-11.37	.194	-0.74	.807
Beta	51.70	13.29	51.79	11.11	55.37	13.53	46.12	5.76	0.991	.766	2.540	.101	0.76	.655	4.70	.196	**-4.29***	.033	**5.05***	.030	**8.99***	.023	-3.94	.305
Hit RT block change	48.43	13.30	48.01	14.05	47.68	14.70	55.23	12.27	0.210	.926	1.466	.305	0.12	.954	0.82	.782	**8.02***	.037	-7.90	.057	-7.20	.128	-0.70	.841
Hit SE block change	49.96	11.74	47.79	11.55	48.35	14.70	55.51	5.80	3.058	.309	3.074	.069	-1.82	.336	-0.43	.882	**6.39***	.009	**-8.21***	.003	-6.82	.061	-1.39	.677
Hit RT ISI change	50.86	9.31	48.56	10.70	55.46	8.60	55.32	10.82	1.201	.766	3.859	.011	-2.23	.182	**4.41***	.005	3.75	.262	-5.97	.100	0.66	.853	**-6.64***	.002
Hit SE ISI change	50.15	9.44	49.53	10.75	55.69	7.41	53.59	5.46	0.330	.879	5.584	.357	-0.12	.939	**5.63***	<.001	**4.20***	.030	-4.33	.071	1.43	.545	**-5.76***	.008
ADHD Confid. Index	43.95	16.14	41.28	15.53	43.62	18.46	47.54	13.13	2.297	.406	1.257	.400	-3.63	.125	-3.39	.359	2.24	.557	-5.87	.154	-5.63	.265	-0.24	.955

Note. SD: standard deviation. BRIEF-P: Behavior Rating Inventory of Executive Function Preschool; I: inhibit; S: shift; EC: emotional control, WM: working memory; PO: plan-organize.

K-CPT: Kiddie-Continuous Performance Test. *Bold: significant contrast (.05 level). p-values adjusted for multiple comparisons (Holm-Bonferroni method).