

ADHD Symptoms and peer problems: Mediation of executive function and theory of mind

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Abstract

Background: The social maladjustment suffered by many children with attention deficit hyperactivity disorder (ADHD) is maintained over time, increasing the risk of subsequent adverse outcomes. The objectives of the study were to explore the mechanisms that operate between ADHD symptoms and social problems with peers, considering the mediation of FE and ToM. **Method:** 35 children with ADHD and 37 with typical development matched in age and IQ were compared. Parents assessed ToM skills and relationships with peers, and teachers provided EF ratings. **Results:** The analyses showed statistically significant indirect mediation effects of EF in the relationship between ADHD symptoms and problems in relationships with peers, whereas ToM did not show these effects. **Conclusions:** EF impairments contribute to the social difficulties of children with ADHD.

Keywords: ADHD symptoms, executive functioning, problems with peers, theory of Mind.

Resumen

Síntomas de TDAH y problemas con los compañeros: mediación del funcionamiento ejecutivo y de la teoría de la mente. Antecedentes: el desajuste social de muchos niños con Trastorno por Déficit de Atención con Hiperactividad (TDAH) se mantiene con el tiempo, aumentando el riesgo de resultados adversos. Los objetivos del estudio fueron explorar los mecanismos que operan entre los síntomas del TDAH y los problemas sociales con los compañeros, teniendo en cuenta el papel de FE y ToM. **Método:** se compararon 35 niños con TDAH y 37 con desarrollo típico de edad y QI. Los padres evaluaron las habilidades y las relaciones con los compañeros, y los maestros proporcionaron calificaciones EF. **Resultados:** los análisis mostraron efectos de mediación indirecta estadísticamente significativos de EF en la relación entre los síntomas del TDAH y los problemas en las relaciones con los compañeros, mientras que ToM no mostró estos efectos. **Conclusiones:** los déficits en EF contribuyen a las dificultades sociales de los niños con TDAH.

Palabras clave: síntomas del ADHD, funcionamiento ejecutivo, problemas con los compañeros, teoría de la Mente.

Children with ADHD show low social acceptance, which becomes more evident in the circle of peers. Negative interactions between children with ADHD and their peers take place early, so that the rejection occurs in days and even in hours. Consequently, more than 50% experience social rejection, and they can have up to 500,000 negative interactions every year (Hoza et al., 2005). They have poorer quality relationships, they spend less time on direct or telephone contact with their friends outside of school, and their social interaction is not characterized by reciprocity or empathic behaviors, such as consoling, sharing, supporting, seeing things from the other person's point of view, or negotiating (Normand et al., 2011).

The social problems persist over time, they interfere with the correct development of social skills and self-regulation, and they increase the risk of cigarette smoking, depression, and overall

maladjustment in adolescence (Mrug et al., 2012). In addition, and even more worrisome, the efficacy of intensive interventions in this area is rather limited (McQuade & Hoza, 2008). Therefore, it is important to perform an in-depth analysis of the possible factors involved in problems with peers in order to improve intervention outcomes.

The symptoms of ADHD according with *the Diagnostic and statistical manual of mental disorders-text revision- 5th edition [DSM-V]* (American Psychiatric Association [APA], 2013), have been considered a primary contributor to dysfunctions experienced by children with ADHD in establishing enduring social relationships. In both the hyperactivity/impulsivity and inattention domains, symptom severity is related to the deterioration in interpersonal relationships, low acceptance by classmates (Kim et al., 2015; Tseng, Kawabata, Gau, & Crick, 2014), and problems in family relationships (Miranda, Berenguer, Colomer, & Roselló, 2014). Moreover, in recent years, researchers have shown increasing interest in the study of the relationship between social problems and executive functioning deficits (see review by Roselló-Miranda, Berenguer- Forner, Baixauli-Fortea, & Miranda-Casas, 2016).

Various studies have shown the relationship between executive impairments and social problems in ADHD in childhood and adolescence. A significant effect of omission and commission errors in a continuous performance test was found on acceptance by classmates (Miller & Hinshaw, 2010), as well as associations between planning and spatial working memory deficits in people with ADHD and problems in relations with peers (Tseng & Gau, 2013). Impairments in EF persist over time, predicting worse social functioning in adolescence, according to the results of a follow-up study (Rinsky & Hinshaw, 2011). Finally, executive impairments on cognitive flexibility, working memory and attention are accompanied by biases or “positive illusions” in the social terrain (McQuade et al., 2011).

Research on theory of mind (ToM), has been revealed too as a valuable way to explore the problems of children with ADHD in social relationships. A meta-analysis by Bora & Pantelis (2016) compared the performance of individuals with ADHD and typical development (TD) on social cognition tasks, showing that, in the recognition of emotions and on theory of mind tasks, the children with ADHD showed worse performance.

There is little information about the relationships between FE and TOM problems in children with ADHD, but the literature supports the associations between EF and ToM in typical development (Carlson, Moses, & Claxton, 2004; Hughes & Ensor, 2007). One of the questions that recent studies have tried to clarify is whether ToM failures have a primary nature, or whether they are the consequence of failing to express ToM skills in situations that require inhibitory control and other executive processes. Some studies point out that children with ADHD show worse performance than children with TD on ToM tasks that require considerable inhibition (Sodian, Hulsken, & Thoermer, 2003; Yang, Zhou, Yao, Su, & McWhinnie, 2009), suggesting that executive impairments produce a lack of consideration of mental states in social situations and could interfere the suppression of irrelevant stimuli, finally affecting the consideration of alternative perspectives of the world.

The evidence also indicates that the inhibitory problems and emotional control of children with ADHD impede the application of ToM skills in contexts of daily life (Papadopoulos, Panayiotou, Spanoudis, & Natsopoulos, 2005; Soltani, Kazemi, Maleki, & Soltani, 2013). In fact, a recent study by Mary et al. (2016) does not find ToM dysfunction to be a primary factor in ADHD either. According to their results, controlling inhibition and attention, the performance of the children with ADHD matched the performance of the children with TD. However, when the performance on the ToM tasks was controlled, the performance on the inhibition and attention tests was not normalized. Therefore, “This unidirectional relationship suggests that impairments in EF and the attentional domain are responsible for the ToM deficits in children with ADHD, which can contribute to their socioemotional difficulties” (p. 345).

In summary, accumulated evidence has shown the contribution of ADHD symptoms and EF impairments to the social problems of children with ADHD, whereas the role of ToM, and especially its relationships with the other domains, has hardly been explored (Papadopoulos et al., 2005; Soltani et al., 2013). As far as we know, only the study by Mary et al. (2016) provides indirect support for the important role of the negative impact of EF on ToM in the social problems of children with ADHD. Furthermore, there is a lack of studies that deepen in the interrelation between the

different domains adopting a naturalistic evaluation approach that represents with more fidelity the behavior in the real life than the laboratory tests.

Taking an ecological assessment approach, the aims of the present study were first to examine differences between children with ADHD and children with TD on executive functioning, ToM components and peer problems. The second aim was to analyze the relationship between the symptoms of ADHD, FE, TOM and peer problems in order to investigate possible mechanisms of mediation between ADHD symptoms and peer problems. It is expected to find significant differences between the two groups in the analyzed variables and secondly it is hypothesized that EF impairments (especially the index of behavioral regulation-BRI), as the primary deficit in ADHD, as opposed to ToM deficits, would act as a mediator variable in the relationship between ADHD symptoms and problems with peers.

Method

Participants

In this study participated 72 children aged between 7 and 11 years, distributed in two groups, one group with ADHD (n=35) and one group with typical development (n=37). Mean age of children with ADHD, $M=9.14$ $SD=1.41$; children with TD, $M=8.54$, $SD=1.26$. All the participants had an overall intelligence coefficient (IQ) equal to or above 80, measured with the K-BIT (Kaufman & Kaufman, 2000): children with ADHD, $M=99.03$, $SD=9.87$; children with TD, $M=102.11$, $SD=8.9$. The two groups were matched on age $t(70)=-1.89$, $p=.062$ on IQ $t(70)=1.43$, $p=.155$, but the majority of the children with ADHD were boys (91.42%) compared to 67.56% of the group with TD ($\chi^2(1, N=72)=6.20$, $p=.013$).

School psychologists identified 42 children with ADHD. They had received a clinical diagnosis in psychiatry and neuropsychiatry services of hospitals and medical centers in the Valencian Community. In order to confirm the diagnosis, the parents and teachers filled out the list of 18 criteria for ADHD according to the DSM-5 (APA, 2013) assessing the severity of each item from 0 to 3. The presence of at least six inattention symptoms and/or six other hyperactivity/impulsivity symptoms, persistence of the symptoms for at least one year, and clear interference in their daily life functioning were the criteria adopted to confirm the diagnosis. Considering the agreement between parents and teachers, 77.14% of the participants showed a combined presentation and 22.86% had an ADHD inattentive presentation. The Kappa-Cohen test value was $\kappa=0.97$. Seven of 42 children were finally eliminated because they did not meet the ADHD criteria in the evaluation. In addition, 71.4% of participants with ADHD were taking psychostimulants and 40% of them had behavioral problems.

The children with typical development (TD) were selected in the same schools where the clinical sample was obtained. They did not present a record of psychopathologies, according to information facilitated by the school and the parents, and they did not meet the DSM-5 (APA, 2013) criteria for ADHD.

Instruments

Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000).

This questionnaire rates the child's EF through the teachers' observation of his/her behavior in the school context. It consists of 86 items scored on a Likert-type scale with three response options (never, sometimes, often). The items are grouped in 8 scales that make up two indexes, which were chosen for this study. The behavioral regulation index (BRI) includes the emotional control, change, and inhibition subscales. The metacognition index (MI) includes the subscales of initiative, working memory, planning/organization, organization of materials, and monitoring. Psychometric characteristics of the BRIEF have been studied in the Spanish population the main indexes (BRI and MI) and the GEC, the Cronbach alpha coefficients of the BRIEF-E were high, around .90 (García Fernández, González-Pienda, Rodríguez-Pérez, Álvarez García, & Álvarez Pérez, 2014). In this study, the Cronbach's alpha was .99 for the teachers' version.

Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997).

This scale, completed by parentes, contains 25 items directed toward children from 4 to 16 years old, and is concentrated in 5 subscales: emotional symptoms, behavioural problems, hyperactivity /inattention, peer problems and prosocial behavior. The peer problems subscale, which includes items that ask about behaviors that show maladaptation in the group of peers ("He is pretty solitary and would rather play alone", or "The other children pick on him/her") was selected as criterion of social development. We also used the other subscales to identify associated problems. The items are scored on a Likert-type scale ranging from 1 (not true) to 3 (certainly true). The SDQ has adequate statistical and psychometric properties (.73) measured with Chronbach's alpha (Goodman, 2001), and in the Spanish population also has good reliability (.76) (Rodríguez et al., 2012).

Theory of Mind Inventory (ToMI; Hutchins, Prelock, & Bonazinga, 2012; Spanish adaptation by Pujals et al., 2016).

This inventory for parents contains 42 items and addresses the wide range of mentalist skills. The items are grouped in 3 subscales and offer a general average score. The early subscale rates skills typical of the first stages of childhood, such as social reference and comprehension of basic emotions; the basic subscale rates ToM characteristics typical of children starting to attend school, such as basic meta-representations and the distinction between physical and mental; the advanced subscale evaluates more mature aspects of theory of mind, such as second-order inferences or making complex social judgments. Finally, the scores of TOMI total includes the sum of the previous three scales. Each item is assessed on a scale ranging from 0 to 20, from "Definitely not" to "Definitely", with a mid-point of "Undecided". High scores show the perception of good ToM competence.

The ToMI has been sufficiently validated and has good test-retest reliability and excellent sensitivity (.90) and specificity (.90), (Hutchins et al., 2012).

Procedure

The present study was approved by the Ethics Committee of the University of Valencia (Declaration of Helsinki in the Convention of the European Council, 1964). Authorization was also obtained from the Board of Education of the Valencian Government to locate children in Schools who had received a previous diagnosis of ADHD by childhood mental health specialists, as well as children with typical development. The objectives of the study were communicated to the parents and principals of the schools, and written consent was obtained from the parents and schools that agreed to participate in the study. The evaluation was carried out by trained psychologists in classrooms set up for this purpose in the different schools.

Data analysis

The statistical analyses were performed with the software *Statistical Package for the Social Science* (SPSS), version 22.00. In this study a cross-sectional design with two comparison groups was performed. Analyses of covariance (ANCOVA) were carried out to test the differences between the ADHD and TD groups on the two EF indexes (BRI and MI), the three levels of theory of mind from the ToMI, and peer relationship problems (SDQ). Sex and age were used as covariables. In addition, partial correlation analyses were carried out to study the associations among the variables being studied. Next, simple mediation analyses, were conducted using the PROCESS program for mediation, moderation, and conditional analysis (Hayes, 2013), which makes it possible to determine whether the relationship between two variables (independent= X and criterion=Y) is maintained when a third variable (mediator=M) is proposed as accounting for the relationship between them. Moreover, a bootstrap non-parametric resampling procedure was applied to try to compensate for the limitations of statistical methods that assume standard distribution in small sample sizes.

Results

The analyses of covariance (ANCOVAs) comparing the teachers' ratings on the two EF indexes showed significant differences between the ADHD and TD groups. Likewise, the results revealed significant differences between the two groups on problems with peers (Table 1). In addition, in the after controlling for sex and age, with the ToMI variables, significant differences

Table 1
Differences between children with ADHD and TD in FE main components and peer problems, with sex and age as covariables (ANCOVAs)

	ADHD (n = 35)		TD (n = 37)		F _{1,68}	p	η ² _p
	M	SD	M	SD			
BRI	60.45	10.86	37.81	6.78	90.46	.000*	.57
MI	104.22	15.98	59.48	11.5	166.69	.000*	.71
Peer problems	2.88	1.90	0.46	.95	39.29	.000*	.36

*p<.05

were obtained on the three levels and on the ToMI total, ToMI Early, ToMI Basic and ToMI Advanced, with significantly lower scores for the ADHD group in all cases (Table 2).

Table 3 shows the partial correlations, controlling for sex and age, among the study variables in the ADHD group. Statistically significant values were found for the correlations between the ADHD symptoms and BRI ($p=.007$) and problems with peers ($p=.032$) in the theoretically expected direction. The BRI correlated with problems with peers ($p=.022$) and the theory of mind early ($p=.022$) and basic ($p=.027$) ToMI. The other EF measure, the MI index, did not reach a statistically significant association with any of the study variables. Furthermore, although the three levels of ToM, early, basic, and advanced, coherently presented significant associations with each other, they did not maintain significant associations with ADHD symptoms or problems in relationships with peers.

Figure 1 provides a summary of three mediational analyses to explore whether the EF (BRI, MI) or TOMI total scale are mediating the relationship between inattention/hyperactivity symptoms and peer relationship problems.

Thus, in figure 1A, we analyze if BRI mediates the relationship between hyperactivity/inattention and peer relationship problems. As expected, ADHD symptoms significantly predicted the BRI (Path A, $R^2=.20$, $F_{(1,33)}= 8.38$, $p = .006$). The second regression analysis showed that the BRI was significantly associated with worse functioning in peer relationships, controlling for ADHD symptoms ($R^2=.18$, $F_{(2,32)}= 3.63$, $p = .037$). Likewise, the total effect of ADHD symptoms significantly predicted all the social peer problems ($R^2 = .11$; $F_{(1,33)} = 4.19$, $p = .048$).

In the final step to determine mediation (Path C'), ADHD symptoms did not predict problems with peers above and beyond what was accounted for by BRI ($p = .271$). The indirect effect

obtained using the bootstrapping procedure for a sample of 10.000 and a confidence interval (CI) de 95% was statistically significant, with a confidence interval that not include the zero value $b= .13$, $SE = .07$, 95% CI [.026, .334]. By dividing the b of the indirect effect by the b of the total effect (Mackinnon & Dwyer, 1993), BRI was found to account for 39% of the path from ADHD manifestations to peer problems. Thus, BRI is a partial mediator in this relationship (with full mediation defined as accounting for 100% of the variance).

As Figure 1B illustrates the standardized indirect effect between ADHD symptoms and peer problems, controlling for MI index was not statistically significant $b= .03$, $SE = .05$, 95% CI [-.021, .206]. Likewise, the standardized indirect effect between ADHD symptoms and peer problems, controlling for ToM was not statistically significant $b= .01$, $SE = .05$, 95% CI [-.037, .210] (figure 1C).

Discussion

The first aim of the present study was to analyze the differences between children with ADHD and children with TD on Executive functioning, ToM components and peer problems. The children with ADHD showed worse development than children with TD on all the EF components assessed, including their ability to inhibit behavior, shift from one situation to another, modulate emotional responses, initiate tasks or activities, organize learning materials, and monitor work effort, as well as their working memory and planning. The findings contribute to the literature supporting impairments in EF in people with ADHD (Schoemaker, Mulder, Dekovic, & Matthys, 2013; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), and they also support the value of reports of children's day-to-day EF in the "school context". Along the same lines, and in agreement with the conclusions of a recent

Table 2
Differences between children with ADHD and TD in ToMI Inventory, with sex and age as covariables (ANCOVAs)

	ADHD (n = 35)		TD (n = 37)		F _{1,68}	p	η ² _p
	M	SD	M	SD			
ToMI Total	15.87	2.13	18.38	1.42	35.82	.000*	.34
ToMI Early	17.22	1.83	18.98	8.23	22.68	.000*	.25
ToMI Basic	16.68	2.14	19.03	1.12	31.95	.000*	.32
ToMI Advanced	14.13	3.05	17.24	2.36	26.47	.000*	.28

* $p < .05$

Table 3
Partial correlations between executive functioning variables, theory of mind, ADHD symptoms, and peer problems; ADHD Group

	1	2	3	4	5	6	7
1. Behavioural Regulation Index							
2. Metacognition Index	.31						
3. ToMI Total	-.32	-.20					
4. ToMI Early	-.39*	-.29	.70**				
5. ToMI Basic	-.38*	-.20	.87**	.68**			
6. ToMI Advanced	-.17	-.08	.89**	.45**	.59**		
7. Peer problems	.39*	.32	-.15	-.20	-.24	-.03	
8. ADHD Symptoms	.46**	.10	-.01	-.15	-.07	-.04	.37*

Note: ToMI (Theory of mind)
* $p < .05$; ** $p < .001$

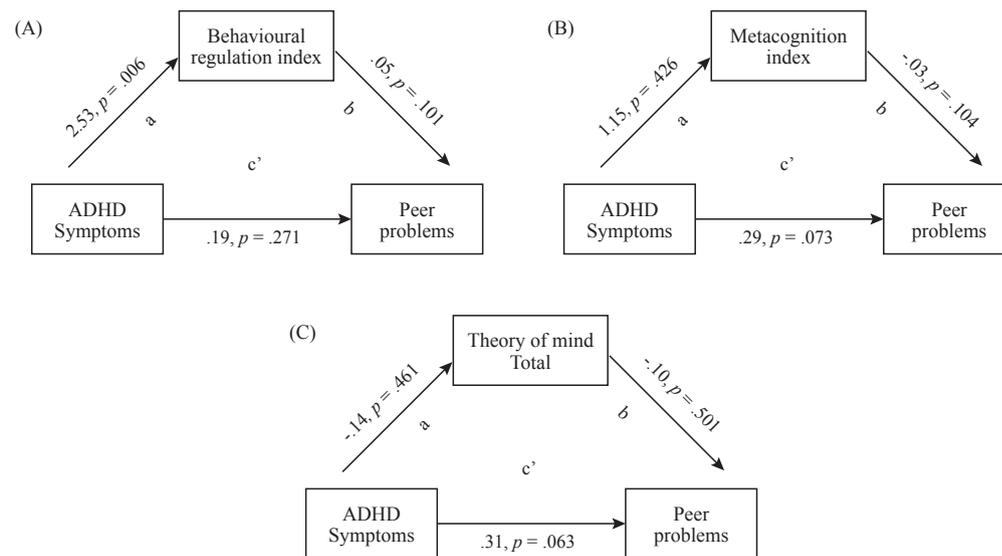


Figure 1. Simple mediation analysis of the effect of: BRI on the relationship between ADHD symptoms and peer problems (1A), MI on the relationship between ADHD symptoms and peer problems (1B), and ToM on the relationship between ADHD symptoms and peer problems (1C)

meta-analysis (Bora & Pantelis, 2016), this study showed worse development in children with ADHD in the three aspects of ToM skills applied to everyday real-life situations: early level (social reference, understanding basic emotions), basic level (basic meta-representations or distinction between physical and mental), and advanced level (second-order inferences and making complex social judgments).

The second aim showed that yielded significant association values between different variables, generally in the expected direction. The ADHD symptoms were related to difficulties in relationships with peers and low social acceptance, coinciding with previous findings (Kim et al., 2015; Tseng et al., 2014). The BRI was also significantly associated with problems with peers, which supports the argument that response inhibition is the primary deficit in ADHD (Barkley, 2005). The BRI also correlated with theory of mind skills, pointing to the importance of behavioral regulation in the practical application of ToM skills in everyday situations in life. By contrast, the MI did not show any statistically significant correlation with the study variables. Nor were there significant associations between the different ToM indicators (early, basic, advanced, and total) and ADHD symptoms or problems with peers.

Finally, the results of the mediational analyses indicated that the BRI had both a direct and indirect influence on problems with peers. As expected, the direct effect of ADHD symptoms on difficulties in social relations with peers tended to disappear when taking into account the mediator role of the BRI, which acts, therefore, as a partial mediator in the relationship between ADHD symptoms and problems with peers. In other words, mediation was defined as a generative mechanism in which the effect of ADHD symptoms on problems with peers was partially transmitted by the BRI. These data could indicate the negative role played by inhibitory problems of children with ADHD (Mary et al., 2016). However, ToM skills and MI do not meet the conditions to be considered a possible mediator.

Although to the best of our knowledge the present research is the first study to explore the potential mediating effects of EF and ToM in the relationship between ADHD symptoms and social

problems, it has various limitations. The sample included a small number of participants, so that the results have to be considered preliminary, and replication studies are needed. Moreover, the majority were boys and had a combined presentation, which restricts the possible generalization to these cases. As well as the methodological limitations, since there is no contrast test and the results may be mediated by overestimation. Another limitation refers to the measure used to rate social conduct. In the present study, we used information from parents to measure social problems with peers by combining items from the SDQ. Although this ad hoc measure showed good psychometric properties, social behavior is a multidimensional construct, and so future analyses should incorporate different facets of it, such as leadership capacity, cooperation, or social skills (Huang-Pollock, Mikami, Pffner, & McBurnett, 2009). In addition, although our data provide evidence for a mediational model, the transversal design does not allow us to determine the directionality of a causal relationship between the variables. Longitudinal or experimental studies would help to verify the causal relationships glimpsed in this study. The lack of studies in this area calls for more research to gain a clearer understanding of the significance of EF components, especially in relation to the broader social impairment that is characteristic of ADHD.

In spite of their preliminary nature, the results of this study warn of the need for early implementation of programs in the family and school that emphasize teaching EF strategies in order to optimize social and personal development. The EF are essential for successfully dealing with relationships with peers. Specifically, the relevance of behavioral regulation components, including inhibition and emotional control, should be underlined when designing early intervention programs for the socioemotional development of children with ADHD.

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