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Cornoldi, C., Giofrè, D., Calgaro, G., & Stupiggia, C. (2013). Attentional WM is not necessarily specifically related with fluid intelligence: The case of smart children with ADHD symptoms. *Psychological Research*, *77*, 508–515. doi:10.1007/s00426-012-0446-8

Attentional WM is Not Necessarily specifically Related with Fluid Intelligence: The case of Smart Children with ADHD Symptoms

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Abstract

Executive functions and, in particular, Attentional (active) Working Memory (WM) have been associated with fluid intelligence. The association contrasts with the hypothesis that children with ADHD exhibit problems with WM tasks requiring controlled attention and may also have a good fluid intelligence. This paper examines whether children who are intelligent but present ADHD symptoms fail in attentional WM tasks. The latter result would be problematic for theories assuming the generality of a strict relationship between intelligence and WM. To study these issues, a battery of tests was administered to a group of 58 children who all displayed symptoms of ADHD. All children were between the age of 8 and 11 years, and were described by their teachers as smart. Children were compared to a control group matched for age, schooling, and gender. The battery included a test of fluid intelligence (Raven's Coloured Matrices), and a series of visuospatial WM tasks.

Results showed that children with ADHD were high in intelligence but significantly lower than the controls in WM tasks requiring high attentional control, whereas there was no difference in WM tasks requiring low attentional control. Furthermore, only high attentional control WM tasks were significantly related to Raven's performance in the control group, whereas all WM tasks were similarly related in the ADHD group. It is concluded that performance in high attentional control WM tasks may be related to fluid intelligence, but also to a specific control component that is independent of intelligence and is poor in children with ADHD.

Keywords: ADHD, working memory, intelligence

Attentional WM is Not Necessarily specifically Related with Fluid Intelligence: The case of Smart Children with ADHD Symptoms

The present study starts from two basic results largely supported in the literature. First, fluid intelligence and working memory are highly related (Kyllonen and Christal, 1990), and the relationship mainly concerns attentional working memory (Engle, Tuholski, Laughlin, & Conway, 1999). Second, children with ADHD typically fail in working memory tasks (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005) and it has been suggested that the failure could be more evident for working memory tasks that require a high attentional control (Cornoldi, Marzocchi, Belotti, Caroli, Meo, & Braga, 2002). Based on these results one could predict that children with ADHD are typically of a lower intelligence and a lower attentional working memory. However, this does not seem to be always the case as the literature has described children with ADHD symptoms, but high intelligence (Cordeiro, Farias, Cunha, Benko, Farias, Costa et al, 2011). These children may be less frequently found in the clinical services as they better manage with their problems, due to their intelligence, and have not been studied extensively by the literature, but are often described in school settings. The present study examines for the first time systematically the working memory of these children, testing a large group of children described by school teachers and a school psychologist as intelligent, but exhibiting ADHD symptoms. The following issues are considered: Do these children present attentional working memory problems? Do they nevertheless have a good performance in a fluid intelligence test? Which is, in their case, the relationship between fluid intelligence and working memory?

Relationships between fluid intelligence and Working Memory (WM).

Large evidence shows a strong relationship between WM, defined as the individual's capacity to temporarily maintain and process information (Baddeley, 2000) and fluid intelligence (Ackerman, Beier, & Boyle, 2005; Kyllonen & Christal, 1990). The assumption is that the capacity to maintain and process a large amount of information yields better performance on a variety of different intellectual tasks, as suggested by Carpenter, Just, and Shell (1990) in a study of the processes underlying the elaboration of Raven's Coloured Progressive Matrices (Raven, Court, & Raven, 1992). However, the observed relationship between WM and fluid intelligence varies in different studies and may be relatively weak (Ackerman et al., 2005). Different results in studies investigating the relationship between WM and intelligence could be partly due to the fact that different aspects of WM can be involved. In fact, different models of WM have been proposed, and many of them suggest that WM is not a unitary system, but that it can be differentiated. One proposal is that there is a difference between tasks that involve low attentional control (by only requiring maintenance of information in memory or a simple manipulation), and tasks that involve high attentional control (by placing additional demands on stored information), and only the latter are strictly related with intelligence. The distinction between high and low attentional control WM tasks has been associated with distinctions between simple and complex spans (Unsworth & Engle, 2005), between short-term ancillary subsystems and central working memory components involving executive processes (Baddeley, 2000; see also Kane et al., 2004), and between passive and active tasks (Cornoldi & Vecchi, 2003; Mammarella, Pazzaglia, & Cornoldi, 2008). The assumption that high attentional control WM is greatly related to intelligence is supported by the general observation that executive processes are related to intellectual functioning (Carpenter et al., 1990; Engle et al., 1999). This is also consistent with the assumption that WM is related to fluid intelligence, to the extent that attentional control is required; this latter idea has gained a large consensus (e.g., Engle et al., 1999; Engel de Abreu, Conway, & Gathercole, 2010; Unsworth & Engle, 2005).

WM impairments in children with ADHD.

ADHD syndrome is a heterogeneous disease including children with a variety of different symptoms. However, when groups, rather than single children with ADHD symptoms are considered, it may be seen that many of them (although not all) present dysfunctions in executive processes (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), attention and WM. In particular, research suggests that children with ADHD may have specific problems with the visuospatial components of WM (see Martinussen et al., 2005, for a meta-analysis). Empirical evidence is not perfectly consistent across studies, though some research suggests that children with ADHD may fail in attentional WM tasks, but not necessarily with tasks that do not require attentional control (i.e., passive tasks) (Cornoldi et al., 2001; Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2005). This result is particularly important in the case of children with ADHD. In fact, if active working memory and attentional control are strictly related to fluid intelligence, the logical consequence is that individuals with poor performance in tests of WM and attentional control should also have a low performance in fluid intelligence tasks. This prediction applies to individuals with intellectual disabilities (Lanfranchi, Cornoldi, & Vianello, 2004), but seems to present problems for cases of individuals with failures in attentional working memory tasks, like children with ADHD. Although the literature suggests that children with ADHD may have a lower IQ than children without ADHD (see Frazier, Demaree, & Youngstrom, 2004, for a meta-analysis), differences in IQ between children with ADHD and controls seem small and disproportionate to the differences observed in active WM. Furthermore there is evidence that ADHD disorder may occur in presence of high IQ (Antshel et al., 2007) and it is not clear whether children with ADHD with an average or above-average intelligence also have an active WM deficit, which would be in contradiction with a theory that assumes WM and intelligence are strictly related. If this is found, how can it be explained?

One possibility could be that the difficulties of children with ADHD concerns passive WM tasks, which are less related to intelligence (Lanfranchi et al., 2004), but do not concern attentional WM tasks; however, the exact opposite seems to happen, as children with ADHD have more difficulties with executive tasks (see Willcutt et al., 2005, for a meta-analysis) and it has been suggested (Cornoldi et al., 2002) that they present specific problems in attentional WM tasks. Another possibility is that, in the case of children with ADHD, not only fluid intelligence but also other factors are associated with WM performance. In particular, performance in working memory tasks could be affected by a general factor related to fluid intelligence and a specific factor (related to the specific attentional and control deficits of children with ADHD) that is independent of intelligence, but that affects the WM performance of a child with ADHD. In fact, active WM tasks typically require prolonged attention in order to maintain the to be processed information. For this reason we hypothesized that children with ADHD, who typically have problems in constantly maintaining attention (Willcutt et al., 2005), could meet specific problems in active WM tasks more than in untimed intelligence tasks, where temporary losses of attention are not critical, or in short term memory tasks where the response can be given immediately. For this reason, in the case of ADHD children, the relationship between active WM tasks and intelligence could be less evident than in the case of typically developing children.

The present study

The present study first intended to examine whether intelligent children with ADHD fail in WM tasks and whether they fail in high attentional (active) WM tasks to a greater extent than in low attentional (passive) WM tasks. Furthermore, the present study aimed to clarify whether in general a relationship between WM and intelligence is further supported, but it assumes a specific pattern in the case of children with ADHD. To study these issues, we looked for a large group of children exhibiting ADHD symptoms but who were also described as smart. We examined whether 1) these children actually presented good performance on an intelligence test; 2) despite this they had working memory difficulties, especially when high control was required; and 3) there was a relationship between WM tasks and intelligence but this was partly different for the ADHD and control groups. Assessment was conducted in line with the conditions imposed by the community in which the study was run: We were allowed to examine a large group of children, but were limited in the number of tests we could administer. Both children with ADHD and controls could be tested only in one fluid intelligence test (Raven's Coloured Progressive Matrices, 1992), as well as two passive and two active visuospatial working memory tasks (distinguished according to the taxonomy proposed by Cornoldi & Vecchi, 2003). Due to the similarity of materials and task requirements, we decided to use the Corsi backward and forward versions as our passive tasks. These tasks are considered by Cornoldi and Vecchi (2003) to be mainly passive, because they require an immediate response, do not involve high attentional control, do produce a pattern of performance similar to other passive tasks (Lanfranchi et al., 2004), and the backward version does not result in a reduced performance with respect to the forward version (Mammarella & Cornoldi, 2005). The active tasks were the pathway tasks from Mammarella, Toso, Pazzaglia and Cornoldi (2008; see Fig. 1), which require imagining a movement within a matrix with the updating of position (Pathway) or also a concurrent tapping (Pathway T; see Cornoldi & Vecchi, 2003; Lanfranchi et al., 2004). We decided to focus on visuospatial working memory tasks because they seem particularly critical in the examination of children with ADHD (see Martinussen, et al. 2005). The optimal way to evaluate fluid intelligence (Cattell, 1971) is to administer a broad range of tasks (see Engle, 2010). However, as for this study, we were allowed to administer only one test, we decided to use Coloured Progressive Matrices (also known as PM 47; Raven, et al., 1992), as the task offers a good measure of fluid intelligence (Deary, Penke, & Johnson, 2010) and has already been successfully used with children with ADHD (Kiris & Karakas, 2004).

Insert Figure 1 about here

Method

Participants

Fifty-eight children (42 male and 16 female) presenting ADHD symptoms (from now defined as ADHD) and fifty-eight controls (40 male and 18 female) were examined for this study. The children were between 8 and 11 years of age (mean ages, in months, were respectively 114.05 [SD = 9.68] and 114.93 [SD = 10.75]), and were selected from an original sample of 1,001 children (all of whom attended school in a small town in northeastern Italy) for having met a series of requirements. Children with ADHD had received a mean rating per item larger than 1.5 in one or both of the subscales (respectively concerning inattention and hyperactivity) of the SDAI (Italian acronym for Sindrome da Deficit Attentivo – Insegnanti [Attention Deficit Syndrome – Teachers]), a teacher rating scale assessing the DSM-IV ADHD symptoms on a 0-3 scale, validated for the Italian population, with a very high inter-judge and test-retest reliability (r > .8) and concurrent validity, obtained by correlating the scale with other scales (r > .95) (Marzocchi, Re, & Cornoldi, 2010). The cut-off of a mean item rating of 1.5 is recommended by the Scale Manual as indicative of symptoms of ADHD, and corresponds to the cut-offs adopted other countries for similar scales (Sandberg, 2002). The referral to the ADHD group had to be further supported by interviews concerning the specific presence of ADHD symptoms with the children's teachers and by the school psychologist who had extensive experience working with the children in the same school system. Children who had modest intellectual abilities or presented psychopathological problems were excluded: These aspects were examined with the COM (Comorbidity) teacher scale (Marzocchi et al., 2010), that has been devised for examining psychological and psychopathological problems of children with ADHD. The Scale requires that teachers rate on a 0-3 scale the presence of a series of symptoms that may be present in ADHD children having a comorbidity with other disorders. The Scale has good reliability and validity. In particular, the manual reports a mean inter-rater agreement of r = .96 and a Spearman rho correlation of .91 between the Conduct Disorder score and the similar score with another scale. More specifically, we excluded children who, according to the ratings given by their teachers in the COM scale, presented psychopathological problems (including conduct disorder, oppositional behaviour, autistic traits, anxiety or depression) above the cut-off indicated in the norms for the scale. For inclusion in the control group, we used the SDAI and COM scores and identified children of the same classes with similar characteristics, ages, and general abilities, but without any attention/hyperactivity problems. All children selected in this way and their families agreed to participate in this study.

Materials and Procedure

Fluid intelligence

Fluid intelligence was evaluated by Raven's Coloured Progressive Matrices (see Raven et al., 1992). The test items are abstract shapes in which a piece is missing. Six response options (1 target, and 5 distractors) are provided below each test item. The test consists of three sets (A, AB, B) of 12 items. Within each set, items are ordered in terms of increasing difficulty. The score is the overall number of correct responses. The test has very good psychometric properties with a test-retest reliability typically around .90 (Raven et al., 1992) and a Cronbach’s alpha of .91 (Belacchi, Scalisi, Cannoni, & Cornoldi, 2008).

Working memory

Working Memory was assessed with a battery of tasks that have been shown to have a good reliability, with Cronbach’s alpha ranging between .59 and .92, according to different studies (see Lanfranchi et al., 2004; Mammarella, Pazzaglia, & Cornoldi, 2008). The tasks task have been also included in an Italian battery (Mammarella, Toso, Pazzaglia, & Cornoldi, 2008) that reports a Cronbach alpha value of .85 for the Pathway task and test-retest reliabilities of .60 and .74 respectively for the forward and backward Corsi tasks. Participants were presented with trials of increasing levels of complexity until they were unable to solve at least two out of three items for each level. When participants were not able to solve two items of the same level the procedure stopped. In contrast, successful identification on two out of three items led to an increase in task difficulty.

Corsi tasks

The Corsi Blocks tasks were based on a display of nine blocks arranged irregularly on a board. On the experimenter's side of the board, the cubes were numbered to facilitate administration. The blocks were tapped by the examiner, at the rate of one block per second, in a sequence, varying in length from 2 to 9 positions, and participants had to reproduce the sequence. Following the classical scoring system, we defined the child's span as the longest sequence correctly reproduced two times.

In the Corsi forward version of the task, participants were required to reproduce the sequence presented by the experimenter in the same order (forward order). In the backward version of the task, participants had to reproduce the sequence presented by the experimenter in reverse.

Pathway tasks

In the Pathway Span tasks, participants were required to mentally visualize a pathway followed by a little man moving on a blank matrix. At the end of a series of statements regarding directions given by the experimenter (i.e., forward, backward, left, or right), participants had to indicate the man's final position in the same matrix. The complexity of the task varied according to the size of the matrices (from 2 x 2 to 6 x 6) and the length of the pathway described. The difficulty of the task ranged from a level of complexity of 2 to a maximum of 10. Each item was assigned a value equal to the level in which the item was included, so that items on the third level had a value of 3, on the fourth level a value of 4, and so on. Final scores were, as suggested by the Manual of the test (see Mammarella, Toso, et al., 2008), the sums of the three most complex items solved. Note that, if the subject failed in two out of three items of the subsequent complexity level, the third item of the previous complexity level was administered. For example, if the last three items correctly solved were the first two on the fourth level and one on the fifth level, then the child's score was 13 (obtained with the formula: 4 + 4 + 5). The final score could vary from 0 to 30.

The Pathway T version (adapted from Lanfranchi et al., 2004) was identical to the previous task but, in addition, required the subject to tap on the table when the experimenter asked to move to the right.

Participants were tested in individual sessions lasting approximately 35-40 minutes in a quiet room away from the classroom. The tasks were administered in the following fixed order: 1) Raven's Coloured Progressive Matrices (PM 47) task, 2) Corsi forward, 3) Corsi backward, 4) Pathway 5) Pathway T.

Results

Statistical analyses

Statistical analyses included group comparisons, concerning the scores both at the intelligence test and at the WM battery, correlational analyses, examining the pattern of relationships between intelligence and WM both in general and in the case of the two groups separately considered and a hierarchical regression analysis.

Group comparisons. We first analyzed the performance on the Raven's PM 47 task. All children performed well at the task, confirming that the children tested were of average or above average intelligence, as suggested by teachers' ratings. Mean scores were 29.66 and 30.60 (ADHD and control group respectively), which are higher than the mean scores reported in the Italian norms for the same age group. The slight difference between the two groups did not reach significance, $t\ (114) = 1.66$, $p = .10$.

The subsequent analysis examined whether, as predicted, the two groups were different in the active WM tasks, but not in the passive ones. Table 1 presents the mean scores obtained by the two groups in the Corsi and Pathways tasks. The Pearson correlations between the two versions of each task were moderate but significant (.37 for the Corsi tasks and .50 for the Pathway tasks). Given these significant correlations, and in order to provide a simpler overall picture of the pattern of correlations, we also computed summed scores for the two Corsi tasks (forward + backward), and also for the two Pathway tasks (Pathway + Pathway T).

We performed two different ANCOVAs, controlling for Raven, respectively in the Corsi and int the Pathway tasks. We found that the groups were significant for the Pathway tasks, F (1, 113) = 15.65, p <.001, $\eta_p{}^2$ = .12 (the mean scores were respectively 15.76 [SD = 4.23] and 18.91 [SD = 4.96] for the ADHD and the control group). On the contrary, in the case of Corsi tasks the difference was far from significance F (1,113) = 2.29, p = .133, $\eta_p{}^2$ = .02 (the mean scores were respectively 8.93 [SD = 1.07] and 9.34 [SD = 1.21] for the ADHD and the control group). Moreover, Table 1 presents the mean scores and the Student-t comparisons of the two groups for the single tasks, showing that groups were significantly different in both Pathway task versions.

Insert Table 1 about here

Correlational analyses. We then considered the correlations between WM and scores on the Raven's PM 47 test, both for the whole group of children and the two groups separately. There were significant correlations between the PM 47 and summed scores at the Corsi tasks, $r(114) = .31$, $p < .01$, and between the PM 47 and summed scores at the Pathway tasks, $r(114) = .38$, $p < .01$.

Hierarchical regression. We also performed a hierarchical regression analysis having as dependent variable the scores on the Raven test and entering as predictors in the first step the group, as a dummy variable, Pathway and Corsi summed scores in the second step, and the interactions in the third step (group x Pathway summed scores, and group x Corsi summed scores). The beta coefficient for the group, entered in the first step, was not significant (β = -.154, t = -1.66, p = .099) and did not significantly predict the Raven score (R^2 = .024, $F(1,114)$ = 2.76, p = .099). We found that only the Pathway score, in the second step, offered a significant contribution (β = .300, t = 2.50, p = .004), and that the effects related with the Corsi test only approached significance (β = .178, t = 1.87, p = .064). The improvement in prediction, in this second step, was significant (R^2 change = .145, $F(2,112)$ = 9.74, p < .001). No significant effects were found with the interaction terms (group x Pathway [β = -.397, *t* = -.94, *p* = .351]; and group x Corsi [β = 1.183, *t* = 1.57, *p* = .120]) and not significant improvement in prediction in this third step (R^2 change = .019, *F*(2,110) = 1.281).

Patterns of correlations in the two groups. Despite the fact that interactions between groups and tasks only revealed not significant tendencies, the analysis of the correlations separately calculated for the two groups (see Table 3) shows that the pattern of the correlations is not exactly the same in the two groups. Correlations between fluid intelligence and WM are significant for both types of tasks for children with ADHD (*r*s = .41 and .31 for the passive and the active tasks, respectively), whereas for the control group only the correlation with the active tasks is significant, *r*(56) = .39, p < .01. It is interesting to note that the relationship between the forward Corsi (the most passive task) and the PM 47 tasks is different in the two groups, despite the fact that both groups performed similarly on the forward Corsi and PM 47 tasks (see Table 1). The different pattern in the two groups was even more evident when we calculated the semi-partial correlations between the PM 47 and the Corsi and Pathway summed scores respectively, controlling for each other. In particular, the correlations with PM 47 were as follows: ADHD group, summed Corsi score (controlling for Pathway; *sr* = .30, *p* < .05) and Pathway (controlling for summed Corsi; *sr* = .15, *n.s.*); Control group, Corsi (controlling for Pathway *sr* = .05, *n.s.*) and Pathway (controlling for Corsi; *sr* = .34, *p* < .01). In other words, the difference between the semi-partial correlations in the two groups was significant: In particular it was of. .15 in favour of the Corsi, in the case of the ADHD group, and was .29 in favour of the Pathway in the case of the controls.

Insert Tables 2 and 3 about here

Discussion

The present study examined the patterns of performance in intelligence and WM tasks in a group of children with ADHD compared with a matched control group of typically developing children. The results confirmed the main predictions of the study. First, children selected by their teachers as intelligent but having symptoms of ADHD scored above the normative average on a measure of intelligence. This result is consistent with the observation (Cordeiro et al., 2011) that many children with ADHD may have a high intelligence. Second, children with ADHD symptoms, although similar in intelligence to the controls according to both the teacher interviews and the Raven's PM 47 scores, had poorer performance on the active working memory tasks but not on the passive working memory. This result is consistent with the conclusions of Cornoldi et al. (2002) and, more generally, with the hypothesis (Willcutt et al., 2005) that ADHD is related to a dysfunction in executive processing. In fact, executive processing is involved in active, but not in passive, working memory (Baddeley & Della Sala, 1996).

Third, working memory performance was, in general, related to the performance in a fluid intelligence task (the PM 47), and the relationship interested active WM to a greater extent than passive WM, consistent with previous evidence (e.g. Engle et al., 1999). This pattern was made particularly evident by the hierarchical regression analysis, which showed that there was only a significant contribution of attentional working memory to intelligence. However, the relationship between WM and intelligence was significant, but lower than the correlation reported in other studies (Ackerman et al., 2005; Kyllonen & Christal, 1990). This result could also be affected by the fact that only intelligent children were included in the present study, and this reduced variability would predictably reduce the magnitude of any correlation, but suggests that the size of the relationship between WM and fluid intelligence should not be overestimated.

Despite the fact that the groups were relatively large in size, for the goals of correlational analyses, numbers of subjects were not sufficient to show statistically significant differences. However it is interesting to notice that the pattern was not the same in the two groups. In particular a specific correlation in the ADHD group between intelligence and active WM were was not evident. This result could be interpreted with reference to hypothesis that, in the case of children with ADHD, the performance on active WM tasks is affected not only by fluid intelligence, but also by a specific control component (on which they are weak), and which is not influential in typically developing children. The simultaneous presence of both aspects in ADHD should reduce the specificity of the relationship between active working memory and fluid intelligence. However, it should be noted that the results on this respect were not particularly clear and, in particular, the interaction between groups and WM did not reach significance. In fact this study has a series of limitations probably also as a consequence of the specific characteristics and reduced sizes and scores variations in our samples that should be considered in future research. First, the values of the correlations we observed in the study were significant, but modest, and had a limited range of variation. In fact, the sample size, although larger relative to many previous studies in the area, may not have been large and severe enough to detect subtle effects, which may have reduced the statistical power of the correlational analyses. In fact, many children of the ADHD, also thanks to their good intelligence, did not present severe problems and had not received a diagnosis of ADHD. Second, we were allowed to use only one intelligence test, and it is possible that a partially different pattern could emerge with other intelligence tasks (Nyman, Taskinen, Gronroos, Haataja, Kahdetie, & Korhonen, 2010). Third, different assessing and scoring procedures adopted for WM tasks may have different outcomes (Unsworth & Engle, 2007). In particular, despite the high reliability of the procedures we adopted, the low range of scores may have reduced the discriminative power of the Corsi tasks and impacted on the pattern of correlations (although not on the differences between the two groups). Finally, the present observations concerned intelligent children with ADHD, considering them as a group without taking into consideration the fact that not all children with ADHD present the same pattern of performance, and cannot be automatically generalized to all children with ADHD. In particular, it is possible that the actual values of the correlations were affected by specific characteristics in the two groups. All these issues should be considered in future research.

In conclusion, the present results offer further support for observations that children with ADHD have poor attentional working memory and that attentional working memory is related to fluid intelligence. Furthermore, the results show that ADHD may have a difficulty in attentional WM that is not present in typically developing children having the same level of intelligence. Further research will have to explain why this happens. Our results suggest that children with ADHD’s difficulty in active working memory tasks may be related to a specific request to maintain attention which is not present in many intelligence tests, but is typically present in active WM tasks, where a temporary loss of attention impairs the elaboration of the to be maintained information. Future research should help to understand which underlying factor is most critical in this weakness of children with ADHD, focusing in particular on variables that could affect the performance of children with ADHD in attentional WM tasks more than in an untimed intelligence task, like Raven as for example mind-wandering (Mrazek, Smallwood, Franklin, Chin, Baird, Schooler, in press) or increased intraindividual variability in tasks where the performance is impaired by temporary fluctuations in attention (Borella, Chicherio, Re, Sensini, & Cornoldi, 2011).

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Figure 1. Sample of the Pathway task (Mammarella, Toso et al., 2008). The line represents the pathway the child has to imagine following a verbal description.

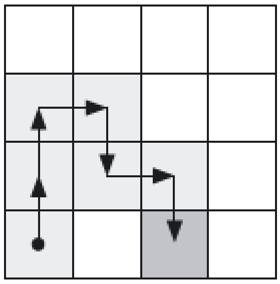

Table 1

Scores obtained by the ADHD and control groups for the PM 47 and WM task, Students' t comparisons between groups, and confidence intervals,

	Group	*M*	*SD*	*t*	*df*	MD	LL	UL	d
PM 47	ADHD	29.66	3.00	-1.66	114	-0.95	-2.08	0.18	-0.31
	Control	30.60	3.14						
Corsi-forward	ADHD	4.52	0.54	-1.36	114	-0.16	-0.38	0.07	-0.25
	Control	4.67	0.69						
Corsi-backward	ADHD	4.41	0.80	-1.82	114	-0.26	-0.54	0.02	-0.34
	Control	4.67	0.73						
Pathways	ADHD	17.33	3.97	-3.96*	107.14	-3.38	-5.07	-1.69	-0.74
	Control	20.71	5.14						
PathwaysT	ADHD	15.76	4.23	-3.68*	114	-3.16	-4.85	-1.46	-0.68
	Control	18.91	4.96						

Note. MD= Mean Difference; LL = Lower Limit, UL = Upper Limit of 95% Confidence Interval of the Difference, d= Cohen's d.

* $p < .01$.

Table 2

Correlations between the tasks and descriptive statistics in the overall group of children.

	PM 47	Corsi-forward	Corsi-backward	Pathways	PathwaysT
PM 47	1				
Corsi-forward	0.17	1			
Corsi-backward	0.32**	0.37**	1		
Pathways	0.30**	0.23*	0.32**	1	
PathwaysT	0.35**	0.24**	0.41**	0.50**	1
M	30.13	4.59	4.54	19.02	17.34
SD	3.09	0.62	0.77	4.88	4.89
Skewness	-0.61	0.53	-0.03	0.68	0.57
Kurtosis	-0.34	-0.60	-0.34	-0.34	0.05

Note. * $p < .05$, ** $p < .01$.

Table 3

Correlations between the tasks in the control group (above the diagonal) and in the ADHD group (below the diagonal).

	PM 47	Corsi-forward	Corsi-backward	Pathways	PathwaysT
PM 47	1	.06	.25	.32*	.32*
Corsi-forward	0.29*	1	.45**	.27*	.29*
Corsi-backward	0.36**	0.27*	1	.18	.28*
Pathways	0.20	0.08	0.40**	1	.36**
PathwaysT	0.33*	0.11	0.49**	0.55**	1

Note. * p < .05, ** *p* < .01.