Numerous studies indicate deficient time estimation in individuals with attention-deficit/hyperactivity disorder (ADHD). Several hypotheses have been raised to explain this deficit including delay aversion, vulnerability to nontemporal distractions, deficient working memory, as well as pure deficit in temporal processing. To test the different hypotheses, adults with or without ADHD performed a prospective time-estimation task under different conditions: with or without nontemporal distraction; and with or without increased load of working memory. Such design was used to rule out the effect of motor control and to manipulate the hypothesized mechanisms of working memory and attention to nontemporal stimuli. The authors report that compared with the control group, adults with ADHD showed greater and more variable deviation in time estimation. In addition, the magnitude of time estimation was affected by allocation of attention to nontemporal stimuli and by load of working memory. The intraindividual variability of time estimation was only partially accounted for by load of working memory. These findings suggest that the ADHD-associated deficit in prospective time estimation is not attributable to special attention to nontemporal stimuli or compromised working memory.

**Keywords:** attention-deficit/hyperactivity disorder, time estimation, working memory, attention to nontemporal stimuli
pends on allocation of attention to temporal, rather than nontemporal stimuli. The limited attention span of people with ADHD causes them to focus more on nontemporal information in the environment and invest fewer resources on temporal stimuli. As a result, the time estimation of ADHD populations is less accurate in comparison to controls (Barkley, Koplowitz, Anderson, & McMurray, 1997). In a study of children with and without ADHD, a time-reproduction task was used in two conditions, with and without nontemporal distractions. Children with ADHD produced greater errors in reproduction than controls. The performance of the experimental group was especially poor when distractions were introduced to the task, whereas the control group’s performance was not impacted by this addition (Barkley et al., 1997).

An alternative explanation of the difficulty in time-reproduction tasks is that children with ADHD cut short the task to avoid the temporal time frames that they dislike. This “delay aversion” that characterizes ADHD is expressed in underestimations that the children produce in the reproduction task (Sonuga-Barke, 2002). In addition, to avoid delay aversion, children with ADHD may also focus on nontemporal stimuli and alter the subjective perception of time. Based on the previously mentioned Zakay’s proposal (Zakay, 1992), the tendency to focus on nontemporal stimuli should result in shorter time estimation.

All the previously mentioned explanations share the common assumption that pure temporal processing is intact in ADHD and that the deficiencies in time estimation result from a deficit in other processes that are associated with the task. However, evidence of pure temporal information-processing deficits in ADHD does exist in the literature concerning temporal tasks like time discrimination, in which neither working memory nor delay-aversion seem to have an affect. For example, both Smith and colleagues (2002) and Toplak and colleagues (2003) found that children with ADHD display a significantly higher temporal threshold when discriminating between two temporal durations ranging around 400 ms. In contrast, children with ADHD did not differ from controls in their ability to discriminate between tone frequencies (Toplak et al., 2003). The general aim of our study was to test the different hypotheses regarding the mechanism of deficient time estimation in ADHD. To do so, we directly manipulated specific components stressed by different hypotheses.

Using time-reproduction tasks is probably not the best way to examine the different hypotheses regarding the deficient time estimation in ADHD, because this task confounds time estimation with other possible deficits of ADHD (Smith et al., 2002). For example, the reproduction task involves motor elements, which may constitute an interfering variable in measuring performance on this task. Empiric evidence indicates that time perception and motor control are both deficient in ADHD, and the relation between the two measures is unclear (Rubia, Taylor, Taylor, & Sergeant, 1999; Toplak et al., 2003). Furthermore, because shorter reproductions are associated with earlier completion of the test session, delay aversion may bias the performance in this task even if pure time estimation is intact.

To look for possible mechanisms of deficient time estimation, reducing complexity should be attempted. Therefore, we chose to avoid the impact of compromised motor control by using time estimation tasks in which the demand for motor control is minimal. Furthermore, in verbal estimation tasks an inaccurate performance does not shorten the duration of the experiment. Verbal estimation tasks typically involve demonstrating or modeling to the participant a particular duration and asking the participant to verbally estimate the length of the demonstrated duration. In spite of the fact that significant group differences have obtained more frequently on duration reproduction tasks (Toplak et al., 2006), for the purpose of focusing on mechanism we chose simpler task involving fewer processes, namely, time estimation task. In addition, preliminary data from our laboratory suggested that adults with ADHD tend to make greater errors, compared with control, on our task (described in the Method section).

Assuming that ADHD is associated with compromised time estimation, attention to nontemporal stimuli, and working memory, the current study aims to provide direct analysis of the impact of working memory and attention to nontemporal stimuli on suprasecond time evaluation in subjects with ADHD. The study was designed to test whether these variables are at the foundation of the deficient time estimation in ADHD populations or whether other elements of the task are at the core of this difficulty.

The first aim of the study was to manipulate the working memory component of a time-estimation task. Our hypothesis was that if working memory has a critical role in time estimation, increasing working memory load will result in compromised time estimation. Moreover, if deficient time estimation in ADHD is attributable to compromised working memory, controlling for working memory capacity should reduce the differences between groups. It is also plausible that differences between groups will be even greater when working memory is particularly exercised.

The second aim was to manipulate attention to nontemporal stimuli during time-estimation tasks. Our hypothesis here was that if attention to nontemporal stimuli has a critical role in time estimation, increasing attention to nontemporal stimuli will result in compromised time estimation. It is also plausible that if differences in attention to nontemporal stimuli undermine time estimation in ADHD, differences between groups will be greater when more distracters are present and more attention to nontemporal stimuli is enforced.

Given the data on intrasubject variability in ADHD and the importance that has been placed on requiring such data (Castellanos et al., 2005; Castellanos & Tannock, 2002), we also tested whether this is greater for ADHD than controls for this task and whether it is affected by working memory load and nontemporal distractors.

In line with the common paradigm in previous studies the aforementioned assumptions have been examined in different suprasecond time periods. It has been assumed that both groups will make greater deviation in time estimation as the time frame is lengthened.

**Method**

**Participants**

For multivariate analysis of variance (MANOVA) power calculation we used the G’Power3 software (Faul, Erdfelder, Lang, & Buchner, 2007). Designed for four comparisons with a Bonferroni correction for Type I error, a power analysis revealed that with a sample size of 60 subjects the study will have a power of 80% to detect a size effect of \( F = 0.3 \) (Pillai’s \( V = 0.286 \) with an alpha of 1.25% (see Faul et al., 2007, for detailed description). The experimental group consisted of 30 university students with...
ADHD. The group was composed of 17 men and 13 women, aged between 20 and 30 years. The participants for the study were recruited through the Learning Disability Center of the Hebrew University of Jerusalem. A flyer soliciting participation in the experiment was distributed to the students through the center by email, and those who seemed suitable candidates were asked to approach the experimenter. Inclusion criteria were the following:

1. A diagnosis of the disorder made by a neurologist, psychiatrist, or psychologist during the last 3 years;
2. Meeting the Brown ADD Scale (BADDS; see below) cut-off point for probable diagnosis of the disorder (a score of 45 and above; Brown, 1996);
3. Endorsing the Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition (DSM–IV) criteria for childhood ADHD in a yes/no structured interview.

Exclusion criteria included a self-report of a diagnosis of a psychotic or neurological disorder, as well as uncorrected vision impairment.

Of 39 potential participants, seven did not meet the inclusion criteria and two were excluded from the study because of history of neurological condition (i.e., traumatic brain injury and hydrocephalus). None of the participants had taken psychostimulants or other anti-ADHD drugs on the day of the experiment.

The control group was composed of adults without ADHD. The group included 30 students of whom 17 were men and 13 were women with an age range from 21 to 31 years. Control subjects were recruited by an announcement at the Hebrew University of Jerusalem. Inclusion criteria were a lack of history of diagnosis of ADHD and not meeting the cut-off point in the BADDS and DSM–IV-based interview. The exclusion criteria were the same as in the experimental group. Of 50 potential participants, 19 students did not meet the inclusion criteria and one was excluded because of a history of traumatic brain injury.

Table 1 summarized the demographic and clinical characteristics of the two diagnostic groups.

Measures

BADDS. This questionnaire was developed as a diagnostic tool for adult ADHD (Brown, 1996). The questionnaire is composed of 40 items that describe present circumstances. The participant is asked to rate these items on a scale of 1 to 4 according to the extent they characterize him/herself. A score of 45 to 59 indicates “probable ADHD,” whereas >60 score indicates “highly probable ADHD.”

Table 1
Demographic and Clinical Characteristics of the Attention-Deficit/Hyperactivity Disorder (ADHD) and Control Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>Male/female ratio</th>
<th>Brown ADD scale score</th>
<th>Working memory task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>25.0 ± 3.5</td>
<td>17/13</td>
<td>24.1 ± 10.1</td>
<td>6.3 ± (1.1)</td>
</tr>
<tr>
<td>ADHD</td>
<td>25.1 ± 2.4</td>
<td>17/13</td>
<td>67.9 ± 20.4</td>
<td>5.1 ± (1.1)</td>
</tr>
<tr>
<td>Statistic</td>
<td>t(58) = −1.13</td>
<td>χ²(1) = 0</td>
<td>t(589) = −10.55</td>
<td>t(58) = 4.25*</td>
</tr>
</tbody>
</table>

Note. ADD = attention deficit disorder. * p < 0.05.
experiment began when the participant successfully completed the practice task. No feedback was given during the rest of the experiment. The participant controlled the pace of the experiment because of the need to use the mouse after each trial to continue to the next trial.

Experimental Design

Subjects from both groups participated in each of the experimental conditions. Each participant was tested in two time intervals (4–6 s and 10–14 s), with and without nontemporal distractors (empty/full task), and with and without working memory load resulting in eight experimental conditions as shown in Table 1. Tasks appeared in random order.

In the 4- to 6-s interval the participant was assigned to six trials in each condition (4 × 6) and in the 10- to 14-s interval the participant was assigned to eight trials in each condition (4 × 8) for a total of 56 trials. The difference in the number of trials stems from the wish to shorten the general duration of the task as much as possible in order to encourage cooperation. We preferred to gain more power on the 10- to 14-s interval, the period in which we expected greater effects, with the cost of losing power on the 4- to 6-s interval.

Statistical Analysis

Errors in time estimation have both size and direction. Therefore, in line with a common paradigm (e.g., Meaux & Chelonis, 2003), two dependent variables were defined to measure time estimation. The relative discrepancy score specifies the direction of the error (verbal estimation/actual interval), where 1.00 equals a perfect score, those higher than 1.00 indicate overestimation, and those lower than 1.00 indicate underestimation. Absolute discrepancy scores (the absolute value of the equation: verbal estimate minus actual interval) reflect overall magnitude of errors regardless of the direction of error. This score prevents balancing errors of opposing direction. In addition, intraindividual variability was calculated for absolute discrepancy score.

The variables were analyzed using analysis of variance (ANOVA) with repeated measures, with group (ADHD vs. Control) as a between-subjects variable and the time interval (4–6/10–14 second), type of stimulus (empty/full), and working memory load (with/without) as within-subjects, repeated measures variables. Separate analyses were performed for the two dependent measures (relative discrepancy and absolute discrepancy). A t test was used to analyze differences between groups on the working memory task.

Results

Tables 2 and 3 show the mean (+SD) and effect sizes of the relative and absolute discrepancies in time estimation of both groups.

Effect of ADHD

ADHD was associated with shorter time estimation. However, this tendency did not reach statistical significance, F(1, 58) = 1.60, p = .21. In contrast, statistical analysis for absolute discrepancies revealed a significant larger discrepancies for ADHD group, F(1, 58) = 4.31, p < .05, as well as greater intraindividual variability, F(1, 58) = 10.36, p < .05.

ADHD was associated with lower scores on the working memory task, r(58) = 4.25, p < .001. Controlling for the performance on the working memory test did not eliminate the effect of ADHD on mean time estimation, F(1, 57) = 3.69, p = .06, and 4.07, p < .05, for the relative and absolute discrepancies, respectively. Controlling for the performance on the working memory test decreased, but not eliminated the effect of ADHD on intraindividual variability, F(1, 57) = 5.14, p < .05.

Effect of Length of Time Interval

Both relative and absolute discrepancies were significantly smaller in the 4–6 second interval, reflected by a main interval effect, F(1, 58) = 12.00 and 754.14, p < .005, for the relative and absolute discrepancies, respectively. Similarly, intraindividual variability was significantly smaller in the 4–6 to 6-s interval, reflected by a main interval effect, F(1, 58) = 222.39, p < .001. No significant interaction was found between groups and the length of interval.

Effect of Working Memory Load

Relative and absolute discrepancies were not significantly affected by the load on working memory, F(1, 58) = 0.02 and 0.83,
Table 2
Mean (±SD) Relative Discrepancies of Time Estimation in Attention-Deficit/Hyperactivity Disorder (ADHD) and Control Groups

<table>
<thead>
<tr>
<th>Duration</th>
<th>Stimulus (full/empty)</th>
<th>Working memory (with/without)</th>
<th>Group (ADHD/control)</th>
<th>Relative discrepancy ratio</th>
<th>Effect size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4–6 s</td>
<td>Empty</td>
<td>Without</td>
<td>ADHD</td>
<td>0.81 ± 0.21</td>
<td>−0.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>0.86 ± 0.19</td>
<td>−0.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With</td>
<td>ADHD</td>
<td>0.87 ± 0.25</td>
<td>−0.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>0.93 ± 0.22</td>
<td>−0.19</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>Without</td>
<td>ADHD</td>
<td>0.88 ± 0.18</td>
<td>−0.20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>0.92 ± 0.20</td>
<td>−0.28</td>
</tr>
<tr>
<td>10–14 s</td>
<td>Empty</td>
<td>Without</td>
<td>ADHD</td>
<td>0.79 ± 0.21</td>
<td>−0.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>0.86 ± 0.18</td>
<td>−0.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With</td>
<td>ADHD</td>
<td>0.80 ± 0.19</td>
<td>−0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>0.84 ± 0.17</td>
<td>−0.23</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>Without</td>
<td>ADHD</td>
<td>0.80 ± 0.21</td>
<td>−0.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>0.87 ± 0.19</td>
<td>−0.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With</td>
<td>ADHD</td>
<td>0.79 ± 0.23</td>
<td>−0.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>0.86 ± 0.21</td>
<td>−0.33</td>
</tr>
</tbody>
</table>

Effect of Type of Stimulus

Relative and absolute discrepancies were not significantly affected by the type of stimulus, $F(1, 58) = 1.309$ and $0.01, p > .05$, for relative and absolute discrepancy, respectively. However, intranidividual variability was greater on the full rime condition, $F(1, 58) = 14.13, p < .05$. In addition, no significant interaction between type of stimulus and group was found, $F(1, 57) = 0.02, 0.38$ and $0.78, p > .05$, for relative and absolute discrepancy and for intranidividual variability, respectively.

Discussion

The purpose of this study was to reexamine the effect of ADHD on suprasecond time estimation and to further test different hy-

Table 3
Mean (SD) Absolute Discrepancy of Time Estimation in Attention-Deficit/Hyperactivity Disorder (ADHD) and Control Groups

<table>
<thead>
<tr>
<th>Duration</th>
<th>Stimulus (full/empty)</th>
<th>Working memory (with/without)</th>
<th>Group (ADHD/control)</th>
<th>Absolute discrepancy (s)</th>
<th>Effect size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4–6 s</td>
<td>Empty</td>
<td>Without</td>
<td>ADHD</td>
<td>3.34 ± 0.65</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>1.01 ± 0.57</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With</td>
<td>ADHD</td>
<td>1.24 ± 0.76</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>1.03 ± 0.57</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>Without</td>
<td>ADHD</td>
<td>1.13 ± 0.39</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>1.13 ± 0.39</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With</td>
<td>ADHD</td>
<td>1.24 ± 0.63</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>1.06 ± 0.47</td>
<td>0.28</td>
</tr>
<tr>
<td>10–14 s</td>
<td>Empty</td>
<td>Without</td>
<td>ADHD</td>
<td>2.58 ± 1.24</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>2.58 ± 1.24</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With</td>
<td>ADHD</td>
<td>3.43 ± 1.58</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>2.68 ± 1.10</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>Full</td>
<td>Without</td>
<td>ADHD</td>
<td>3.38 ± 1.53</td>
<td>0.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>2.71 ± 1.41</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>With</td>
<td>ADHD</td>
<td>3.63 ± 1.84</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Control</td>
<td>2.86 ± 1.40</td>
<td>0.50</td>
</tr>
</tbody>
</table>
hypotheses that have been proposed to explain this effect. In our sample, adults with ADHD produced greater and more variable errors in time estimations in comparison to the matched control group. This group effect is consistent with the ADHD literature, showing that both children and adults with the disorder tend to be less accurate than controls on task involving time evaluation. In particular, our study replicated findings of group differences on verbal estimation tasks (Toplak et al., 2006).

Several mechanisms have been proposed to explain the effect of ADHD on time estimation. These explanations can be divided into two classes: those that suggested a pure deficit in temporal processing and those that favored a deficit in other cognitive processes that indirectly affect time estimation. The current study aimed to test these hypotheses by systematically manipulating working memory load and attention to nontemporal stimuli.

A main hypothesis of the study was that in conditions with higher demand on working memory, the experimental group would produce greater errors in estimation, as opposed to conditions with no load on working memory. ADHD was associated in our study with a poorer performance in the working memory test. However, increasing the load of working memory did not result in significantly greater errors in time estimation in either group. However, this could be due to the trade-off feature of the high working memory condition. As subjects could potentially decide to exert more effort in the time-estimation task and not in the working memory task, the potential effect of an increase in working memory on time estimation might be obscured. Indeed, controlling for the performance in the working memory test revealed that increasing the load of working memory impaired time estimation. Despite these findings, the effect of ADHD on mean time estimation was not eliminated after controlling for working memory deficits. The effect of ADHD on intraindividual variability of time estimation was reduced, but not eliminated, after controlling for the performance on the working memory task, suggesting that working memory only partially mediates ADHD-related deficits in time estimation. In addition, time estimation of both ADHD and control subjects were similarly affected by increasing the load of working memory, suggesting that deficient time estimation in ADHD is not modulated by poorer working memory. This finding is challenging to the accepted hypothesis that deficient time estimation in ADHD is due to working memory deficit (Barkley, Kopelowitz, et al., 1997; Barkley, Edwards, et al., 2001; Barkley, Murphy, et al., 2001; Meaux & Chelonis, 2003; Paule et al., 2000; Smith et al., 2002).

A second hypothesis of the study was that the experimental group would produce greater errors in estimation when nontemporal distractors are presented, as opposed to empty stimuli. The findings showed that the presence of a nontemporal stimulus did not impact time evaluations in both groups. A main characteristic of people suffering from ADHD is a greater tendency toward distraction than people who do not suffer from the disorder (American Psychiatric Association, 1994). On this basis, Barkley and colleagues (1997) examined time estimation of children with ADHD as compared with controls using a time-reproduction task with an empty stimulus as compared with conditions of distraction. In contrast to the findings of the current study, Barkley found that the conditions with distraction affected the experimental group but did not affect the control group. Children with ADHD produced greater errors in the presence of distractions as compared with children without the disorder. One possible explanation for these findings is related to the fact that the present study examined adults with ADHD as opposed to Barkley who included children on his study.

In addition, the results of the current study do not fit with the claims of Sonuga-Barke, Saxton, and Hall (1998), who contended that the shorter time evaluation in ADHD populations is a result of “delay aversion.” According to this theory, people with ADHD discontinue their time evaluation earlier than expected as a result of aversion from the temporal stimulus. This theory can explain the underestimation of ADHD participants in the reproduction task, as this task allows participants to “shorten” the time interval by pressing the button in order to complete the time estimation. However, in the task used in the present study, the ability of the participants to actively shorten the time frame was neutralized. This was achieved by writing the amount of time that the stimulus was presented in each time frame on the computer screen. Even though, the differences between the groups were significant and the experimental group showed a greater tendency toward underestimation.

The assumption that difficulty in time evaluation in adults with ADHD is based on deficient working memory and/or attention mechanism, as well as on delay aversion, was not supported in the present study. A better explanation to the deficit in time evaluation might be that people with ADHD have a basic deficiency in time perception, which is beyond their behavioral-inhibition deficit, a tendency to be distracted by nontemporal stimuli or working memory deficit. This assumption for separate temporal information processing is consistent with Smith and colleagues (2002) and Toplak and colleagues (2003) who found differences between ADHD and control groups on time discrimination tasks, and by various studies that did not find correlations between measures of executive functions and time-evaluation tasks (Kerns, McInerney, & Wilde, 2001; Smith et al., 2002; Toplak et al., 2003). In addition, methylphenidate, which has been proven to affect cognitive functioning of ADHD populations, including improvement in working memory and other cognitive tasks related to executive functions (Pietrzak, Mollica, Maruff, & Snyder, 2006) had either no (Barkley et al., 1997) or minimal (Frazier, Demaree, & Youngstrom, 2004) effect on the accuracy of time evaluation in ADHD participants. This lack of effect calls into question the causal role of working memory in the ADHD-associated deficit time estimation.

This study contains certain limitations. First, the current study examines prospective time evaluation by verbal task and not by reproduction task, upon which most conclusions regarding ADHD and time evaluations are based. Therefore, the possibility that the time-reproduction task does rely on working memory cannot be ruled out. In any case, we conclude that time estimation is related to a separate cognitive difficulty in people suffering from ADHD. Second, the question of comorbidity was not addressed. The existence of comorbid disorders is very common in ADHD, and therefore it is important to ascertain whether deficient time evaluation is related to these disorders or is unique to ADHD. Future studies should examine if learning disabilities, as well as externalizing and internalizing disorders, affect the differences between ADHD and controls in time evaluations. Previous studies suggest that the most significant contributor to differences in time evaluation is learning disabilities (Farmer & Klein, 1995; Nicolson, Fawcett, & Dean, 2001). For example, Toplak and colleagues (2003) demonstrated
greater deficiency in time evaluation in children and adolescents with comorbid-ADHD and reading disorder compared with ADHD only and control groups. In our study, subjects have undergone neither comprehensive psychiatric interview nor neuropsychological examination, and therefore we could not establish comorbidities. Third, IQ was not measured despite its possible relevance to time estimation. Specifically, Smith et al. (2002) reported that a significant part of the inaccurate time reproduction of children with ADHD could be explained by lower IQ. Fourth, only accuracy of time estimation was measured. It might be the case that using other aspects of time estimation, such as reaction time or variability of reaction time, would have resulted in different findings. Fifth, because this study examined mediators of ADHD-related deficits in time estimation, multiple comparisons were needed. Power calculation indicated that the sample size that was used was able to detect medium-to-large effect size. Additional studies are necessary to rule out the possibility that with more power, smaller but significant mediators would be revealed.

We conclude that suprasecond time evaluation is a complex cognitive function which is deficient in adults suffering from ADHD. This deficit seem to be only partially accounted for by the difficulties adults with ADHD have in working memory, and not to be accounted for by greater attention to nontemporal stimuli. Understanding the mechanisms of deficient time evaluation in adults with ADHD is important considering that time evaluation is a central tool for everyday life and the great difficulties that these people experience in everyday time management.

References


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