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Does the Continuous Performance Test predict ADHD symptoms severity and ADHD presentation in adults?

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Abstract

Objective. Our study aimed to provide empirical evidence on the usefulness of one of the most popular neuropsychological tests, the continuous performance test (CPT), as a marker of attention deficit-hyperactivity disorder (ADHD) severity and presentations among adults.

Method. ADHD participants were recruited in a specialized center for the diagnosis and treatment of adults suffering from ADHD (n=201). Measures included the CPT3™ and ADHD symptoms using a clinical interview and self-reported measures.

Results. Only 51.7% were classified as likely to have a disorder characterized by attention deficit, such as ADHD, by the CPT. The relationships between CPT variables and ADHD symptoms were small. The classification error was 80.3% for the inattentive presentation and 22.5% for the hyperactive presentation when using the CPT to identify ADHD presentations.

Conclusion. There was no evidence of the clinical utility of the CPT to assess or monitor ADHD in adult populations diagnosed and treated for ADHD.

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Stéphanie Baggio, PhD, is mission head at the Division of Prison Health, Geneva University Hospitals and University of Geneva and lecturer at the University of Lausanne. Her research interests include psychiatric disorders, prison health and health care, substance use, and health disparities.

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Sébastien Weibel is a psychiatrist specialized in adult ADHD and mood disorders at Strasbourg University Hospital. He received his PhD in Neuroscience (experimental psychology) from Strasbourg University, France. His research interests are relations between ADHD, mood and emotional disorders. He develops specialized care for patients with attention deficits and emotional dysregulation.

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Marie-Pierre Deiber, PhD, PD, is head neurobiologist at the Service of Psychiatric Specialties, Geneva University Hospitals, and lecturer at the University of Geneva. She is specialized in the exploration of human brain functions using electroencephalography (EEG) and derived techniques. She has a long-lasting experience in the study of cerebral responses in association with various physiological and pathological states. Her main research interests are sensorimotor functions, aging and cognitive decline, and attention deficits in psychiatric disorders. She has many publications in the field of brain electrophysiological imaging.

Does the Continuous Performance Test predict ADHD symptoms severity and ADHD presentation in adults?

Attention-deficit hyperactivity disorder (ADHD) is an early-onset neuro-developmental disorder characterized by difficulties in impulse control, hyperactivity, and attention deficits. The assessment of ADHD is challenging because there is a large heterogeneity of symptoms and a high rate of comorbidities with overlapping symptoms. Reliable assessment tools are therefore needed to avoid non-accurate diagnostics. Along with comprehensive diagnostic interviews, neuropsychological evaluations are part of the "gold standard" for ADHD diagnosis (Díaz-Orueta et al., 2014; Gualtieri & Johnson, 2005). These evaluations became popular because they intend to provide an objective assessment of cognitive functions (Fasmer et al., 2016; Hall et al., 2016), susceptible to overcome the limitations of subjective measures (Erdodi & Lajiness-O'Neill, 2014; Hall et al., 2016). As a consequence, neuropsychological evaluations are widely used as objective markers of ADHD in clinical settings.

One classic neuropsychological evaluation is the Conners Continuous Performance Test (CPT), a neuropsychological test often used for the evaluation of ADHD in clinical populations (Fasmer et al., 2016). It measures attention-related problems using a task-oriented computerized assessment. Participants respond to a given target and withhold to non-targets. The test provides information on inattentiveness (not responding to a target: omission errors), impulsivity (responding to a non-target: commission errors), and sustained attention (reaction time and reaction time variability).

However, the usefulness and reliability of these neuropsychological evaluations are questionable. There is mixed evidence on the performance of the CPT as a useful clinical tool to assess and manage ADHD (Hall et al., 2016). In their meta-analysis among children, Hall et al. (2016) found that omissions errors were associated with selective attention, commissions errors with impulsivity, and reaction time/reaction time variability with sustained attention. The increased variability in reaction time seems to be an acknowledged feature of ADHD (Hall et al., 2016; Kofler et al., 2013) and individuals with ADHD are "consistently inconsistent" (Kofler et al., 2013). However, if the CPT is somewhat sensitive to ADHD features, the meta-analysis concluded that the CPT had a limited clinical utility (Hall et al., 2016). Indeed, most of the time, the CPT did not accurately discriminate ADHD patients from controls or patients with other disorders and it lacks of specificity, with a very high false-negative rate. Even the reaction time variability did not appear as unequivocally associated with ADHD: it also lacks of specificity and should be considered as a general marker of psychopathology rather than a diagnostic marker of ADHD (Kofler et al., 2013). Furthermore, the CPT has a limited test-retest reliability (Gualtieri & Johnson, 2005) and a low ecological validity (Berger, Slobodin, & Cassuto, 2017). In other words, there is a growing evidence of the invalid performance of the CPT (Erdodi & Lajiness-O'Neill, 2014). In addition, most studies focused on comparisons between ADHD patients and healthy controls or patients with other disorders (Hall et al., 2016). Few studies considered whether the CPT can be useful in clinical contexts, for example to evaluate and monitor the severity of ADHD symptoms. Therefore, there is a limited evidence of the usefulness of the CPT in clinical settings. However, all CPT procedures are not the same. For example, they may vary in duration, number of stimuli, and time interval. This may lead to different associations with ADHD because they can assess different aspects of attention problems, and therefore it limits comparisons between studies.

Finally, most studies relied on samples of children, and therefore the utility of the CPT among ADHD adults remains understudied, even if neuropsychological evaluations are also used in adult clinical populations. As ADHD often persists in adulthood (Ramos-Quiroga, Montoya, Kutzelnigg, Deberdt, & Sobanski, 2013) and is likely to be associated with detrimental outcomes, information on this age group is needed. In the few studies among adults, findings are inconsistent and thus the evidence of the usefulness of the CPT is also limited. Some studies reported that the CPT did discern ADHD in adults. For example, there are more omissions, a longer response time, and a greater variability among ADHD adults (e.g., Advokat, Martino, Hill, & Gouvier, 2007; Epstein, Conners, Sitarenios, & Erhardt, 1998; Holdnack, Moberg, Arnold, Gur, & et al., 1995). Fasmer et al. (2016) concluded that the CPT was useful to discriminate between ADHD patients and clinical controls. On the contrary, other studies reported that the CPT was not associated with ADHD diagnostic (Cohen & Shapiro, 2007; Pettersson, Söderström, & Nilsson, 2015; Saleh, Fuchs, Taylor, & Niarhos, 2018; Solanto, Etefia, & Marks, 2004). Other studies provided mixed findings, for example Riccio & Reynolds (2001) concluded that the CPT has a good sensitivity but lacks of specificity. To our knowledge, no study investigated the association of CPT with symptoms severity among adult ADHD patients.

Therefore, our study tested 1) whether the CPT was associated with the severity of ADHD symptoms in a clinical adult population, and 2) whether it helped to identify the different presentations of ADHD (inattentive and hyperactive/mixed presentations). It aimed to provide empirical evidence on the usefulness of the CPT as a marker of ADHD severity and presentations among adults diagnosed and treated for ADHD.

Methods

Participants and procedures

A total of 201 adult outpatients with an ADHD diagnostic participated in the study. They were recruited in a specialized center for the diagnosis and treatment for adults suffering from ADHD at the Geneva University Hospitals, Switzerland. All patients underwent a clinical evaluation to diagnose ADHD according to the DSM-5 criteria. Five or more symptoms were required and must have been present before 12. The number of symptoms was used to determine the ADHD presentation (inattention, hyperactive, and mixed). The inclusion criterion was to be diagnosed with ADHD and to provide informed consent to participate in the study.

After being diagnosed with ADHD, the participants signed a consent form and were asked to complete the screening instruments at home (n=126, response rate=62.7%). In a second appointment, they were administered a semi-structured interview designed to assess ADHD and ADHD symptoms severity and the CPT (n=201). Both appointments were conducted by a trained psychiatrist or psychologist. Participants were asked to refrain from having their psychostimulant medication 24 hours before the CPT because it slows reaction time and reaction time variability (Epstein et al., 2005). The participants had never been administered the CPT before the study.

The study was approved by the Ethics Committee of the Geneva University Hospitals.

Measures

Conners continuous performance test. The Conners CPT 3 ™ was used to assess attention-related problems. Participants were seated in front of a computer and were required to respond when any letter except the letter X appeared on the monitor. In total, there were six blocks of trials, each composed of three sub-blocks with 20 trials (total=360 trials and 14 minutes). The inter-stimuli intervals (ISI) were 1, 2, and 4 seconds with a display time of 250 milliseconds. Sub-blocks had different ISI. The following scores were computed from the 360 trials:

- Response style: the individual natural response style can be conservative (emphasizes accuracy over speed), liberal (emphasizes speed over accuracy) or balanced (biased neither to speed nor accuracy);
- Detectability: discrimination between non-targets and targets;
- Omission: missed targets;
- Commission: incorrect responses to non-targets;
- Perseveration: responses made in less than 100 milliseconds;
- Hit reaction time (HRT): mean response speed for non-perseverative responses;
- HRT standard deviation (HRT SD): consistency of response speed for the entire test;
- Variability: consistency of response speed within sub-blocks;
- HRT block change: slope of change in HRT across the six blocks of the test;
- HRT ISI change: slope of change in HRT within the three ISI (1, 2, and 4 seconds).

We used standardized T-scores (mean=50, standard deviation=10, upper limit=90, lower limit=0) for each measure. Higher T-scores indicate worse performance, except for response style (a low score indicate a liberal style and a high score a conservative style) and HRT (both low and high scores are atypical). Atypical scores are higher than 60 (lower than 45 and higher than 60 for HRT).

The CPT 3 also provides a score for the likelihood of having ADHD, from moderate to very high likelihood of having ADHD. In the present paper, we used a categorical (yes/no) variable of likelihood of having ADHD (yes including the moderate to high likelihood of having ADHD).

Diagnostic of ADHD. The Diagnostic Interview for Adult ADHD (DIVA 2.0, Kooij & Francken, 2010) was used to assess symptoms of childhood and adulthood ADHD. The DIVA 2.0 is based on DSM-IV criteria but they were updated accordingly to the DSM-5 criteria. The number of symptoms of hyperactivity and inattention in childhood and adulthood (0 to 9 symptoms) were computed.

Self-reported measures of ADHD. The Wender Utah Rating Scale (WURS, 25 items, Ward, Wender, & Reimherr, 1993) and the Adult ADHD Self-Report Scale (ASRS v1.1, 18 items, Kessler et al., 2005) were used to assess respectively the severity of childhood and adult ADHD. The ADHD quality of life scale (AAQOL, 29 items, Brod, Johnston, Able, & Swindle, 2006) was used to investigate the impact of ADHD on patients' life. Sum-scores were used for all variables.

Socio-demographic variables. We recorded age, gender, level of education (number of years of education), and having a job (yes/no). We also recorded current medications that may affect the results and psychiatric comorbidities (see Table 1).

Statistical analyses

We first performed descriptive statistics on the sample's characteristics, ADHD, and CPT variables. Second, we computed pairwise Spearman correlations between the CPT variables and ADHD variables (Spearman point biserial correlations for the CPT clinical likelihood of ADHD). In a third set of analyses, we ran negative binomial regressions using CPT variables to predict ADHD variables, controlling for gender and age. We performed separate regressions for each CPT variable because the different measures of the CPT were colinear. We also ran analyses controlling for medications and comorbidities (n=124). Finally, we used random forests classification and cross-validation to investigate the relationship between CPT variables and ADHD presentations. This algorithmic modelling answers different research questions in comparison with classical hypothesis tests (Genuer, Poggi, & Tuleau-Malot, 2010). First, it identifies a sample of potential predictors of an outcome. In our study, we aimed to identify the most important CPT variables (predictors) to predict ADHD presentation (outcome). Random forests rank the different predictors according to link with the outcome and thus provides a measure of importance. As few participants had the hyperactive presentation, the study considered inattentive versus hyperactive/mixed presentations. Second, random forests show whether the predictors provide a good classification of the outcome. We reported the percentage of incorrect classification for each presentation.

As the response rate for the self-reported screenings was low (62.7%), we ran analyses to test whether there were differences between respondents and non-respondents. We found no significant differences for demographics (age, gender, level of education, and job), ADHD variables (sum-scores of DIVA 2.0 symptoms), and CPT variables. We also ran sensitivity analyses to test whether some medications or comorbidities (listed in Table 1) changed the association between CPT variables and ADHD variables, but the results were similar.

Analyses were run using R 3.4.3 (package caret 6.0-80) for random forests and Stata 15 for all other analyses.

Results

Descriptive statistics

Descriptive statistics are reported in Table 1. Participants were on average 35.2 ± 0.90 years old and 45.3% were females. Of note only 21 patients (13.0%) were taking psychostimulants at the time of the assessment. A total of 41.9% (54/129) had a medication (psychostimulant or other), and 48.8% (79/162) had a comorbid psychiatric disorder (the most common disorders were major depression disorder, anxiety disorder, and substance use disorder). Details for medications and psychiatric comorbidities are reported in Table 1.

A total of 64.2% of the participants had the mixed or hyperactive presentation and 35.8% the inattentive presentation. Overall, the mean numbers of symptoms assessed using the DIVA 2.0 were high (≥ 5.94), especially for inattention (≥ 7.97).

The results of the CPT showed that only 51.7% were classified as likely to have ADHD (40.3% of the hyperactive and mixed presentations and 58.1% of the inattentive presentation, results not shown in Table 1). All scores could be considered as typical (between 45 and 60 for HRT and below 60 for all other variables except response style).

Associations between CPT and ADHD variables

Spearman correlations between CPT and ADHD variables are reported in Table 2. The CPT clinical likelihood of ADHD was significantly associated with one variable: the WURS score ($r=.18$, $p=.047$). Detectability displayed several significant correlations with ADHD variables (except AAQOL), with r ranging from .14 to .25 ($p<.043$). Commissions also had several significant relationships with ADHD variables (except DIVA 2.0 adult inattention score and AAQOL), with r ranging from .17 to .31 ($p<.025$). Variability and omissions were only associated with DIVA 2.0 hyperactivity scores (in childhood and adulthood, r ranging from .15 to .20, $p<.040$), and HRT SD with DIVA 2.0 scores ($r \leq .15$, $p\geq.036$) except adult inattention score. HRT was significantly associated with the WURS score ($r=-.18$, $p=.045$) and the ASRS score ($r=-.21$, $p=.017$), whereas response style was only associated with the WURS score ($r=-.24$, $p=.008$). Perseverance, HRT by block and HRT time change were not significantly associated with ADHD variables. Overall, ADHD hyperactive symptoms (childhood and adulthood) and the WURS displayed the larger number of significant relationships with CPT variables. However, most effects were small ones (significant associations ranging from .14 to .25), except one correlation that could be classified as moderate (r=.31 between commissions and WURS total score). Overall, the amount of common variance was maximum 9.6% ($.31^2$).

When age and gender were controlled for, the DIVA 2.0 hyperactive scores were significantly associated with the CPT clinical likelihood of ADHD (adulthood: p=.007, childhood: p=.004), detectability (adulthood: p=.018, childhood: .006), omissions (adulthood: p=.051, childhood: p=.001), commissions (adulthood: p=.009, childhood: p=.008), HRT SD (adulthood: p=.007. childhood: p=.005), and variability (adulthood: p=.006, childhood: p=.005). The WURS remained significantly associated with response style (p=.011), detectability (p=.005), and commissions (p<.001). Results are reported in Table 3. All effect sizes were lower than 1% (pseudo R^2 for negative binomial regressions).

When medications and comorbidities were controlled for, it decreased again the number of significant relationships. Only some DIVA 2.0 hyperactive scores were significantly associated with CPT variables: commissions (adulthood: p=.026, childhood: p=.047), HRT SD (adulthood: p=.013, childhood: p=.012), and variability (adulthood: p=.047, childhood: not significant). Effect sizes were again very low (max.=1.6%). For self-reported scales, only the WURS was significantly associated with CPT variables: response style (p<.001), detectability (p=.004), and commissions (p=.001), with small effect sizes (≤2.5%).

Prediction of ADHD presentations using CPT variables

Using the ten CPT variables (excluding the CPT clinical likelihood of ADHD), the results of the random forests showed that the CPT variables failed to discriminate between presentations. The classification error was 80.3% for the inattentive presentation and 22.5% for the hyperactive presentation. Figure 1 shows the importance of each variable. HRT was the most important variable, whereas omissions and perseverance had the lowest importance to predict ADHD presentation. Other variables related to HRT (HRT by block, HRT SD, and HRT ISI change) were also important, along with response style.

Discussion

This study investigated whether the CPT predicted 1) ADHD symptoms severity and 2) ADHD presentations among a clinical sample of adults diagnosed and treated for ADHD.

Descriptive statistics already provided an answer to our first research question. In this sample composed of patients with ADHD, only 51.7% were classified by the CPT as likely to have ADHD. Furthermore, all CPT scores were on average in the range of typical scores (< 60, and between 45 and 60 for HRT). Therefore, the CPT failed to identify adequately ADHD in this clinical sample of adult subjects. This suggested a lack of specificity of the CPT with a very high rate of false negatives.

The CPT variables at the edge of the normative range were the response style, indicating a liberal style of response, the high commission rate, and the fast HRT, all three suggesting an impulsive style of response. A significantly higher commission rate was also recently reported in a group of 60 adult ADHD patients compared with 48 adult non-ADHD patients, together with larger HRT standard deviation and variability (Pettersson et al., 2015). However, studies reporting CPT scores in adult ADHD remains scarce limiting the evaluation of data consistency across centers.

The bivariate associations confirmed the lack of usefulness of the CPT. Indeed, there were some significant associations between ADHD variables and CPT variables, but most of them were of small magnitude (only one correlation greater than .30) and could be considered as negligible (maximum of common variance = 9.6%). This meant that ADHD symptoms severity was negligibly related to CPT. Associations between some CPT variables and hyperactive symptoms remained significant when controlling for age and gender. These associations were also similar or even decreased when controlling for medications and comorbidities. As highlighted in previous studies (Hall et al., 2016; Kofler et al., 2013), omissions, commissions, and variability (HRT SD and variability) were associated with ADHD features. However, these effects were small ones, with an effect size lower than 1% in all cases. Therefore, some CPT variables could be helpful for the clinician: a high number of omissions, commissions, and variability may be indicators of ADHD hyperactivity. However, given the small effect sizes, these associations should be interpreted very cautiously.

Our study also focused on the quality of life of patients with ADHD, which is an important outcome in clinical settings (Agarwal, Goldenberg, Perry, & Ishak, 2012). There was no association between CPT variables and AAQOL, meaning that the CPT could not provide any relevant information on the well-being and functioning of adults with ADHD.

Regarding our second research question, the CPT failed to discriminate between ADHD presentations. The classification error rate was high for the hyperactive presentation (22.5%) and unacceptable for the inattentive presentation (80.3%). The CPT has been described as a measure of sustained attention (Gualtieri & Johnson, 2005), but it failed to identify the inattentive presentation. A previous study reported that the CPT may be sensitive only to some of the core deficits of ADHD, but not hyperactivity (Berger et al., 2017). However, our findings suggested that inattentive symptoms are not well captured by the CPT variables. This finding adds to the growing evidence that the results of the CPT should be interpreted with caution.

Overall, our study confirmed the lack of evidence of the clinical utility of the CPT found in samples of children (Hall et al., 2016). With its low correlations with ADHD severity assessed with a clinical interview and absence of relationship with patients' quality of life, it seemed that the CPT is not actually the most reliable tool for treatment monitoring.

Various reasons may explain why the CPT was not so accurate to discriminate the different ADHD's presentation. First, it lacks of ecological validity (Berger et al., 2017). Indeed, the CPT does not adequately simulate the difficulties that patients with ADHD may experience in their everyday life. For example, it is free from external distractions that are likely to impair the performance of ADHD patients in real life (Berger et al., 2017). These distractors may be especially important to measure difficulties in paying attention, as suggested by a significant increase of omission and commission errors in CPT sessions displaying auditory and visual noise (Uno et al., 2006). Furthermore, the task has a duration of 14 minutes, which is rather short to represent the overall patient performance, considering that the arousal level may also be influenced by the fact of being observed during the test. Another explanation is that there is a high heterogeneity in cognitive functions of patients with ADHD (Fuermaier, Fricke, Vries, Tucha, & Tucha, 2018) that the CPT may not be able to capture. Indeed, 16 cognitive functions have been identified as important to assess ADHD among adults, of which several are not included in the CPT (e.g., task planning, self-monitoring, decision making; see Fuermaier et al., 2018). In addition, CPT may not differentiate between psychiatric and neurological disorders that result in executive dysfunctions (Surman, 2013). Finally, we cannot exclude that subjective and objective measures assess different features of ADHD. We may also consider the fact that CPT is an attention task but not specifically an ADHD task. Indeed, our study showed that low attention levels (in the CPT) was not necessarily synonym of ADHD. Future studies should use more extensive neuropsychological tests in order to see whether they are more useful from a clinical point of view. In this study, we showed that low processing

This study has some limitations. The main shortcoming was that some participants had medical treatments or other comorbidities susceptible to influence their performance to the CPT. However, participants were asked to refrain from stimulant medication 24 hours before the CPT, and the analyses controlling for medications and comorbidities yielded similar findings. Another limitation was that participants might be exposed to prior psychological testing, which influences performance on cognitive tasks. It might have reduced the effect of the CPT among participants who underwent psychological testing (Collie, Maruff, Darby, & McStephen, 2003). However, it was the first time that the participants were exposed to the CPT and there was probably a long test-retest interval for other cognitive tasks, so we believe that the bias was negligible in our study. Finally, there are different kinds of CPT (with different stimuli, duration, and time interval) that may lead to different associations with ADHD variables. Our findings should be confirmed using other measures of attention problems.

In the absence of convincing evidence, we suggest that the results of the CPT should be interpreted very cautiously to assess or monitor ADHD in adult populations. As pointed out years ago by DuPaul et al. (1992), there is still a need of standardized clinic-based measures of ADHD.

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Table 1. Descriptive statistics for socio-demographics, CPT variables, and ADHD

Variables	**Mean (sd)**	**% (n)**
Socio-demographic variables		
Age	35.2 (0.90)	-
Gender		
Male	-	54.7 (110)
Female	-	45.3 (91)
No. of years of education[1]	15.7 (0.28)	-
Job[1]		
No	-	40.5 (47)
Yes	-	59.5 (69)
Medication		
Anti-depressants (n=124)	-	22.6 (28)
Benzodiazepine (n=124)	-	6.5 (8)
Hypnotics (n=124)	-	5.7 (7)
Neuroleptic (n=124)	-	7.3 (9)
Psychostimulants (n=162)	-	13.0 (21)
Comorbidities		
Major depression disorder (n=162)	-	14.2 (23)
Anxiety disorders (n=162)	-	14.2 (23)
Bipolar disorder (n=161)	-	1.2 (2)
Borderline personality disorder (n=162)	-	4.3 (7)
Eating disorders (n=162)	-	3.7 (6)
Substance use disorders (n=162)	-	27.8 (45)
CPT variables		
Measures of the CPT (0-90)		
Response style	44.09 (0.7)	-
Detectability	52.91 (0.70)	22.9 (46)[2]
Omissions	48.55 (0.45)	6.0 (12)[2]
Commissions	55.56 (0.75)	33.3 (67)[2]
Perseverance	51.81 (0.84)	15.4 (31)[2]
HRT	45.28 (0.57)	59.2 (119)[2]
HRT standard deviation	52.11 (0.67)	16.4 (33)[2]
Variability	50.36 (0.70)	12.4 (33)[2]
HRT block change	50.91(0.70)	17.4 (35)[2]
HRT inter-stimulus interval change	51.22 (0.69)	16.4 (33)[2]
CPT clinical likelihood of ADHD		
ADHD absent	-	48.3 (97)
ADHD present	-	51.7 (104)
ADHD variables		
Presentation		
Inattentive	-	35.8 (72)
Hyperactive	-	6.5 (13)
Mixed	-	57.7 (116)
DIVA 2.0 scores (0-9)		
Childhood inattention	7.97 (0.13)	-
Childhood hyperactivity	6.30 (0.20)	-
Adult inattention	8.02 (0.12)	-
Adult hyperactivity	5.94 (0.20)	-
ASRS (0-72)[1]	47.74 (0.90)	-
WURS (0-100)[1]	52.74 (1.38)	-
AAQOL (0-100)[1]	51.29 (1.43)	-

CPT: continuous performance test, HRT: hit reaction time, ADHD: attention-deficit hyperactivity disorder, DIVA: Diagnostic Interview for Adult ADHD, ASRS: Adult ADHD Self-Report Scale, WURS: Wender Utah Rating Scale, AAQOL: ADHD quality of life scale.

[1] n=126 (otherwise, n=201).

[2] Percentages (n) of participants with atypical scores (≤ 45 and ≥ 60 for HRT, respectively 53.7% and 5.5%; ≥ 60 for all other variables).

Table 2. Spearman correlations between CPT variables and ADHD variables

	DIVA-2 Adult inattention		DIVA-2 Adult hyperactivity		DIVA-2 Child inattention		DIVA-2 Child hyperactivity		WURS[2]		ASRS[2]		AAQOL[2]	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p
CPT binary classification[1]	-.01	.893	.15	.102	-.06	.533	.17	.060	**.18**	**.047**	.02	.831	.04	.669
Response style	-.04	.579	-.06	.418	-.04	.560	-.01	.959	**-.24**	**.008**	-.15	.105	.08	.394
Detectability	**.14**	**.043**	**.19**	**.007**	**.17**	**.015**	**.22**	**.002**	**.25**	**.005**	**.18**	**.040**	-.15	.084
Omissions	.10	.179	**.15**	**.040**	.12	.081	**.20**	**.004**	.11	.238	.07	.456	-.07	.424
Commissions	.13	.060	**.18**	**.011**	**.17**	**.018**	**.18**	**.011**	**.31**	**<.001**	**.20**	**.025**	-.13	.136
Perseverance	.02	.740	.03	.704	.01	.885	.02	.829	.05	.584	.08	.361	-.09	.317
HRT	-.06	.369	-.02	.803	-.05	.459	-.02	.732	**-.18**	**.045**	**-.21**	**.017**	.15	.097
HRT SD	.11	.135	**.20**	**.005**	**.15**	**.036**	**.21**	**.003**	.16	.067	.15	.101	.00	.998
Variability	.12	.085	**.20**	**.004**	.12	.080	**.20**	**.005**	.17	.059	.14	.110	-.02	.806
Hit reaction time by block	-.04	.556	-.01	.930	.05	.496	.01	.363	.12	.200	.08	.403	-.02	.856
Hit reaction time change	-.09	.215	.08	.243	-.08	.247	.07	.363	-.05	.600	-.05	.580	.08	.375

CPT: continuous performance test, HRT: hit reaction time, ADHD: attention-deficit hyperactivity disorder, DIVA: Diagnostic Interview for Adult ADHD, ASRS: Adult ADHD Self-Report Scale, WURS: Wender Utah Rating Scale, AAQOL: ADHD quality of life scale.

Correlations significant at the .05 level are highlighted in bold.

[1] Spearman point biserial correlations are reported.

[2] n=126 (otherwise, n=201).

Table 3. Negative binomial regressions between CPT variables and ADHD variables controlling for age and gender

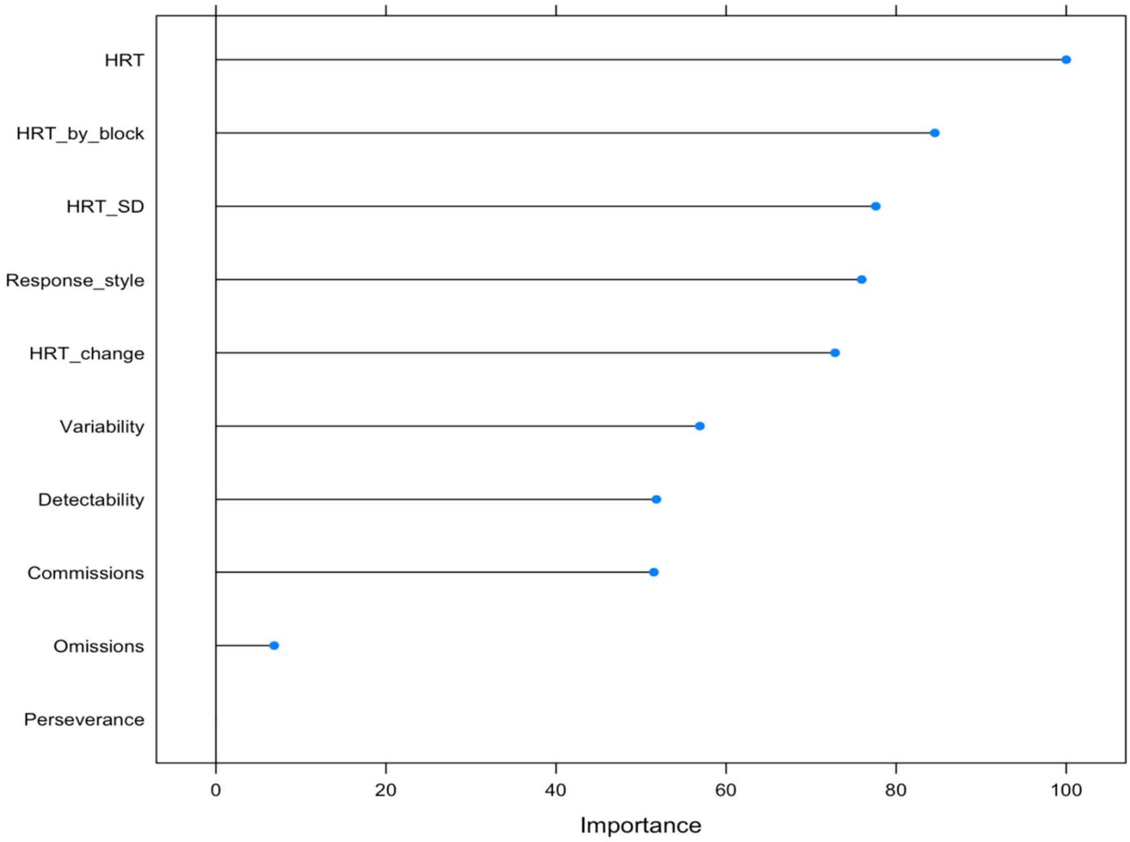
	DIVA-2 Adult inattention		DIVA-2 Adult hyperactivity		DIVA-2 Child inattention		DIVA-2 Child hyperactivity		WURS[2]		ASRS[2]		AAQOL[2]	
	b	p	b	p	b	p	b	p	b	p	b	p	b	p
CPT binary classification	0.027	.594	**0.196**	**.007**	0.042	.402	**0.191**	**.004**	0.095	.078	0.004	.971	0.035	.544
Response style	0.000	.844	-0.004	.328	-0.002	.552	-0.002	.581	**-0.007**	**.011**	-0.004	.472	0.004	.194
Detectability	0.002	.393	**0.009**	**.018**	0.003	.225	**0.009**	**.006**	**0.008**	**.005**	0.004	.462	-0.005	.085
Omissions	0.002	.537	0.011	.051	0.003	.469	**0.011**	**.001**	0.006	.211	0.002	.857	-0.001	.794
Commissions	0.002	.441	**0.009**	**.009**	0.003	.208	**0.008**	**.008**	**0.008**	**.001**	0.004	.406	-0.004	.095
Perseverance	0.000	.996	0.003	.288	0.001	.823	0.004	.123	0.002	.276	0.001	.898	0.000	.918
HRT	0.002	.950	0.000	.978	-0.001	.815	0.000	.955	-0.005	.145	-0.005	.424	0.005	.192
HRT SD	0.003	.253	**0.010**	**.007**	0.003	.220	**0.010**	**.005**	0.005	.124	0.002	.748	0.001	.830
Variability	0.002	.464	**0.010**	**.006**	0.002	.485	**0.009**	**.005**	0.003	.263	0.003	.637	0.001	.834
Hit reaction time by block	0.000	.983	0.000	.973	0.001	.817	-0.001	.809	0.004	.160	0.002	.683	-0.003	.413
Hit reaction time change	0.000	.903	0.005	.214	0.000	.915	0.004	.215	-0.001	.854	-0.002	.776	0.004	.185

CPT: continuous performance test, HRT: hit reaction time, ADHD: attention-deficit hyperactivity disorder, DIVA: Diagnostic Interview for Adult ADHD, ASRS: Adult ADHD Self-Report Scale, WURS: Wender Utah Rating Scale, AAQOL: ADHD quality of life scale.

Associations significant at the .05 level are highlighted in bold.

[2] n=126 (otherwise, n=201).

Figure 1. Random forest variable importance plot



CPT: continuous performance test, HRT: hit reaction time, HRT SD: hit reaction time standard deviation.