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The Integrated Visual and Auditory Continuous Performance Test as a neuropsychological measure

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Abstract

The Integrated Visual and Auditory (IVA) Continuous Performance Test (CPT) and Neuropsychological Impairment Scale (NIS) were completed by adults diagnosed with mild traumatic brain injury (mTBI), adults diagnosed with attention deficit hyperactivity disorder (ADHD), and controls. On the IVA CPT, the mTBI and ADHD groups performed significantly lower on the full and secondary scales for attention and response accuracy. For individual scales, the mTBI and ADHD groups showed lower performance on measures of reaction time, inattention, impulsivity, and variability of RT. The mTBI and ADHD groups showed similar patterns of performance on the IVA. On the NIS, the mTBI and ADHD groups reported more neuropsychological symptoms than the control group, and the mTBI group reported more neuropsychological symptoms than the ADHD group. The results are discussed in regard to changes in cognitive processing and sustained attention in individuals diagnosed with mTBI and ADHD.

Keywords: mTBI; Attention; Brain injury; ADHD; Head injury

1. Introduction

A change in attention is the most common neuropsychological symptom associated with brain damage (Lezak, 1995). The sequential processing and capacity characteristics of attention assessed with the Digit Span Test (Wechsler, 1981) can be resistant to aging and brain damage (Lezak, 1995). Other characteristics of attention, such as focused or selective attention, sustained attention, divided attention, and alternating attention (Solhberg & Mateer, 1989; Van Zomeren & Brouwer, 1990), may be more important and often of greater clinical

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concern after brain damage (Lezak, 1995). Slow processing (i.e., reaction time, RT) in combination with these characteristics may have broad-ranging effects on all cognitive functions and reduce cognitive productivity (Lezak, 1995). A Continuous Performance Test (CPT) can measure processing speed in addition to focused, sustained, divided, and alternating attention characteristics in a neuropsychological evaluation. The term CPT was first coined by Rosvold, Mirsky, Sarason, Bransome, and Beck (1956), but researchers use a wide variety of presentation methods (auditory, visual, or verbal) and performance measures such as hit rate, commission (impulsivity), and omission (inattention). Some studies have examined simple reaction time (SRT) to one stimulus, while other studies have used choice reaction time (CRT) to two or more stimuli that require different responses to the stimuli or require a response for one stimulus and inhibition of a response for another stimulus.

Separate reviews found that auditory-sustained attention on a CPT (Gentilini, Nichelli, & Schoenhuber, 1989; Parasuraman, Mutter, & Molloy, 1991) and verbal-sustained attention with the Paced Auditory Serial Attention Task (Gronwall, 1989) were impaired after mild traumatic brain injury (mTBI). Using a computer to present visual stimuli and measure RT on a CPT task, individuals with mTBI (Collins & Long, 1996; Stuss et al., 1989) and severe TBI (Loken, Thornton, Otto, & Long, 1995) had slower choice visual RT. Recently, SRT and CRT on a visual CPT were highly correlated with the Halstad Impairment Index of the Halstad–Reitan Battery in individuals with traumatic brain injury (Western & Long, 1996) and discriminated between individuals with TBI and controls (Collins & Long, 1996).

A deficit in attention is a symptom of Post Concussion Syndrome (e.g., mTBI) and attention deficit hyperactivity disorder (ADHD) diagnoses found in the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV; American Psychiatric Association, 1994). The DSM-IV also lists three core symptoms of inattention, impulsivity, and hyperactivity for ADHD. ADHD was originally described as a childhood disorder, but clinical experience suggested that adults or parents of a child with symptoms of ADHD also might show problems with sustained attention. The diagnosis of attention problems in adults with mTBI and ADHD can be evaluated with a CPT or a structured self-report to quantify the number and severity of symptoms. There are self-report scales to measure symptoms of attention problems in adults with ADHD (Conners, Erhardt, & Sparrow, 1999) or other neuropsychological disorders such as mTBI (O'Donnell, DeSoto, DeSota, & Reynolds, 1994). On a visual CPT, mTBI and ADHD groups had slower RT and more variability in RT compared to the control group (Arcia & Gualtieri, 1994). On the Gordon Diagnostic to System CPT (Gordon, 1988), adults diagnosed with mTBI had fewer correct responses and greater block variability on the vigilance and distractibility tasks but no differences in RT (Burg, Burright, & Donovick, 1995).

Despite the clinical use of self-report scales or a CPT to measure attention, there is little information comparing self-report of attention and CPT performance in mTBI and ADHD groups. Thus, the purpose of this study was to measure the performance of adults with mTBI and ADHD on a CPT task, to measure the self-report of neuropsychological symptoms in mTBI and ADHD groups, and to determine if there was a relationship between self-report of symptoms and performance on a CPT. The CPT used was the Integrated Visual and Auditory (IVA) CPT, which can assess auditory and visual attention on the same task. Previous CPT studies measured on a computer in persons with mTBI and ADHD used visual stimuli to record RT as a measure of processing speed. The RT for auditory attention could not be measured in neuropsychological testing and the IVA may provide a method to measure the characteristics of auditory attention. The literature reviewed above suggests deficits in visual-sustained attention in mTBI and ADHD groups, and it was hypothesized that a separate pattern of deficits on the IVA CPT auditory and visual subscales could be identified in mTBI and ADHD groups. The Neuropsychological Impairment Scale (NIS; O'Donnell et al., 1994) was used for a quantitative measure of self-report symptoms. This scale would help determine if there is a different pattern in the self-report of neuropsychological symptoms in the mTBI group compared to the ADHD group. Past research has shown a wide variety of cognitive, emotional, and physical symptoms after mTBI (Rimel, Giordani, Barth, Boll, & Jane, 1981) and it was hypothesized that the mTBI group would report more symptoms than the ADHD group. Finally, it was hypothesized that there would be a positive relationship between self-report and CPT performance.

2. Method

2.1. Participants

There were 120 adults (55 males, 65 females) used in this study (age range = 17–68). The control group consisted of 23 individuals (14 males, 9 females) from the normative group of the IVA CPT and 18 individuals (5 males, 13 females) from the local community recruited to participate in the study. The control group was screened and had a negative history of neurological and neuropsychological problems. The mTBI group consisted of 41 individuals (19 males, 22 females) referred for a neuropsychological evaluation and received a diagnosis of mTBI through interview, history, and neuropsychological tests. Participants in the mTBI group met the criteria of loss of consciousness of less than 30 min, posttraumatic amnesia of less than 24 h, and/or feeling dazed or stunned at the time of injury (Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American College of Rehabilitation Medicine, 1993. The ADHD group consisted of 38 individuals (17 males, 21 females) referred for a psychological evaluation and received a diagnosis of ADHD, residual type, by achieving six of nine criteria in DSM-IV (American Psychiatric Association, 1994). The demographic data of the control, mTBI, and ADHD groups are shown in Table 1.

2.2. Procedure

All individuals in the control, mTBI, and ADHD groups completed the IVA CPT (Sandford & Turner, 1995). The scales for the IVA are described in Figure 9. When available, the NIS (O'Donnell et al., 1994) raw scores and the Wechsler Adult Intelligence Scale—Revised (WAIS-R; Wechsler, 1981) full scale IQ score were obtained. The NIS and WAIS-R scores were obtained from 12 of the individuals from the local community control group. All testings were completed in accordance with the standardized procedures outlined in the administration manuals of the IVA, NIS, and WAIS-R. The NIS is a 72-item self-report questionnaire. Subjects were asked to rate the severity of each item on a scale of 0 = *Not At All*, 1 = *A Little Bit*, 2 = *Moderately*, 3 = *Quite A Bit*, and 4 = *Extremely* (higher scores reflected a greater intensity of symptoms). There are three validity scales of Defensiveness, Affective,

Table 1
Means and standard deviations for demographic data of the control, mTBI, and ADHD groups

Group	*n*	Age	Education	FSIQ	Days since injury
Control					
Male	22	32.2 (10.8)	15.5 (2.8)	106.3 (3.8)	
Female	19	30.5 (9.9)	14.7 (2.8)	106.8 (10.4)	
Total	41	31.3 (10.2)	15.1 (2.8)	106.6 (8.5)	
mTBI					
Male	19	40.9 (11.9)	12.0 (1.0)	98.0 (14.7)	568.1 (509.4)
Female	22	33.2 (15.1)	13.5 (3.1)	96.4 (11.2)	455.4 (340.2)
Total	41	36.8 (14.1)	12.8 (2.5)	97.3 (13.1)	507.6 (425.2)
ADHD					
Male	21	30.5 (11.3)	13.8 (2.1)	104.9 (12.3)	
Female	17	32.9 (10.2)	13.3 (1.8)	101.3 (15.7)	
Total	38	31.8 (10.6)	13.6 (1.9)	103.2 (13.8)	

and Inconsistency; three summary scales of General Measurement of Impairment (total of five symptom scales), Total Items Checked (rating greater than 0), and Symptom Intensity Measure (Global Measure of Impairment/Total Items Checked); and seven symptom scales of Critical Neurological Items, Cognitive Efficiency, Attention, Memory, Frustration Tolerance, Language–Verbal Learning, and Academic.

The IVA test was completed on a 386 IBM-compatible computer. Subjects were seated in front of the VGA computer monitor about 15–24 in away from the screen. The center of the monitor was 1–2 in. below eye level. A two-button ergonomic mouse was placed in front of the computer screen and the left button was used to record responses. The subject's arm was allowed to rest on the table in a comfortable position. The visual stimuli (1 or 2) were green in color, 1.5 in. high, and were presented for 167 ms inside a rectangle positioned in the middle of the computer screen. The auditory stimuli (1 or 2) were presented with Sony model 30 headphones attached to an eight-bit Sound Blaster card and lasted for 500 ms. The rectangle on the computer screen was blank during auditory presentation. The response result of each stimulus was saved on the computer for analysis. During analysis, IVA raw score variables for subjects in the control, mTBI, and ADHD groups were converted to standard scores ($M = 100$ and S.D. $= 15$) based upon the normative data from the IVA. A description of the IVA variables is shown in Figure 9.

Task instructions for the IVA were presented on the computer. In the warm-up part of the test, the subject was instructed by the voice on the computer to click the mouse when he or she saw a "1." Next, the subject was instructed by the voice on the computer to click the mouse when he or she heard a "1" for 10 trials. Subjects were instructed and given a demonstration that they would see or hear a "1" or a "2." They were instructed to click the mouse when they saw or heard a "1" (target) and not click the mouse when they saw or heard a "2" (error). Ten trials were presented and responses recorded. In the main part of the test, CRT was collected on five blocks of 100 trials (500 trials total) and lasted approximately 13 min. Again the subjects were instructed to click the mouse when they saw or heard a "1" (target) and not click the mouse when they saw or heard a "2" (error). During the first 50 trials of a 100-trial block, the target was presented on 42 of the trials (84%) and the error on eight trials (16%) for a target-to-error ratio of 5.25:1. In the second 50 trials of the 100-trial blocks, the target was presented on eight of the trials (16%) and the error on 42 trials (84%) with a target-to-error ratio of 1:5.25. The presentation of visual and auditory stimuli was equally balanced in each 100-trial block. After the 500 trials, the cool-down part of the test was completed. The cool-down was identical to the warm-up previously described. The entire IVA test lasted about 20 min to complete instructions, warm-up, main test, and cool-down.

3. Results

The IVA Full Scale Attention Quotient was not correlated with age, education, and FSIQ in the control and mTBI groups (all Ps $> .05$), but was significantly correlated (all Ps $> .05$) with age ($r = .38$), education ($r = .38$), and FSIQ ($r = .64$) in the ADHD group. The NIS General Measure of Impairment was not correlated with age, education, and FSIQ in the control, mTBI, and ADHD groups (all Ps $> .05$). The number of days between injury and testing was not correlated with IVA Full Scale Attention Quotient, NIS General Measure of Impairment, or FSIQ (all Ps $> .05$) in the mTBI group. Gender was not used in the analysis because preliminary analysis found no significant main effect of gender or interaction of Group and Gender on the IVA and NIS scales. For groups of dependent variables, a multivariate analysis of variance (MANOVA) between group design was used with Group (Control, mTBI, ADHD) as a between-subjects factor. Significant univariate analyses were analyzed with post hoc Bonferroni *t* tests and significant post hoc comparisons were reported.

The MANOVA Full Scale Attention Quotient, Full Scale Response Quotient, Hyperactivity, and Balance IVA Scales found a significant multivariate main effect for Group [$F(8, 226) = 10.00$, $P < .001$]. Univariate analysis of Full Scale Attention Quotient [$F(2, 117) = 22.47$, $P < .001$], Full Scale Response Quotient [$F(2, 117) = 27.42$, $P < .001$], and Hyperactivity [$F(2, 117) = 15.99$, $P < .001$] were significant, while the univariate analysis of Balance ($F < 1$) was not significant. As can be seen in Figure 1, the mTBI and ADHD groups scored lower than the control group on Full Scale Attention Quotient, Full Scale Response Quotient, and Hyperactivity (all Ps $< .001$).

The MANOVA for Auditory Attention Quotient, Visual Attention Quotient, Auditory Response Control Quotient, and Visual Response Control Quotient IVA Scales found a significant multivariate main effect for Group [$F(8, 226) = 9.36$, $P < .001$]. Univariate analysis for Auditory Attention Quotient [$F(2, 117) = 26.38$, $P < .001$], Visual Attention Quotient [$F(2, 117) = 19.45$, $P < .001$], Auditory Response Control Quotient [$F(2, 117) = 20.44$, $P < .001$], and Visual Response Control Quotient [$F(2, 117) = 15.12$, $P < .001$] were significant. As can be seen in Figure 2, the mTBI and ADHD groups scored significantly lower than the control group (all Ps $< .001$) on the Auditory Attention Quotient, Visual Attention Quotient, Auditory Response Control Quotient, and Visual Response Control Quotient.

The MANOVA for Auditory Vigilance, Visual Vigilance, Auditory Focus, Visual Focus, Auditory Speed, Visual Speed, Auditory Prudence, Visual Prudence, Auditory Consistency,

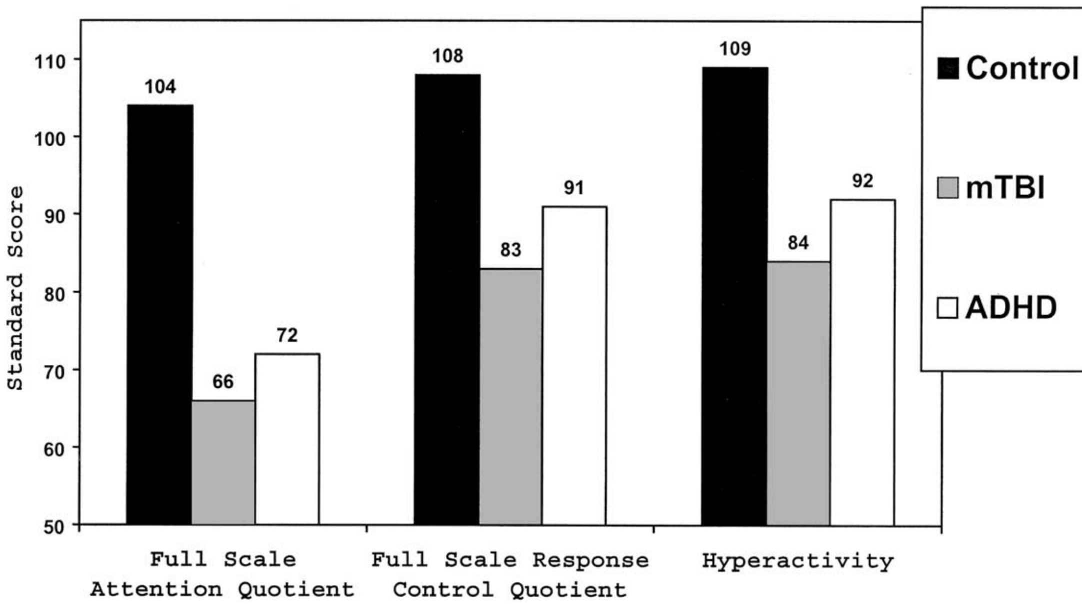


Fig. 1. Mean standard score for Full Scale Attention Quotient, Full Scale Response Control Quotient, and Hyperactivity from the IVA CPT.

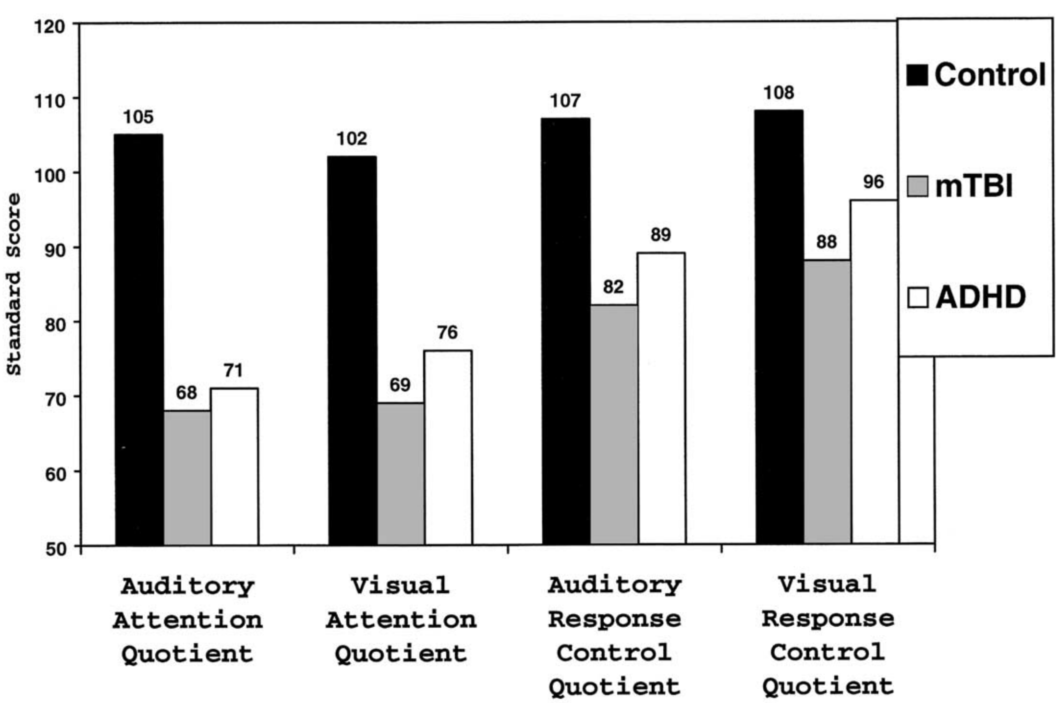


Fig. 2. Mean standard score for Auditory Attention Quotient, Visual Attention Quotient, Auditory Response Control Quotient, and Visual Response Control Quotient from the IVA CPT.

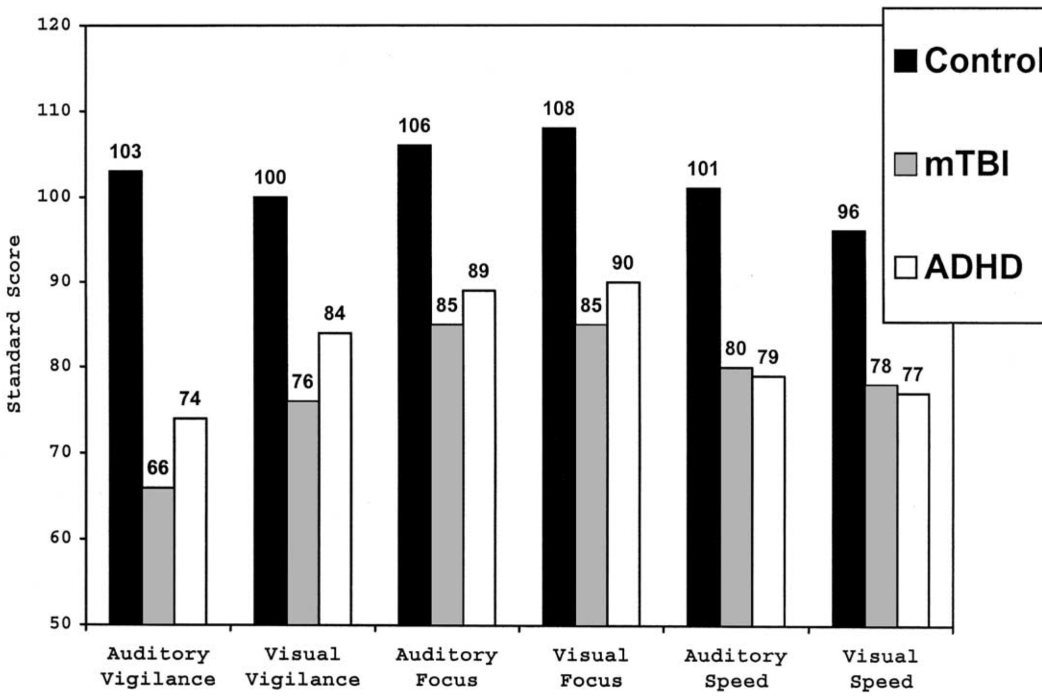


Fig. 3. Mean standard score for Auditory Vigilance, Visual Vigilance, Auditory Focus, Visual Focus, Auditory Speed, and Visual Speed from the IVA CPT.

Visual Consistency, Auditory Stamina, and Visual Stamina IVA Scales found a significant multivariate main effect for Group [$F(df = 24, 204) = 3.83$, $P < .001$]. Univariate analysis for Auditory Vigilance [$F(2, 114) = 11.78$, $P < .001$], Visual Vigilance [$F(2, 114) = 6.87$, $P = .002$], Auditory Focus [$F(2, 114) = 24.15$, $P < .001$], Visual Focus [$F(2, 114) = 18.62$, $P < .001$], Auditory Speed [$F(2, 114) = 15.00$, $P < .001$], Visual Speed [$F(2, 114) = 10.64$, $P < .001$], Auditory Prudence [$F(2, 114) = 9.57$, $P < .001$], Visual Prudence [$F(2, 114) = 10.90$, $P < .001$], Auditory Consistency [$F(2, 114) = 25.59$, $P < .001$], Visual Consistency [$F(2, 114) = 10.82$, $P < .001$] was significant. As can be seen in Figures 3 and 4, the mTBI and ADHD groups scored significantly lower than the control group on Auditory Vigilance, Auditory Focus, Auditory Speed, Auditory Consistency, Visual Focus, Visual Speed, Visual Prudence, and Visual Consistency. The mTBI groups scored significantly lower than the control group on Auditory Prudence and Visual Vigilance.

The MANOVA for Auditory Readiness, Visual Readiness, Auditory Comprehension, Visual Comprehension, Auditory Sensory/Motor, Visual Sensory/Motor, Auditory Persistence, and Visual Persistence IVA Scales found a significant multivariate main effect for Group [$F(16, 214) = 3.97$, $P < .001$]. Univariate analysis found significant main effects for Auditory Comprehension [$F(2, 115) = 15.78$, $P < .001$], Visual Comprehension [$F(2, 115) = 16.14$, $P < .001$], Visual Persistence [$F(2, 115) = 4.13$, $P = .01$], and Auditory Sensory/Motor [$F(2, 115) = 4.47$, $P = .01$]. The mTBI and ADHD groups. scored significantly lower than the control group on Auditory Comprehension and Visual Comprehension. The mTBI

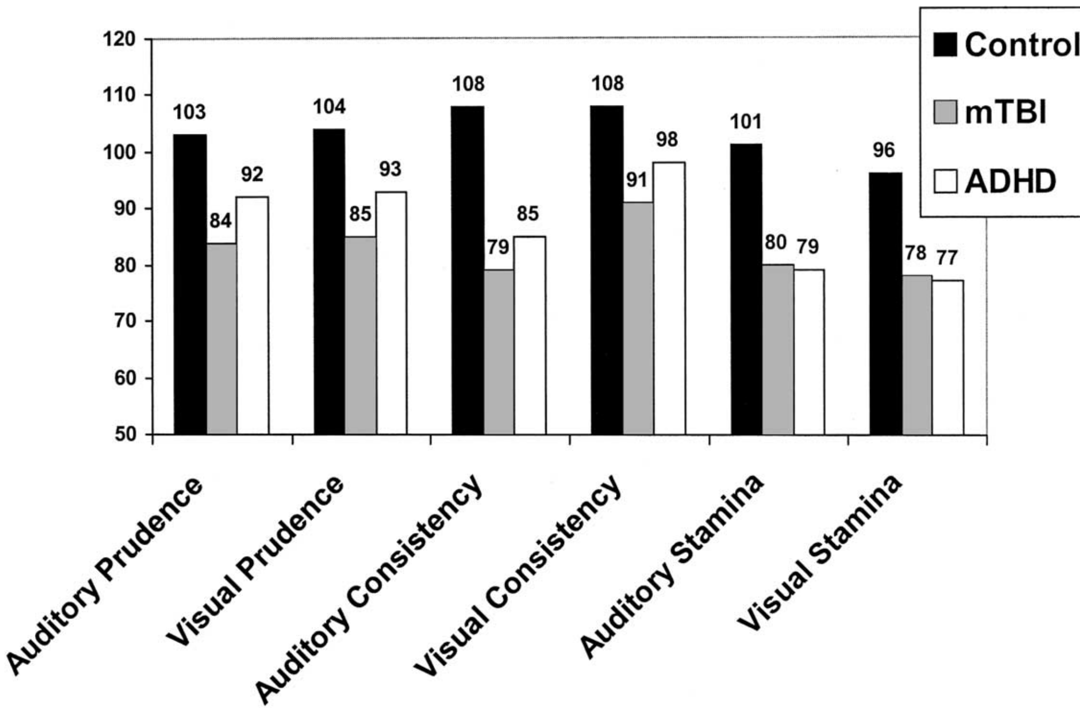


Fig. 4. Mean standard score for Auditory Prudence, Visual Prudence, Auditory Consistency, Visual Consistency, Auditory Stamina, and Visual Stamina from the IVA CPT.

group scored higher than the ADHD group on Visual Persistence. The ADHD group scored significantly lower than the control group on Auditory Sensory/Motor.

The MANOVA for the NIS validity scales raw scores (Defensiveness, Affective, Inconsistency) and NIS summary scales (Global Measure of Impairment, Total Items Checked, and Symptom Intensity Measure) (Fig. 5) found a significant multivariate main effect for Group [$F(12, 146) = 5.83$, $P < .001$]. Univariate main effects for Group found a significant main effect for Affective [$F(2, 79) = 6.16$, $P = .003$], Inconsistency [$F(2, 79) = 3.25$, $P < .04$], General Measure of Impairment [$F(2, 79) = 20.18$, $P < .001$], Total Items Checked [$F(2, 79) = 22.49$, $P = .001$], and Symptom Intensity Measure [$F(2, 79) = 12.34$, $P < .001$]. As can be seen in Figure 6, the mTBI group reported more symptoms compared to the control group on the measures of Affective, Inconsistency of Symptoms, and Symptom Intensity. The mTBI and ADHD groups rated a significantly higher level of symptoms compared to the control group on Global Measure of Impairment and checked more items on the Total Items Checked . The mTBI group rated a significantly higher level of symptoms compared to the ADHD group on Global Measure of Impairment and checked more items on the Total Items Checked.

The MANOVA for the NIS raw scores for symptom scales (Critical Neurological Items, Cognitive Efficiency, Attention, Memory, Frustration Tolerance, Language–Verbal Learning, and Academic) found a significant multivariate main effect for Group [$F(14, 144) = 8.24$,

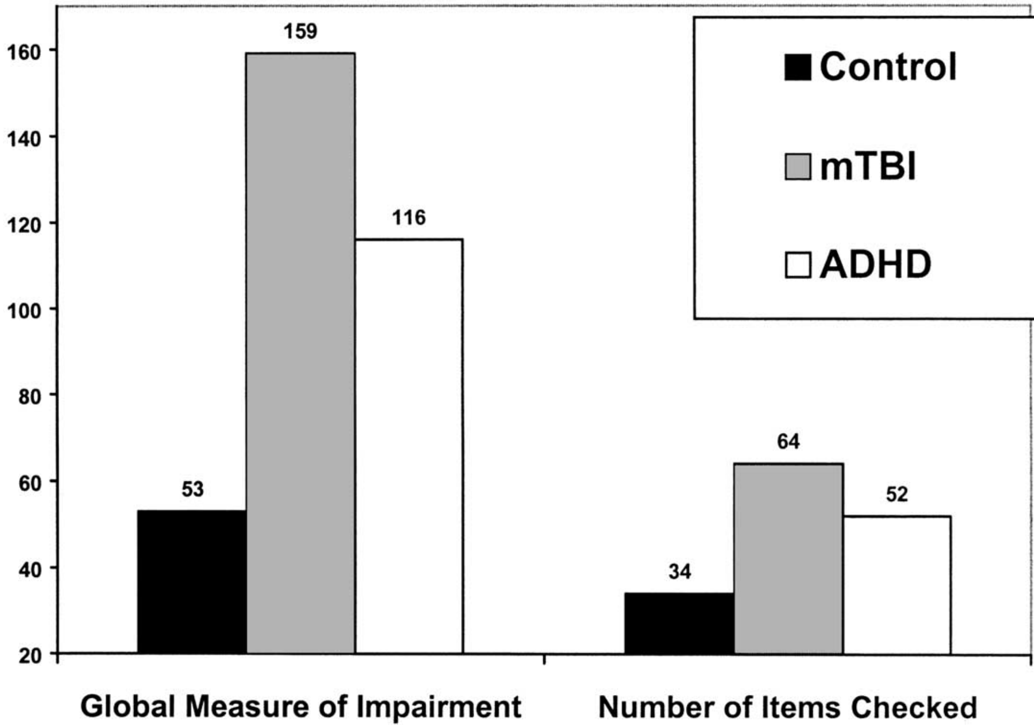


Fig. 5. Mean raw score for Global Measure of Impairment and Number of Items Checked self-report scales from the NIS.

$P < .001$]. Univariate analysis for Group found significant main effects for Critical Neurological Items [$F(2, 79) = 37.63$, $P < .001$], Cognitive Efficiency [$F(2, 79) = 15.47$, $P < .001$], Attention [$F(2, 79) = 16.01$, $P < .001$], Memory [$F(2, 79) = 11.12$, $P < .001$], Frustration Tolerance [$F(2, 79) = 8.97$, $P = .001$], Language–Verbal Learning [$F(2, 79) = 18.66$, $P < .001$], and Academic [$F(2, 79) = 11.10$, $P < .001$]. As can be seen in Figures 7 and 8, the mTBI group rated more symptoms on Critical Neurological Items compared to the control group. The mTBI and ADHD groups rated more symptoms on Cognitive Efficiency, Attention, Memory, Frustration Tolerance, Language–Verbal Learning and Academic compared to the control group. The mTBI group rated more symptoms on Cognitive Efficiency and Language–Verbal Learning compared to the ADHD group.

4. Discussion

For the IVA, the results show visual and auditory full scale attention, and full scale response accuracy scales were significantly lower for the mTBI and ADHD groups. Also, the secondary scales for auditory and visual attention and auditory and visual response accuracy were significantly lower for the mTBI and ADHD groups. The results suggest a similar neuropsychological

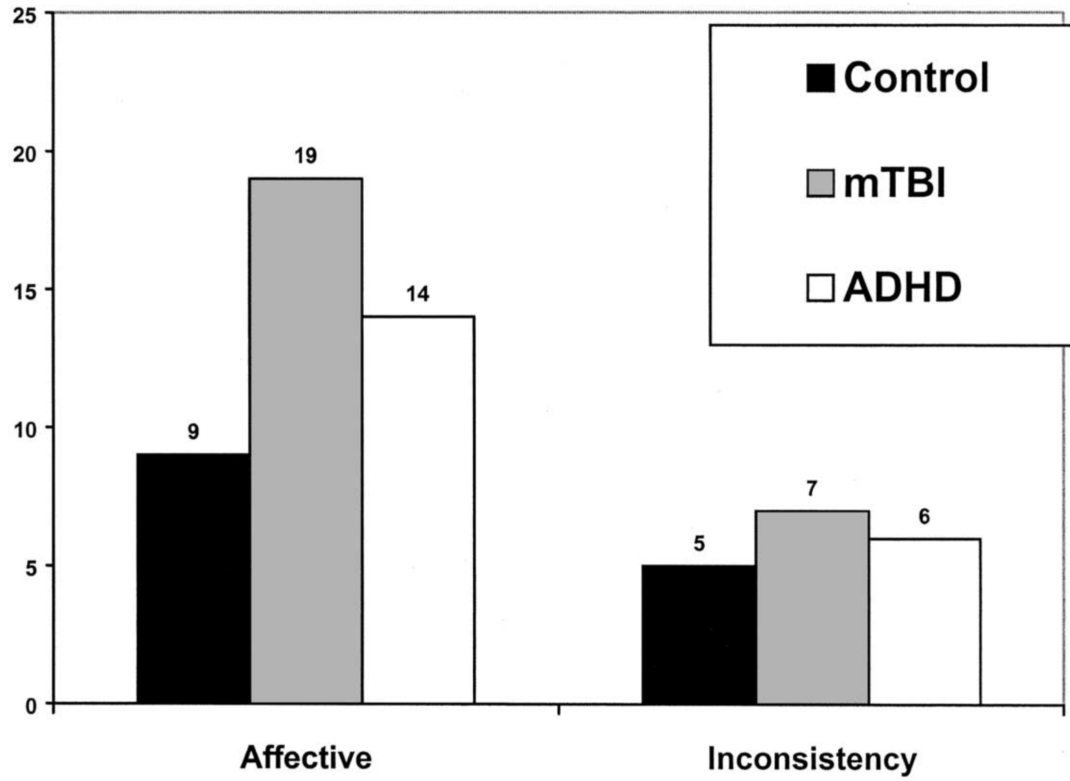


Fig. 6. Mean raw score for Affective and Inconsistency self-report scales from the NIS.

deficit in sustained attention measured by the IVA for the mTBI and ADHD groups that could be due to underarousal (Van Zomeren & Deelman, 1978) or frontal lobe damage common to both groups (Arcia & Gualtieri, 1994). Both groups completed the attention task but could not maintain an optimum level of performance and the repeated demands of the task seemed to erode their ability to maintain a consistent performance on the task (Stuss et al., 1989). From a practical standpoint, the low performance on a CPT task may be related to the poor educational performance and poor work performance often seen after mTBI or in persons diagnosed with ADHD.

For individual scales, there were no differences on measures of simple auditory and visual RT (sensory/motor scale) in the mTBI group. Changes in simple visual RT after mTBI from past research were not clear as some of the previous studies that found differences after mTBI (Klensch, 1973; Stuss et al., 1989), while others did not (Miller, 1970; Norman & Svahn, 1961). Slowed CRT for auditory presentation in mTBI and ADHD groups has not been described in previous research. The changes in visual CRT in this study (speed) are consistent with several published studies that utilized a visual CRT on a computer (Collins & Long, 1996; Stuss et al., 1989). For the ADHD group, this study found slower simple RT only for auditory presentation, while the significantly slowed visual CRT was inconsistent with the results of Arcia and Gualtieri (1994) who found no differences in visual CRT.

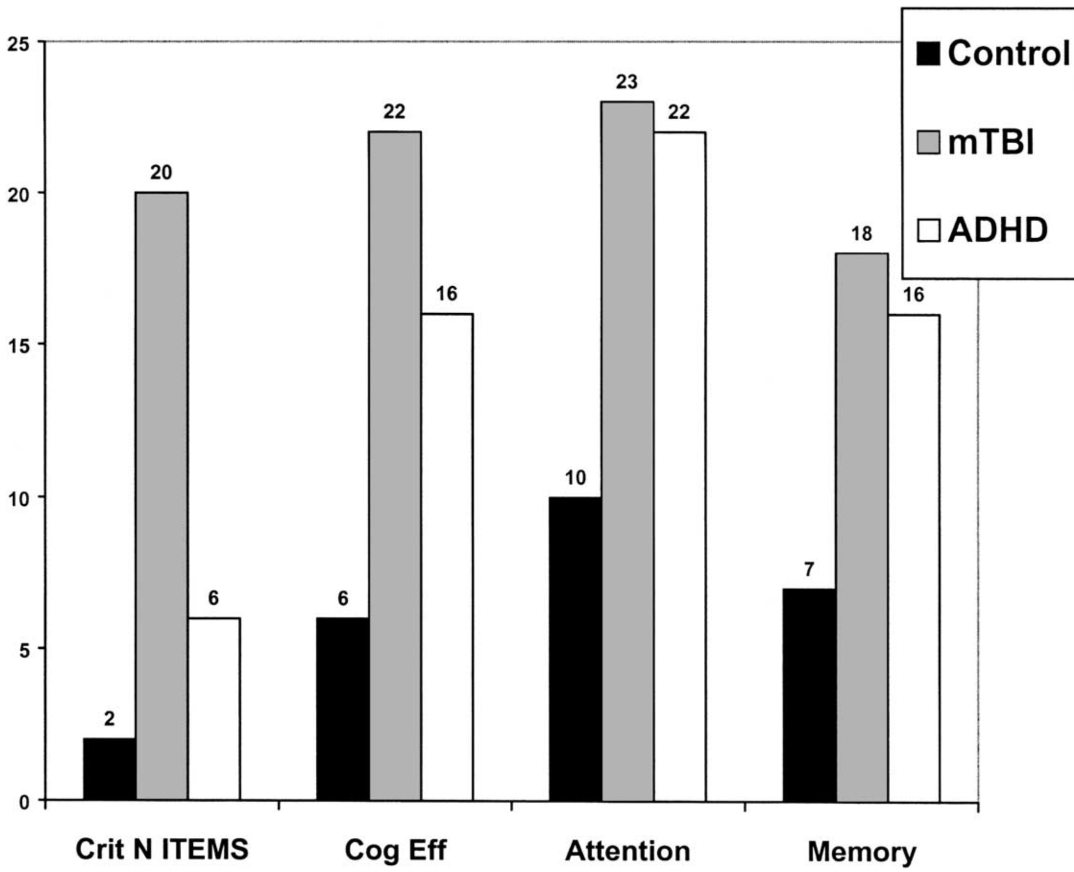


Fig. 7. Mean raw score for Critical Neurological Items, Cognitive Efficacy, Attention, and Memory self-report scales from the NIS.

For both auditory and visual presentation, there were significant deficits with RT inconsistency and variability (focus) in mTBI and ADHD groups. The variability of auditory RT has not been described previously for mTBI or ADHD groups and the level of deficit was similar to visual presentation. For the mTBI group, the results are consistent with previous research on a visual choice CPT (Arcia & Gualtieri, 1994; Collins & Long, 1996; Stuss et al., 1989) and the GDS (Burg et al., 1995) as variability appears to be a significant factor in persons with mTBI (Stuss et al., 1989). For the ADHD group, the result of high variability for visual RT is consistent with the result of Arcia and Gualtieri (1994). RT variability was described as "wondering attention" by Stuss and Benson (1984) in that the person is fully alert and cooperative, but distracted by external or internal stimuli resulting in processing speed fluctuation throughout the task. Secondary to the variability on tasks, processing speed may be quick at times while slow at other times. The person with high RT variability may or may not notice the changes in attention, but this problem has a large effect on the other characteristics of attention (Lezak, 1995). Professionals and significant others of a person with slow or variable RT may

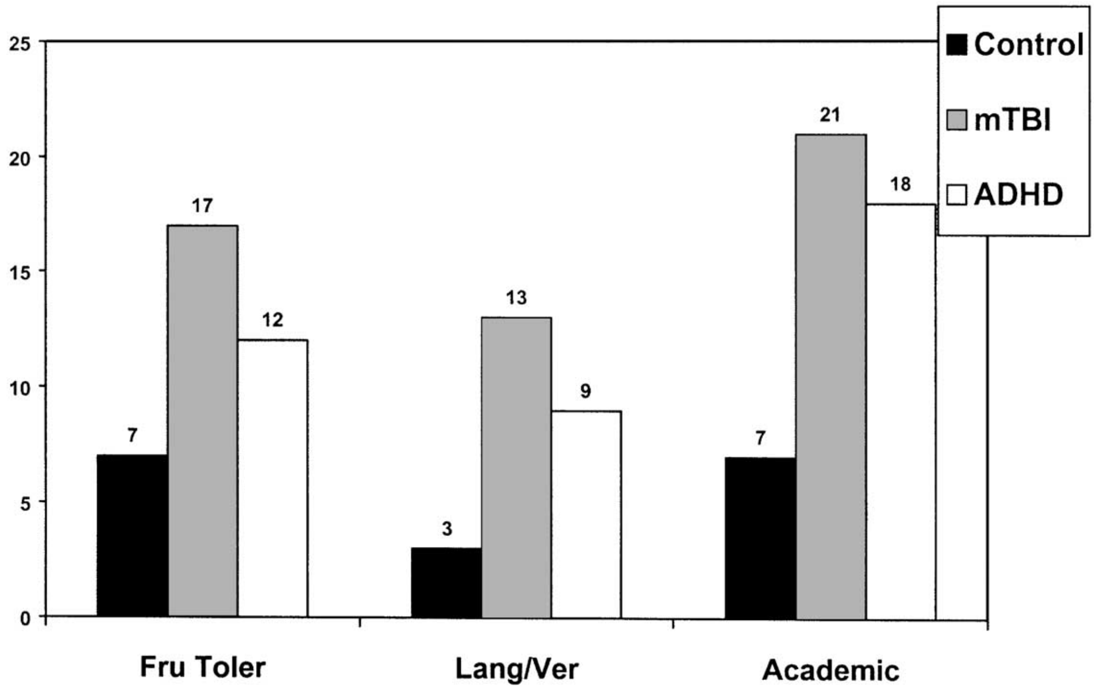


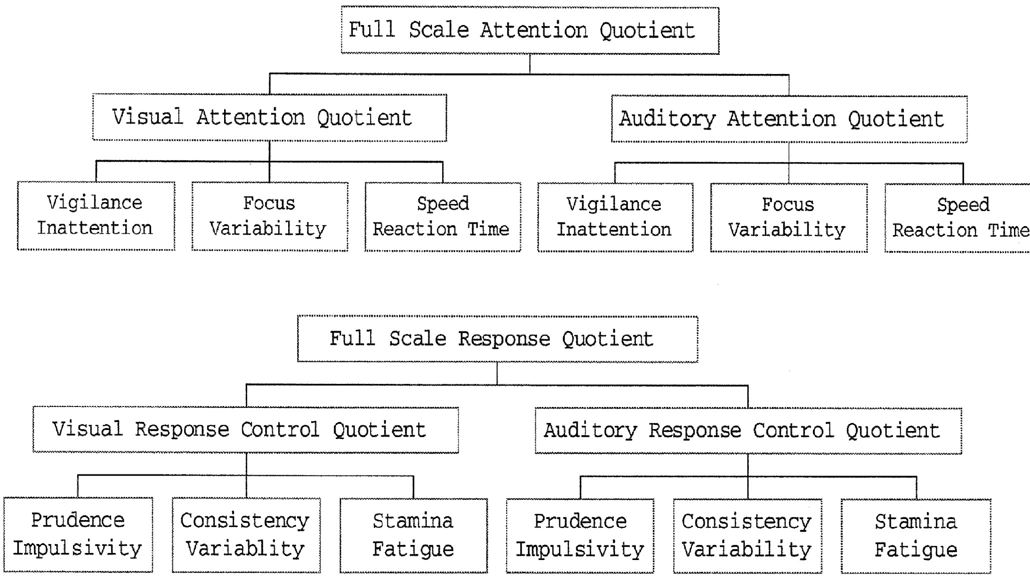
Fig. 8. Mean raw score for Frustration Tolerance, Language–Verbal Learning, and Academic self-report scales from the NIS.

attribute these changes to poor effort, lack of motivation, anxiety, or depression. In sum, RT data may provide an additional measure of cognitive functions and increase the accuracy of decisions regarding the presence and the extent of brain damage (Western & Long, 1996), and these changes are easier to measure with a computer. Further, auditory RT and variability of RT measured with a computer are an additional measure of cognitive functioning in a neuropsychological evaluation of persons with mTBI and ADHD.

Inattention deficits (vigilance) were found for auditory presentation in mTBI and ADHD groups and for visual presentation in the mTBI group suggesting internal or external distraction during the task. For the ADHD group, deficits in auditory and visual inattention had not been described on a computer-administered CPT. For the mTBI group, the inattention is consistent with the results of Burg et al. (1995) for visual presentation. Auditory inattention was not impaired for the mTBI group and may suggest greater visual distraction or problems in the mTBI group. Inattention is a problem in which the person "misses" or does not register information into his or her working memory for further processing. These individuals spend more time on work or school tasks trying to catch up or figure out what information they missed (due to the inattention) and as a result, the processing of information is delayed, stalled, or they become overwhelmed. Also, there were deficits noted on measures of impulsivity. Both mTBI and ADHD groups showed more impulsivity (prudence) on auditory and visual presentation, suggesting significant deficits with quick selection of stimuli for accurate response on the task. These individuals fail to efficiently discriminate between stimuli and their performance fails. The error is ignored and the importance is placed on a quick performance regardless of accuracy. Similarly, the comprehension scales showed that the mTBI and ADHD groups had more unusual movement or mouse clicks while completing the IVA. The readiness scale found that the difference in performance was not due to the presentation sequence of the stimuli. Consistent with the conclusions of Stuss et al. (1989), there is an inability to suppress an automatic response when a conflicting response is presented on focused attention tasks. The failure to suppress automatic responses interferes with performance and directly impacts accuracy. Finally, fatigue as defined by the IVA (stamina) was not different in the clinical groups consistent, with the results of Stuss et al. who found little evidence for fatigue on a simple RT measured over 1 h after mTBI.

The first hypothesis was false as the mTBI and ADHD groups showed similar deficits in regard to focused attention, sustained attention, divided attention, and alternating attention as measured by the IVA CPT (Fig. 9). Although the mTBI group scored lower than the ADHD group on the full scale and secondary IVA scores, the difference was not statistically significant. There was no pattern of full, secondary, or individual visual or auditory scales that could differentiate the mTBI and ADHD groups. For the mTBI group, length of time since injury was not related to full scale attention performance consistent with two other studies that found no relationship between the length of time after mild (Stuss et al., 1989) and severe TBI (Loken et al., 1995) and CPT performance. Age, education, and FSIQ were not correlated with the IVA CPT scores for the control and mTBI groups. The IVA CPT measures a cognitive function different from intelligence for the control and mTBI groups. Persons in the ADHD group performed better on full scales attention if they were older, more educated, and had greater levels of intelligence on the WAIS-R. This would suggest that individuals with ADHD may have adapted to their attention problems over the years as attention and intelligence become related concepts in persons with ADHD.

The second hypothesis was true as the self-report neuropsychological symptoms differentiated the mTBI and ADHD groups. The mTBI group reported more symptoms than the ADHD group on the Global Measure of Impairment and Total Items Checked. For specific clinical scales, the mTBI group reported more problems on Critical Neurological Items, Cognitive Efficiency, Frustration Tolerance, and Language–Verbal Learning than the control group and the ADHD group, but similar scores on to the ADHD group on clinical measures of Attention, Memory, and Academic problems. Despite these differences between groups, the NIS scales did not predict performance on the Full Scale Attention Quotient or Full Scale Response Quotient of the IVA for all three groups. Errico, Nixon, Parsons, and Tassey (1990) found that the NIS scales did not predict performance on neuropsychological tests, but were correlated with the Beck Depression Inventory (Beck, 1967) and the Spielberger State–Trait Inventory (Spielberger, Gorsuch, & Lushene, 1970) in a group of alcoholics. They suggested that the NIS might measure “affective” components rather than neuropsychological dysfunction. Alternatively, the results of this study with a control group suggest that the NIS measures a person’s perception of functioning in multiple situations where attention may play an unnoticeable role in performance. The subtle changes in attention measured by a CPT may not be perceptible enough to be self-reported on standard scales or not sampled in a self-report scale. In other words, the common variance accounted for by neuropsychological tests of attention may only



SCALE	DESCRIPTION
Fine Motor Hyperactivity	Off-task movement and button presses with mouse
Balance	Ratio of visual RT to auditory RT
Validity Scales	
Readiness (auditory & visual)	Ratio of average RT infrequent to frequent 1's
Comprehension (auditory & visual)	Random and inconsistent responses
Sensory/Motor (auditory & visual)	Mean of the 3 fastest Warm Up or Cool Down RT's
Persistence (auditory & visual)	Ratio of Cool Down to Warm Up mean RT

Fig. 9. Descriptions of scales measured in the IVA CPT.

account amount to a small proportion of the total variance of self-rating scales (Spreen & Strauss, 1998).

Although the present results support the suggestion that a CPT task can make a significant contribution to neuropsychological testing (Collins & Long, 1996; Spreen & Strauss, 1998; Western & Long, 1996), the IVA cannot differentiate between mTBI and ADHD groups. The lack of a relationship between IVA CPT performance and self-report found the third hypothesis to be false. The interview, CPT, and self-report scale measure different areas of functioning. Self-report scales cannot be used for the sole means of evaluating attention or memory (Larrabee & Crook, 1996). However, self-report scales may be helpful to differentiate between the mTBI and ADHD groups. The effect of variables such as motivation and awareness of neuropsychological deficits on CPT performance needs to be described. There is no data to help identify what IVA scales differentiate an individual with mTBI from an individual with mTBI with premorbid diagnosis such as a CVA or a learning disability. This study does not provide information to describe how many IVA scales need to be below average for a diagnosis of attention problems to be made. Clearer definition of ADHD and mTBI subgroups based upon clinical impression and diagnostic criteria, MRI, or PET Scan results or statistical analysis may help identify patterns on the IVA that may distinguish between mTBI and ADHD groups.

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