# Summary of IVA-2 Research Studies

The IVA+Plus and IVA-2 test procedures, structure and quotient scales are the same. Since the test itself, including the norms, have not changed, all of the original reliability and validity research studies for the IVA+Plus apply to the IVA-2. In the discussion below of the relevant research this instrument will be referred to as the IVA CPT. Five diagnostic validity studies are discussed below for children, adults and clinical populations. Further studies that document the effectiveness and value of the IVA CPT in research are available at www.braintrain.com.

### IVA-2 Test Construct Validity

The IVA-2 has a construct validity based on the well establish Continuous Performance Test (CPT) model. This model has been extensively researched and when fully implemented consists of both high and a low demand components. In high demand conditions the test taker is required to rapidly respond to targets that are frequently presented with occasional non-targets. The primary purpose of the high demand test phase is to measure impulsivity (i.e., clicking to the non-target proceeded by a series of targets). In contrast, the low demand condition is incorporated in order to assess inattention. In the low demand condition the non-targets are frequent and targets rarely presented; requiring the test taker to sustain attention throughout this inherently boring task. Both high and low demand conditions are included in the IVA-2 test construction and they alternate every 50 trials. In addition, the IVA-2 is the only CPT that integrates both visual and auditory test stimuli and, thus, does not require the administration of two separate sensory modality tests. Whereas, many individuals taking a CPT can learn to expect after a number of targets of the same sensory modality are presented that soon there will be a non-target and vice versa for the low demand condition, it is extremely challenging to apply this type of test taking strategy to the IVA-2 when presented with inter-mixed visual and auditory test stimuli. This unique construct design of the IVA-2 forces each person to pay close attention to each test item and any wavering of attention is very likely to result in either an error of impulsivity or inattention. This unique test construction design contributes to the high level of sensitivity and specificity found in the research studies discussed below.

### Neuropsychological, QEEG and fMRI IVA CPT Validation with Adults

There are three significant studies that have been published that support the diagnostic validity of the IVA CPT based on published neuropsychological, QEEG and fMRI research studies. First, a study by Tinius (2003) found that adults with both mTBI and ADHD scored significantly lower on the global measures of attention and response accuracy than a control group without any identified impairments. These individuals showed specific impairments of reaction time, inattention, impulsivity, and variable in their response times to test targets. The author concluded that the IVA CPT was found to validly measure both attentional and response control impairments, because it did significantly differentiate two clinical adult groups with known cognitive deficits based on a comprehensive neuropsychological evaluation from a non-clinical “normal” population.

The second study by White et al., (2005) showed that the IVA CPT is significantly correlated with QEEG measures that are known to be diagnostic indicators of ADHD. This indicator is called the Theta/Beta ratio and it is an identifier used in an FDA approved EEG test for ADHD. The IVA CPT's Full Scale Attention quotient was correlated .78 ($p<.007$) with the Theta/Beta ratio of individuals diagnosed as having ADHD based on a comprehensive psychological evaluation. In addition, this study did not find that the Pace Serial Addition Test and the Wisconsin Card Sort tests significantly differentiated ADHD and control groups. The findings of this study provided QEEG validation of the IVA CPT and to date no other CPT has been validated using this diagnostic methodology.

The third study provided fMRI validation of the IVA CPT (Ghaziri et al., 2013). This study found significant positive correlations of fMRI measurements of white matter, ranging from .66 to .68, in brain regions associated with sustained attention and the IVA CPT measure of visual attention. In addition, individuals receiving neurofeedback significantly enhanced their IVA CPT global Full Scale attention in comparison to a sham neurofeedback control group ($p<.005$).

In conclusion, the IVA CPT has been independently validated for adults with neuropsychological assessments, QEEG measurements of impaired attention, and fMRI brain regions involved in the ability to develop sustained attention. These studies provide strong evidence of the clinical sensitivity and validity of the IVA CPT for measuring attentional functioning, because of its significant correlation with the underlying psychophysiological inter-neuronal connections in the brain's network involving attention and response control abilities.

**Diagnostic and Concurrent IVA CPT Validity Study with Children**

To date, most computerized CPTs are visual, leaving out the assessment of possible auditory impulsivity and inattention problems associated with ADHD. There has been an assumption that there are no significant differences between auditory and visual CPTs, but research by Taylor (1994) found that "normal" college students were significantly more impulsive on auditory as compared to visual CPT tasks. The concurrent and diagnostic validity of the IVA CPT, which includes both auditory and visual measures of impulsivity and inattention, was explored in this study (Fine, Goldman, & Sandford, 1995). The purpose of this research was to determine whether the IVA CPT's diagnostic accuracy was sufficient that it would be clinically valid to use routinely for individual assessments. This study was completed by Fine

The first group was 26 children (22 boys and 4 girls) between the ages of 7 to 12 years old who were diagnosed by a physician or psychologist as having ADHD. The second group was comprised of 31 children (17 boys and 14 girls) who were 7 to 12 years old, except for one 15 year old. This second group was selected as a "normal" comparison group based on the parental report that these individuals were not identified to have any neurological, learning, emotional, or ADHD related problems. All subjects were volunteers.

The test instruments used included the IVA CPT, the Gordon CPT, the TOVA CPT, the CPRS-39 ADHD rating scale and the Children's Attention Scale (CAS). A standardized procedure was utilized in administering the CPTs, as described in their respective

 

manuals. The CPTs were given in a counterbalanced order to control for fatigue effects. The rating scales were completed by one parent.

Diagnostic discriminative validity was evaluated by comparing the accuracy of the IVA CPT to diagnoses made by a physician or psychologist who had independently evaluated the child previously. IVA CPT's overall accuracy was found to be significant ($p<.0001$).

**Table 1a. IVA CPT Classification of ADHD and non-ADHD groups**

| | **Clinically Dx ADHD** | **Parent Rating Non-ADHD Dx** |
|---|---|---|
| **IVA CPT ADHD Dx** | 24 | 3 |
| **IVA CPT Non-ADHD Dx** | 2 | 28 |
| **Total** | 26 | 31 |

**Table 1b. Diagnostic Accuracy of the IVA CPT Test for ADHD**

| | **Diagnostic Accuracy** |
|---|---|
| **Sensitivity** | 92% |
| **Specificity** | 90% |
| **Positive Predictive Power** | 89% |
| **Negative Predictive Power** | 93% |

The Sensitivity (proportion of ADHD children who are found positive on the measure) of IVA CPT was 92%. The Specificity (proportion of non-ADHD children who received a negative finding on the measure) of IVA CPT was 90%. The Positive Predictive Power (the proportion of test positives that have ADHD) of IVA CPT was 89% and the Negative Predictive Power (the proportion of test negatives that do not have ADHD) was 93%

Concurrent validity was examined by comparing the children identified by IVA CPT to be ADHD in relationship to those ADHD children which were identified as positive by the other diagnostic instruments.

**Table 2. Percent of Agreement of IVA CPT's Dx of ADHD with the Dx of ADHD made using other test instruments**

| | TOVA+ | GORDON+ | CPRS-39+ | CAS+ |
|---|---|---|---|---|
| **IVA CPT+** | 90.0% | 100.0% | 91.7% | 100.0% |

The comparative accuracy of the various diagnostic instruments was assessed by examining their false negative rates. The criterion reference for this comparison of diagnostic accuracy was the pre-study clinical diagnosis.

**Table 3. Percent of False Negatives by Test Instruments when compared to the Dx of ADHD made by Clinicians**

| | IVA CPT | TOVA | GORDON | CPRS-39 | CAS |
|---|---|---|---|---|---|
| **False Negative** | 7.7% | 12.5% | 36.0% | 45.5% | 59.1% |

These results demonstrate that the IVA CPT has sufficient sensitivity (92%) and positive predictive power (89%) to be clinically useful in the diagnosis of ADHD in children on an individual basis. In the case of normal children populations, IVA CPT has an acceptable rate of false positives (less than 10%). IVA CPT had the lowest rate of false negatives among these test instruments, which previous research had shown was a major weakness of visual only CPTs. IVA CPT was also found to have excellent concurrent validity for both CPTs and parental ADHD rating scales. This validity research supports the conclusion that IVA CPT is an accurate cognitive test which can provide important objective data as part of a comprehensive evaluation of ADHD with children.

### IVA CPT and ADHD Rating Scale Clinical Population Diagnostic Validity Study

The clinical usefulness and diagnostic validity of combining the IVA CPT and ADHD Rating scales was explored in a study of a clinical population of equal sex and matched ages over a wide age range. While the IVA CPT provides an objective measure of attention and response control in a quiet, structured environment, ADHD rating scale scores can help clinicians evaluate an individual’s functioning in school, home and social/work environments. More distractions and off-task behavior can more easily occur in these settings. In addition, many individuals who are hyperactive will often show these types of ADHD symptoms when required to sit still over longer periods of time. Consequently, an evaluation of ADHD symptoms may prove clinically more

 

accurate when the IVA CPT is used in conjunction with ADHD rating scales as part of a comprehensive evaluation for the typical types of clients seen in clinical practice..

In this study thirty clients previously diagnosed by Dr. Sandford as having a primary diagnosis of ADHD were selected. His diagnosis was based on a full evaluation including comprehensive psychological testing and ADHD rating scales. These clients had volunteered and given permission to have their clinical test data used in this study. These data records were de-identified. The patient data used in this study were selected from patients seen between the years of 2001 and 2011. Fifteen of these individuals were male, and fifteen were female. The ages ranged from 6 to 55, and the mean age was 17.1. Most of these individuals were diagnosed solely as having ADHD, but a few had a secondary diagnosis of Cognitive Disorder, Not Otherwise Specified. In these cases they were found to have significant cognitive processing problems in addition to their attentional deficits. Thirty individuals from the normative database, matched by age and sex, were randomly selected for comparison to this group. None of these individuals from the normative group were identified as having been diagnosed with ADHD, having ADHD-type symptoms, or having any other factors likely to impair their test functioning.

The ADHD diagnoses derived from the IVA-2 using the flowchart diagnostic algorithm were compared to the clinical diagnosis, which was based on a full evaluation including diagnostic intake evaluation and comprehensive psychological testing; including ADHD rating scales and a clinical interpretation of the IVA CPT. A comparison of the clinical diagnosis and the IVA CPT diagnosis for ADHD is presented below in Table 1a and 1b.

**Table 1a. Comparison of Clinical Diagnosis and IVA CPT Diagnosis for ADHD**

| | | **Clinical Diagnosis** | | |
|---|---|---|---|---|
| | | **ADHD** | **No ADHD** | **Total** |
| **IVA CPT Diagnosis** | **ADHD** | 24 | 5 | 29 |
| | **No ADHD** | 6 | 25 | 31 |
| | **Total** | 30 | 30 | 60 |

 

**Table 1b. Diagnostic Accuracy of the IVA CPT Test for ADHD**

| | Diagnostic Accuracy |
|---|---|
| **Sensitivity** | 80% |
| **Specificity** | 83% |
| **Positive Predictive Power** | 83% |
| **Negative Predictive Power** | 81% |

The diagnostic accuracy of the IVA CPT test by itself showed that it was able to correctly identify about four out of five individuals who had been clinically diagnosed as having ADHD. The results in this second study also showed that the test misdiagnosed about one out of five individuals who did not have ADHD as having ADHD. Generally, rating scales are used by many clinicians to provide data in determining a diagnosis of ADHD. Thus, it is useful to compare the accuracy of the IVA CPT test to the accuracy of rating scales reported in the research literature in order to clinically evaluate the relative accuracy of it.

In this diagnostic validity study, the question was also addressed as to whether the IVA CPT test results in combination with the rating scales may further help clinicians in accurately diagnosing ADHD. The IVA CPT and rating scale data were combined in diagnosing ADHD. If either of these two methods supported a diagnosis of ADHD, then that diagnosis was assigned. There was no rating scale data for the normative population, so for the normative population, only the IVA CPT results were used in determining a diagnosis of ADHD. The results of the IVA CPT and rating scale diagnoses in comparison to the clinical diagnosis are presented below in Tables 2a and 2b.

**Table 2a. ADHD Dx compared with the IVA CPT and ADHD Rating Scale Combined Dx**

| | | Clinical Diagnosis | | |
|---|---|---|---|---|
| | | **ADHD** | **No ADHD** | **Total** |
| **IVA CPT & Rating Scale Combined Diagnosis** | **ADHD** | 27 | 5 | 32 |
| | **No ADHD** | 3 | 25 | 28 |
| | **Total** | 30 | 30 | 60 |

**Table 2b. Diagnostic Accuracy of the IVA CPT and ADHD Rating Scale Combined Dx for ADHD**

| | Diagnostic Accuracy |
|---|---|
| **Sensitivity** | 90% |
| **Specificity** | 83% |
| **Positive Predictive Power** | 84% |
| **Negative Predictive Power** | 89% |

The combination of the IVA CPT test results and the rating scales increased the overall sensitivity by 10%. The specificity remained the same. The positive predictive power increased by 1%. The negative predictive power improved by 8%. Clinicians using the IVA CPT in combination with ADHD rating scales would be able to diagnose individuals with ADHD and without ADHD with an overall accuracy of 90%.

This validity study differs from the first validity study discussed above in a number of ways. This first study only examined the diagnostic validity of the IVA CPT by itself for use with children suspected of having ADHD. The subjects in the first study were mostly boys (85%) and the age range was 7 to 12 years old. In the second validity study subjects were selected so that number for each sex was equal and the age range was much wider (ages 6 to 55). The Sensitivity in the first study was 92% in comparison to the IVA CPT's Sensitivity with a mixed age clinical group of 80%. It is likely that this difference is due in part to what appears to be the greater sensitivity of the IVA CPT in identifying ADHD symptoms of young boys. In addition, the second study included subjects who had presented for general clinical treatment and not just for ADHD, but with ADHD-type symptoms pertaining to other diagnoses. Thus, the diagnostic validity for using both the IVA CPT and ADHD rating scales with clinical populations of all ages is evident in this study by the diagnostic sensitivity of 90% for identifying ADHD and at the same time the ability to classify 89% of individuals who did not have ADHD.

### IVA CPT Test-Retest Reliability Study

Joseph A. Sandford, Ph.D. completed a reliability study of IVA+Plus in conjunction with Philip Seckler, M.S., William Burns, Ph.D., and Doil Montgomery, Ph.D. from NOVA Southeastern University. This study was included as part of Dr. Seckler’s dissertation.

Reliability refers to the consistency of test score performance for repeated testing by an individual under similar conditions. A test-retest reliability study of IVA CPT was completed by BrainTrain in conjunction with NOVA University. This type of reliability test provided an index about the stability of IVA CPT test scores over time (Anastasi, 1988) that allows therapists to be confident that the changes observed in scores reflect differences in a person's performance and are not solely due to random errors. If the

 

IVA CPT test results are found to be consistent over time, then they can be practically used in clinical diagnostic decision making and in the evaluation of medication and/or treatment effects. The purpose of this study was to determine the test-retest reliability of the 22 raw scale scores and the derived six composite quotient scales. The composite quotient scores are based on the raw scores of selected relevant scales and statistically derived.

A total of 70 individuals without identified problems of neurological, current psychological, learning, attention or self-control problems were given the IVA CPT on two separate occasions. The age range of volunteers was 5 to 70 years old and the mean age was 21.8 years. Sixty percent of these individuals were females and 40% were males. All subjects were volunteers. A standardized procedure was utilized in administering the IVA CPT, as described in its manual.

The first way to assess test reliability is to determine if the test scores significantly change when the same person is re-tested. The IVA CPT Reliability study shows very small practice effects for the subjects who completed the IVA CPT on two separate occasions. Only the Full Scale and Visual Attention quotient scores significantly changed ($p<.03$ and $p<.003$, respectively). The other four global scales showed no significant practice effect change. It needs to be noted that the Full Scale Attention (FAQ) quotient score improved by a mean of 2 points and the improvement for the Visual Attention (VAQ) quotient was 3 points on average. This increase of between two to three quotient points is the same practice effect reported in various studies for the WISC-III Verbal IQ test scores. The WISC-III Performance IQ test scores had a much greater practice effect of 11-13 points. Thus, the IVA CPT quotient scores showed very little change on the second test administration and the change observed was less than what has been observed in re-testing of IQ.

A second way to analyze a test's reliability is to examine the scale score correlations between the two test administrations. All of the correlations between the two IVA CPT test administrations were significant for the Global scales and for all except one of the key primary scales. These correlations were rated as Strong for the Global Attention scales FAQ, AAQ and VAQ (.66 to .75) and mild to moderate for the Response control scales (.37 to .41). Almost all of the main key primary scales had strong correlations (.52 to .88), but the two Stamina scales both had weak correlations (.18 to .26). On the second test administration the subjects probably lost interest in maintaining their effort and were slower in their reaction time as the test proceeded. It was the Stamina scale that loads on the Global Response Control scales and accounts for being lower. Thus, the scale quotient score changes and the overall correlation test re-test findings support that the IVA CPT has good test reliability.

All IVA CPT composite quotient scores showed significant correlations for test-retest scores, demonstrating the stability of this test over time. The correlations ranged from .37 to .75. The response control quotients had correlations which showed a moderately strong positive relationship and the attention quotient score correlations demonstrated

 

very strong positive relationships. Given that the scores for many of the IVA CPT primary scales for this "normal" population showed very low error rates (1% to 6%), the relatively high correlations obtained further reflect the stability of the IVA CPT test. The analysis of the 22 IVA CPT scale raw scores found 20 scales had significant positive relationships and 18 out of these 20 correlations showed a moderately strong to very strong relationship (.46 to .88). Thus, the IVA CPT was found to be a significantly stable measure of performance in many ways both globally and in terms of specific scales.

Five tables are presented below which summarize the data of this reliability study.

**Table 1.**

**The Means and SD of IVA CPT Composite Quotient Scores for Test 1 (T1) and Test 2 (T2)**

| Scale | Mean T1 | Std Dev | Mean T2 | Std Dev |
|---|---|---|---|---|
| FRCQ | 101.12 | 13.53 | 103.41 | 13.50 |
| ARCQ | 101.94 | 13.70 | 103.32 | 14.25 |
| VRCQ | 100.17 | 13.58 | 102.88 | 14.77 |
| FAQ | 104.43 | 10.85 | 106.72 | 12.97 |
| AAQ | 104.54 | 11.07 | 105.64 | 14.04 |
| VAQ | 103.69 | 12.10 | 106.83 | 11.88 |

**Table 2.**

**The Pearson *r* for the Test-Retest of the IVA+Plus Composite Quotient**

| Scale | Correlation (r) | Sig. 2 tail |
|---|---|---|
| FRCQ | 0.41 | p<.01 |
| ARCQ | 0.39 | p<.01 |
| VRCQ | 0.37 | p<.01 |
| FAQ | 0.74 | p<.01 |
| AAQ | 0.66 | p<.01 |
| VAQ | 0.75 | p<.01 |

**Table 3.**

**The Pearson *r* for the Test-Retest of the 22 IVA+Plus Scale Raw Scores in Rank Order of Lowest to Highest Correlations**

| Scale | Correlation (r) | Sig. 2 tail |
|---|---|---|
| RWCA | 0.02 | n.s. |
| STMV | 0.18 | n.s. |
| STMA | 0.26 | p<.05 |
| VIA% | 0.32 | p<.01 |
| RWCV | 0.34 | p<.01 |
| RFRA | 0.46 | p<.01 |
| RFRV | 0.47 | p<.01 |
| CONV | 0.52 | p<.01 |
| SMA | 0.58 | p<.01 |
| PRV% | 0.61 | p<.01 |
| PRA% | 0.64 | p<.01 |
| FOCV | 0.65 | p<.01 |
| FOCA | 0.68 | p<.01 |
| CONA | 0.68 | p<.01 |
| RVAC | 0.69 | p<.01 |
| CMPA | 0.70 | p<.01 |
| SMV | 0.70 | p<.01 |
| VIV% | 0.71 | p<.01 |
| HYP | 0.80 | p<.01 |
| CMPV | 0.80 | p<.01 |
| MNA | 0.87 | p<.01 |
| MNV | 0.88 | p<.01 |

**Table 4.**

**The T-Test Probability and Percent Change for the Test-Retest of the IVA Composite Quotient Scores**

| Scale | Diff T2 – T1 | Change % | Prob. |
|---|---|---|---|
| FRCQ | 2.29 | 2.26% | 0.195 |
| ARCQ | 1.38 | 1.35% | 0.456 |
| VRCQ | 2.71 | 2.71% | 0.159 |
| FAQ | 2.29 | 2.19% | 0.033 |
| AAQ | 1.10 | 1.05% | 0.391 |
| VAQ | 3.14 | 3.03% | 0.003 |

**Table 5.**

**The T-Test Probability and Percent Change for the Test-Retest of the 22 IVA Scale Raw Scores in Rank Order of Lowest to Highest Probabilities**

| Scale | Diff T2 – T1 | Change % | Prob. |
|---|---|---|---|
| CONV | 1.87 | 2.68% | 0.003 |
| PRA% | 1.64 | 1.75% | 0.008 |
| MNA | -18.57 | -3.88% | 0.008 |
| CMPA | -0.37 | -0.37% | 0.024 |
| CONA | -1.50 | -2.06% | 0.034 |
| MNV | -11.17 | -3.25% | 0.043 |
| RWCV | 6.56 | 7.09% | 0.083 |
| CMPV | -0.29 | -0.29% | 0.098 |
| RFRV | -1.94 | -2.21% | 0.131 |
| SMA | -13.73 | -7.71% | 0.143 |
| FOCV | 0.59 | 0.82% | 0.388 |
| STMA | 1.14 | 1.22% | 0.406 |
| SMV | -3.64 | -2.53% | 0.410 |
| RVAC | 0.57 | 0.80% | 0.492 |
| RFRA | 0.91 | 1.00% | 0.500 |
| HYP | -0.47 | -7.75% | 0.550 |
| VIV% | 0.20 | 0.20% | 0.608 |
| RWCA | 3.26 | 3.24% | 0.636 |
| STMV | 0.51 | 0.53% | 0.716 |
| FOCA | 0.11 | 0.16% | 0.877 |
| PRV% | 0.10 | 0.11% | 0.898 |
| VIA% | -0.03 | -0.03% | 0.933 |