Test of Variables of Attention®

PROFESSIONAL MANUAL

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T.O.V.A.® Professional Manual

Test Of Variables of Attention Continuous Performance Test

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1 Introduction to the T.O.V.A.

1.1 The History of the T.O.V.A.

The continuous performance test (CPT) is a paradigm first introduced by Rosvold, Mirsky, Sarason, Bransome & Beck in the mid-50's. Their CPT was a visual, language based, sequential A-X task in which the subject was asked to make a button press whenever they saw an "A" followed by "X" in a stream of characters presented one at a time. Since then, many CPTs have been created primarily for use in research projects, and a few have been made available commercially for researchers, schools, and clinicians.

The T.O.V.A. (Test of Variables of Attention) began life as a large rack of electronics controlling a tachistoscopic shutter and slide projector. This apparatus (nicknamed "Herman" by one of the children in an early study) was used in our earliest clinical research in 1966, focused on was then called "the Hyperkinetic Reaction of Childhood" (McMahon, Deem & Greenberg, 1970). This double blind, placebo controlled study examined the effects of three classes of medications (a psychostimulant, a tranquilizer, and a minor tranquilizer), and was one of the first to utilize a CPT as an outcome measure in research involving children.

This early CPT introduced some key features found in the T.O.V.A. The stimuli were non-alphanumeric, non-sequential, and randomly (but infrequently) presented. Even with an accuracy of only ±100 milliseconds ($\pm ms$), this early CPT showed the efficacy of a psychostimulant (dextroamphetamine) compared to a tranquilizer (chlorpromazine) in the treatment of hyperkinetic children. It is noteworthy that the classroom behavior rating scale used (the Conners' Parent-Teacher Questionnaire) was not useful in showing medication effects. This study also demonstrated the importance of measuring symptoms of inattention and hyperactivity separately, underscoring the need to develop appropriate tools to measure each set of symptoms.

Shortly after the release of the Apple II microcomputer in the late 70's, the current T.O.V.A. paradigm (infrequent followed by frequent stimulus conditions) and the electronic T.O.V.A. microswitch were developed. The new set-up was initially named the "MCA" (for"Minnesota Computer Assessment"). However, a potential copyright conflict was identified, and the MCA was renamed the "Test of Variables of Attention" or "T.O.V.A." During the 80's, the T.O.V.A. underwent wide-scale norming and was used in a number of clinical trials.

The DOS/PC version, programmed in the early 80's, continued the innovative use of two stimulus-frequency conditions and included tallies of anticipatory responses and commission errors as measures of validity. In those days, the data were sent directly to Lawrence Greenberg, MD for hand scoring and interpretation. The Macintosh version, programmed in the early 90's, and later DOS/PC versions were self-scoring, using an elaborate algorithm based on data from of some 10,000 clinical cases and numerous studies.

A distribution company, Universal Attention Disorders, Inc, was formed in 1990 with the hiring of full-time technical and clinical support services and the formation T.O.V.A. Research Foundation. The name of the company was changed in 2006 to The TOVA Company.

Since the early 1990s, the T.O.V.A. has evolved into the *Tests* of Variables of Attention, still collectively referred to as "the T.O.V.A.," but incorporating two versions, the auditory T.O.V.A.- A., and the original, visual T.O.V.A. The T.O.V.A. has continued to be upgraded with improved user friendliness, development of the School and Home Intervention Reports, expansion of the normative base to year-by-year, gender-based norms for children, and the addition of signal detection indices for comparison to an identified-ADHD sample.

The current T.O.V.A. tests measure many more components of auditory and visual information processing than do earlier CPTs. These tests are laboratory-grade tools that provide precise, direct, and objective assessment of attention and self-regulation. While many clinicians rely on behavior rating scales, rater bias and inexperience are frequent contaminants of such measures. The T.O.V.A. tests provide a tool to directly

and objectively address critical aspects of attention functioning are a vital part of any broad assessment of attention and concentration skills.

Accurate measurement of the subject's response speed and variability of response speed is crucial for a CPT to be useful. On any compatible computer system, T.O.V.A. timing errors are controlled to within ±1 millisecond (ms), an unparalleled level of precision for these key parameters. This precision is attained through a number of technical innovations, including use of a standard, precision input device (the T.O.V.A. microswitch), and a specialized software foundation that overcomes the timing issues presented by complex, graphically-based operating systems. Because of the variable number of invisible, background tasks and the inconsistent rate at which polling of standard input devices (the mouse and keyboard) occurs, no Windows-based CPT program can deliver comparable timing precision.

To attain the $\pm 1ms$ timing accuracy, the TOVA boots the testing computer to the "Precision Test Environment" (PTE). With the aide of 32-bit "helper applications," the T.O.V.A. user is seamlessly and safely transitioned from Windows into and out of the PTE as needed for T.O.V.A. administration. This critical feature–and the precision that it facilitates–is not available in any other commercially available CPT.

1.2 The T.O.V.A. Tests

The Tests of Variables of Attention (T.O.V.A.) are individually administered computerized tests developed to assess attention and impulse control in normal and clinical populations. They are commonly used in conjunction with other clinical tools or diagnostic tests in neuropsychological or psychological evaluations. The T.O.V.A. was developed to measure attention and impulse control processes in four areas: response time variability, response time, impulse control (commission errors), and inattention (omission errors).

The visual T.O.V.A.'s stimuli are two easily discriminated geometric figures centered on the computer screen. A sample of the visual target and nontarget stimuli appears in Figure 1. The stimuli are squares; some widescreen LCD panel displays may distort the images into the form of rectangles. If this occurs, we recommend that the display resolution be modified in the computer's system control panel, or that an external monitor be used to display the stimuli.

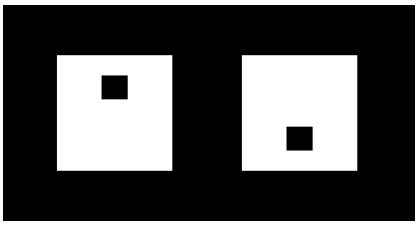

Figure 1: T.O.V.A. Stimuli, Target and Nontarget

The visual T.O.V.A. was normed using stimuli under the following conditions:

- A 12 inch (diagonally measured) monitor
- A stimulus size of roughly 3 inches (measured diagonally)
- An eye-to-monitor distance of roughly 24 - 36 inches (with an emphasis on 36 inches)
- Presentation of the stimuli at roughly eye level to the subject

These are the recommended conditions, however, monitor size, monitor resolution and distance from the subject's eyes may vary. For a typical distance from a typical display (sized 15 to 17 inches) it is recommended

that the stimuli be sized to about three inches, measured diagonally. Because it may not be always possible to achieve this with precision, an acceptable range is around 15% - 30% of the monitor's size (measured diagonally), depending on the subject's distance to the monitor and the size of the screen (the greater the distance, the larger the desired stimulus). Target size is important for the following reasons:

- Stimuli that are too small (or too far away) can be visually fatiguing. Since the T.O.V.A. is a test of attention, not visual acuity, the subject must be able to readily discerning the target and nontarget stimuli for results to be valid.
- Stimuli that are too large (or too close) require large eye sweeps to discern targets from nontargets. Eye sweeping can slow response time and be visually fatiguing. The subject should be able to see the complete stimuli and screen all at once, without having to sweep their eyes to discern the target/nontarget.

Most computer configurations are well within these parameters. However, some laptop screens may not have the capability to "expand" the T.O.V.A.'s smaller VGA testing screen resolution to an appropriate size. This can result in a "miniature screen" in the middle of a larger monitor, and the stimuli are subsequently very small on the screen. To address situations such as this, the T.O.V.A. software has built-in scale adjustment settings. There are four stimulus size options to choose from so that the one closest to the ideal settings can be selected:

- 1.0x (normal stimuli)
- 1.5x (50% larger)
- 2.0x (100% larger)
- 2.5x (150% larger)

It is recommended that if possible, the user select an option that most closely approximates the three inches diagonal measurement or 25%-of-screen rule. If, on a laptop screen, the stimuli are outside the recommended range, we again recommend the use of an external monitor for T.O.V.A. testing so that proper conditions can be achieved.

Stimuli for the auditory T.O.V.A.- A. are two easily discriminated audible tones: the target is G above middle C, and the nontarget is middle C, played though external speakers connected to the computer.

In both versions of the T.O.V.A., a stimulus is presented for 100 ms at 2000 ms intervals. The target stimulus is presented in 22.5% ($\underline{n} = 72$) of the trials during the first half of the test (stimulus infrequent condition) and 77.5% ($\underline{n} = 252$) of the trials during the second half (stimulus frequent condition). The subject is instructed to respond to the target as quickly as possible. The varying target-nontarget ratio allows for the examination of the effects of differing response demands on response time variability, response time, inattention and impulsivity.

Specifically, quarters 1 and 2, representing the first half or stimulus infrequent condition, have 36 targets out of 162 stimuli per quarter (ratio of 1:3.5). Quarters 3 and 4, representing the second half or stimulus frequent condition, have 126 targets out of 162 stimuli per quarter (ratio of 3.5:1; see Table 1.) The targets are presented in a fixed, random sequence per quarter. The first half scores refer to the subject's performance across quarters 1 and 2 combined, and the second half refers to the combined scores for quarters 3 and 4. The total score reflects subject's performance over the entire test. The total test time of 21.6 minutes, which equates to 10.8 minutes per condition or half, and 5.4 minutes for each of the four quarters.

The T.O.V.A. software automatically records the subject's responses, nonresponses, and reaction times and then calculates raw scores, standard scores, and percentages. The T.O.V.A. Interpretation Report provides

Table 1: Test Stimuli Breakdown

	Quarter				Half		Total
	1	2	3	4	1	2	
# Targets	36	36	126	126	72	252	324
# Nontargets	126	126	36	36	252	72	324

standard scores for each variable by quarters, halves, and totals, and provides printable reports displaying the subject's results in narrative and graphic forms.

In addition to the primary attention variables, secondary indices provide information about the subject's performance in several ways: (a) anticipatory responses, (b) multiple responses, (c) post-commission response time and response time variability, (d) d' (d-prime), or discriminability, and (e) beta, or response style. A discriminate function measure comparing the current subject's performance to a known-ADHD group, the ADHD Score, is also provided.

1.2.1 T.O.V.A. Variables and Scoring

The following section provides explanatory information on each variable along with the formulas used to calculate the scores.

Response Time Variability is a measure of the variability in the subject's reaction time for accurate responses; that is, the consistency of their speed of responding. The Response Time Variability score is based on the standard deviation of the mean correct response times.

The Response Time Variability formula is:

$$\text{Response Time Variability} = \frac{\Sigma(\text{ Response Times - Mean Correct Response Time})^2}{\text{\# Correct Responses}} \tag{1}$$

Response Time is the average time it takes the subject to respond correctly to a target. Specifically, it is the amount of time from when a target is presented, to when the microswitch is pressed by the subject. The Response Time score is the average of correct response times, in which the sum of all correct responses times are divided by the number of correct target "hits," and is reported by quarter, half and total.

The Response Time formula is:

$$\text{Response Time} = \frac{\Sigma \text{ Correct Response Times}}{\text{\# Targets}} \tag{2}$$

Errors of Commission occur when the subject fails to inhibit responding and incorrectly responds to a nontarget; that is, the subject presses the button after a nontarget is presented. The commission score is calculated as the ratio of the subject's incorrect responses to nontargets to the number of nontargets presented, minus the number of anticipatory responses made to nontarget stimuli. Commission errors are considered a measure of impulsivity or behavioral disinhibition.

The formula used to calculate the commission percentage is as follows:

$$\text{Errors of Commission (or Impulsivity/Disinhibition)} = \frac{\text{\# Commissions}}{\text{\# Nontargets} - \text{\# Nontarget Anticipatory Responses}} \times 100 \tag{3}$$

Errors of Omission occur when the subject does not respond to the designated target; that is, the subject fails to press the T.O.V.A. microswitch button when a target is presented. Omission scores are calculated as the ratio of correct responses to targets, divided by the number of targets presented, minus the number of anticipatory responses to targets. Omission errors are considered a measure of inattention.

The formula used to calculate the omission percentage is as follows:

$$\text{Errors of Omission (or Inattention)} = \frac{\text{\# Omissions}}{\text{\# Targets - \# Target Anticipatory Responses}} \times 100 \tag{4}$$

The d' (D Prime) score is a response discriminability score reflecting the ratio of hits to "false alarms". The measure is derived from Signal Detection Theory and has been shown to help distinguish non-impaired individuals from those diagnosed with attention disorders (Mussgay & Hertwig (1990). The score reflects the accuracy of target (signal) and nontarget (noise) discrimination and can be interpreted as a measure of "perceptual sensitivity." The calculation of D Prime is complex, and is detailed below.

Calculating D Prime (d')

1. Obtain the Omission and Commission percentage from the quarter, half, or total for which you wish to calculate D Prime (these can be found in the Results Table).

2. Calculate the Hit Rate and the False Alarm Rate:

$$\text{Hit Rate} = 1 - \frac{\text{Omission Percentage}}{100} \tag{5}$$

$$\text{False Alarm Rate} = \frac{\text{Commission Percentage}}{100} \tag{6}$$

- If the Hit Rate is exactly 0, then set the Hit Rate equal to 0.00001
- If the Hit Rate is exactly 1, then set the Hit Rate equal to 0.99999
- If the False Alarm Rate is exactly 0, then set the False Alarm Rate equal to 0.00001
- If the False Alarm Rate is exactly 1, then set the False Alarm Rate equal to 0.99999

3. Calculate the probabilities (called pHit Rate and pFalse Alarm Rate):

$$\text{pHit Rate} = 1 - \text{ (Hit Rate)} \tag{7}$$

$$\text{pFalse Alarm Rate} = 1 - \text{ (False Alarm Rate)} \tag{8}$$

- If the pHit Rate > 0.5, then subtract the pHit Rate from 1 - i.e., the new pHit Rate = 1 - (old pHit Rate)
- If the pFalse Alarm Rate > 0.5, then subtract the pFalse Alarm Rate from 1 - i.e., the new pFalse Alarm Rate = 1 - (old pFalse Alarm Rate)

4. Calculate the Z scores (called zHit Rate and zFalse Alarm Rate):

If you have access to a spread sheet or statistical program:

- zHit Rate = InverseDistributionFunction(pHit Rate)
- zFalse Alarm Rate = InverseDistributionFunction(pFalse Alarm Rate)
- Skip directly to Part 5

Otherwise (Ref 1),

$$\text{Let T} = \sqrt{\ln \frac{1}{\text{pHit Rate}^2}} \tag{9}$$

$$\text{zHit Rate} = T - \frac{2.515517 + 0.802853 \times T + 0.010328 \times T^2}{1 + 1.432788 \times T + 0.189269 \times T^2 + 0.001308 \times T^3} \tag{10}$$

$$\text{Let T} = \sqrt{\ln \frac{1}{\text{pFalse Alarm Rate}^2}} \tag{11}$$

$$\text{zFalse Alarm Rate} = T - \frac{2.515517 + 0.802853 \times T + 0.010328 \times T^2}{1 + 1.432788 \times T + 0.189269 \times T^2 + 0.001308 \times T^3} \tag{12}$$

- If the pHit Rate was ≤ 0.5 , multiply the zHit Rate by -1
- If the pFalse Alarm Rate was ≤ 0.5, multiply the zFalse Alarm Rate by -1

5. Calculate D Prime:

D Prime = zFalse Alarm Rate - zHit Rate

(Ref 1: Approximation to the Inverse Normal Distribution Function. The Handbook of Mathematical Functions, Abramowitz and Stegun, Section 26.2.23)

The ADHD score is a comparison between the subject's T.O.V.A. performance to an identified ADHD sample's performance. The score tells how similar the performance is to the ADHD profile.

The formula used to derive the ADHD score is as follows:

ADHD Score = Response Time Z score (Half 1) + D' Z score (Half 2) + Variability Z score (Total)

Post-Commission Response Time is the measure of time (in milliseconds) that the subject took to respond to a target immediately after a commission had been recorded.

The formula used to derive the Post-Commission Response Time is as follows:

$$\text{Post Commission Response Time} = \frac{\Sigma \text{ Post Commission Response Times}}{\#\text{ Post Commission Responses}} \tag{13}$$

Anticipatory Responses are recorded when the subject presses the microswitch within 150 ms of stimulus onset (target or nontarget), and represents the subject making a "guess" that the stimulus will be a target - in effect, they made a response after the stimulus was presented, but before they could have fully perceived and/or processed the stimulus (and known whether the stimulus actually was a target or nontarget). These responses are not included in calculations of the omission error, commission error, response time or response time variability scores. The Anticipatory Response score is used as a test validity measure, since such responses detract from both the number of correct responses possible (impacting the omission score) and from the number of commission responses possible. The number of anticipatory responses is recorded for each quarter, half and total. Note that, because subject's who make frequent commission errors tend to respond more often overall, excessive Anticipatory Responses generally result in fewer omission errors, increased commission errors, shortened response time and increased variability, and trails in which anticipatory responses occur therefore removed from calculation of other scores.

The formula used to calculate the Anticipatory percentage is as follows:

$$\text{Anticipatory} = \frac{\#\text{ Anticipatory Responses}}{\#\text{ Total Stimuli}} \times 100 \tag{14}$$

Multiple Responses occurs when a subject presses the microswitch more than once per stimulus presentation. The Multiple Response score reflects the actual sum of multiple responses by the subject, whether the stimuli are targets or nontargets. Multiple Responses differ from Anticipatory Responses in that multiple responses do not detract from any other variable.

2 Test Materials and Use

2.1 Software

The T.O.V.A. operates on most Windows-based personal computers that are equipped with a standard parallel printer port. The T.O.V.A. software is installed on the computer's hard drive and the test is administered via the computer's monitor (visual test) or via a set of speakers (auditory test).

Test administration is performed in the T.O.V.A. Precision Test Environment (PTE) since Windows-based operating systems are not appropriate for tasks requiring precise and consistent timing. The PTE allows consistent and reliable timing down to ±1 ms.

Supported T.O.V.A. Installations:

OS	Partition Type	Installer used	Environment
DOS	FAT 12/16	DOS	DOS mode Boot CD (Automatically chooses 'run DOS mode T.O.V.A. on FAT partition')
Win 95/98	FAT12/16/32	Windows	Boot from HD into DOS mode (either on startup, on restart, or a DOS Mode shortcut) Boot CD (Automatically chooses 'run DOS mode T.O.V.A. on FAT partition')
Win ME	FAT32	Windows	Boot CD (Automatically chooses 'run DOS mode T.O.V.A. on FAT partition')
Win XP/2K	FAT32 NTFS w/ FAT32	Windows	Test mode using the PTE* Test mode using the Boot CD DOS mode using the Boot CD
Win XP/2K	NTFS	Windows	Test mode using the PTE* DOS mode using MS-DOS mode

* T.O.V.A. Precision Test Environment (PTE)

Windows 2000/XP Installation Requirements:

- PC running Windows 2000 or XP
- DOS-compatible parallel port (this does not include USB parallel port adapters)
- Printing requires any Windows-compatible printer
- 5MB or more free on disk
- Requires administrative privileges to install and run

Windows 95/98/ME Installation Requirements:

- PC running Windows 95, 98, 98SE, or ME
- DOS-compatible parallel port (this does not include USB parallel port adapters)
- Printing requires a DOS-compatible parallel port printer
- 5MB or more free on disk
- Windows ME requires the use of a boot CD (or floppy disk)

DOS Installation Requirements:

- PC with x386 or better processor running MS DOS 6.22, or FreeDOS 0.9 or later

- DOS-compatible parallel port (this does not include USB parallel port adapters)
- Printing requires a DOS-compatible parallel port printer
- 5MB or more free on disk
- VGA or better graphics card
- 2 MB of memory (450 KB free conventional memory, 1 MB of XMS memory)

If you are unsure about your computer system please contact the TOVA Company Technical Support staff for assistance at (800) PAY-ATTN (729-2886).

2.2 Hardware

The T.O.V.A. requires the use of a standardized microswitch as a subject response device which is included with the software kit. Use of the T.O.V.A. microswitch removes the timing and ergonomic variability that are present with the range and variety of input devices that used in typical Windows computer configurations.

The T.O.V.A. kit also includes the T.O.V.A. Speaker Driver, which generates the auditory stimuli (tones) for the auditory T.O.V.A. test and the T.O.V.A. Scorebox, which stores the user's serial number and interpretation credits.

2.3 Sample Populations

T.O.V.A.- Visual The T.O.V.A. has been normed on children and adults, ages 4 to 80+ years. All norms are stratified by age and gender. Ages are calculated by rounding to the nearest birthday within six months.

The 4 and 5 year old normative samples were gathered using a shorter version of the T.O.V.A. test (see the Appendices for visual normative data), consisting of the infrequent stimulus condition from quarter one, and the frequent stimulus condition from quarter 3.

The full 21.6 minute test was normed on children and adults, 6 to 80+ years of age. Adult normative data are provided in decade groupings (i.e., 30 - 39 years).

Since the visual T.O.V.A. is a visual continuous performance test, use of the test with visually impaired subjects is not advised. Subjects must also be able to use the microswitch to respond to the test. The test user must ensure that subjects are able to use the microswitch prior to administering the test.

T.O.V.A.-A - Auditory

The T.O.V.A.-A. has been normed on children 6 to 19 years (see the Appendices for auditory normative data).

Since the test is an auditory continuous performance test, use of the test with subjects with auditory impairment is not advised. The subject must also be able to use the microswitch to respond to the demands of the test. The test user must make certain the subject is sufficiently able to use the microswitch prior to administering the test.

2.4 Professional Requirements

The test administrator must meet the requirements of the state in which the user practices. These requirements vary by state. It is recommended that the test user investigate laws and professional board guidelines appropriate to their state.

2.5 Test Administration

As with other assessment tools, it is important for the subject and the test user to have developed sufficient interpersonal rapport prior to test administration. The computer and /or monitor on which the test is being operated should be directly in front of the subject, at a comfortable position, easily seen by the subject.

Lighting must not produce glare on the monitor. Seating and environment must be comfortable and appropriate for the approximate half hour testing session.

Outside or environmental distractions, such as intercoms, telephones, and the like should be avoided during the test administration. Headphones may be used instead of speakers or to minimize auditory distractions.

The T.O.V.A. was normed with test administrations occurring in the morning before to 1 p.m. to avoid possible diurnal variations. If more than one test was administered, the T.O.V.A. was the first test administered. Note that test order effects have not been studied systematically.

The recommended testing procedure for repeated T.O.V.A. testing in the same day is that there be at least 1 1/2 hours in between tests to minimize the effects of fatigue. If there is less than one hour between tests, the second test should be considered invalid, and it is recommend that the test be repeated on a different day.

Note that normative data was obtained with an observer present in the room at all times during the T.O.V.A. Even though the observer (test administrator) was not interactive during the testing, the observer was physically present. We recommend that the user maintain physical presence throughout testing. If behavioral cues are needed to assist the subject in staying on task, please make note of the cues and frequency to add to the behavioral information during the testing session.

Prompting is permitted during the practice test, but not during the actual testing (unless absolutely necessary). This was the format used for the normative study. Some younger subjects may require some encouragement to continue the task, however interaction show be as minimal as possible.

Please note interactions and frequencies to add to the behavioral information obtained during the testing session. A “T.O.V.A. Observer Behavior Rating Form” is provided in the appendices.

The test administrator should be familiar with the administration instructions prior to the use of the test. To properly utilize the interpreted T.O.V.A. test profile, the administrator should be thoroughly familiar with the test scores and their meaning. Knowledge of attention processes, impulse control, cognitive processes, childhood development, medical disorders, psychiatric disorders and neuropsychological functioning is essential to the utilization of the test data.

One of the great advantages of the T.O.V.A. is that the tasks do not utilize language-based stimuli. Since the tests are not language dependent, instructions may be given in the subject’s native language.

2.6 Overview of Test Administration

The T.O.V.A. is a visual CPT. Subjects are presented with visual targets and nontargets (See Figure 1, Chapter 1). The subjects are instructed to press the microswitch as quickly as possible after seeing the target stimulus. They are instructed to not press the switch (i.e., do nothing) when they see the nontarget. The targets and nontargets are presented in two target-frequency conditions, stimulus infrequent and stimulus frequent. The stimulus infrequent condition is presented in quarters 1 and 2, and is comprised of 36 targets and 126 nontargets per quarter. The stimulus frequent condition is presented in quarters 3 and 4, and is comprised of 126 targets and 36 nontargets per quarter. The duration of the test is 21.6 minutes. Testing is usually scheduled as a half-hour session.

The T.O.V.A.-A. is an auditory CPT. Subjects are presented with auditory targets and nontargets. The auditory target sound is G above middle C, and the nontarget sound is middle C. Like the visual test, two stimulus conditions are employed, stimulus infrequent and stimulus frequent. Subjects are instructed to press the microswitch as quickly as possible after they hear the target stimulus. They are instructed to not press the switch (i.e., do nothing) when they hear the nontarget. As with the visual T.O.V.A., the infrequent stimulus condition is defined by 36 targets and 126 nontargets per quarter in quarters 1 and 2. The frequent stimulus condition is defined by 126 targets, 36 nontargets per quarter in quarters, 3 and 4. The test is 21.6 minutes in length. Testing is usually scheduled as a half hour session.

We recommend that the computer and monitor be turned on with the T.O.V.A. "booted up" and tested prior to the subject entering the test room. The examiner must enter the necessary demographic information needed to run the test (See T.O.V.A. Clinical Manual for additional assistance).

2.7 Administration of Practice Test for the Visual T.O.V.A.

The T.O.V.A. tests offer practice tests to insure that the subject understands the testing conditions and instructions. Note that, since the three minute practice test was administered before the T.O.V.A. and T.O.V.A.-A. norming data were obtained, it is recommended that it be administered before testing a subject for the first time. A quick verification of the practice summary data also ensures that the program is operating correctly before the subject starts a full session.

Prior to administering the T.O.V.A. tests, the examiner should read (or paraphrase) the following:

> "This test measures your ability to pay attention. Two different kinds of squares will flash on this computer screen. The squares will differ only in that one of them will have a small hole near the top (indicate with a picture or use DISPLAY STIMULI on screen), and one will have the hole near the bottom (indicate). We want you to press this button (indicate) every time you see the square with the hole near the top (indicate). (Find out which hand they use for writing.) I want you to hold this button in your writing hand with your thumb resting lightly on top, like this (indicate). Here... take the button. Let up when you hear the click; don't hold the button down very long. Push it down only once for each correct picture.
>
> "Now we are going to flash the squares on the screen, and your job is to press the button AS FAST AS YOU CAN every time you see a square with a hole near the top (indicate). But the trick is that you are NOT to press the button when the hole is near the bottom (indicate). Remember to press the button as fast as you can but only for the square with the hole near the top. The whole idea of this test is for you to be as fast, but also as accurate as you can. Try not to make any mistakes. But, if you do make a mistake...don't get upset, don't worry. Everyone can make a mistake on this test. Try and press the button as fast as you can but only for the square with the hole in the top. Don't be too fast – take enough time to see which picture it is. Don't guess. Once you've pressed the button, let up. Don't press it more than once when you see the correct signal. Any questions...?

> "Now we are going to have a short practice. After I press the button, you are going to see a dot appear in the middle of the screen. That's where the squares are going to appear. After the dot appears, the numbers 3...2...1... are going to appear and then the first square will flash on the screen. Remember, the whole idea is to be as fast AND accurate as you can be. Any questions...?"

2.8 Starting the Practice Test

Now start the practice. The practice test lasts 3 minutes. Observe to be sure the subject is doing it correctly and give prompts freely early in the practice test. Instruct again if necessary. Rerun practice if necessary until subject understands.

Check the practice test results to ensure the proper response recording and confirm that the subject understands the task. If errors are excessive, repeat the practice test with special instructions and/ or reinforcement that the subject is to attempt to be both fast AND accurate.

Keep notes of observations of distractibility, attentiveness, mood, compliance, activity level, style of performance, medications and dosages taken in last 12 hours, etc. A form is provided in the Appendices. These observations provide behavioral information to go with the data provided in the TOVA report.

2.9 Administering a Practice Test After the First Test

In subsequent tests with the same subject, you may run partial practice tests to remind the subject of the task and to reinforce the goals of speed AND accuracy. However, always look at the summary scores of the practice test to ensure the test is recording correctly before continuing to the full test. The recommended testing procedure for sequential T.O.V.A. testing in the same day is that there be at least 1 1/2 hours in between tests to minimize the effects of fatigue.

2.10 Administering the T.O.V.A.

After the practice test is over, slowly read the following:

> "OK, now we are going to do the test for about 20 minutes. Do the best job you can. Also, you should know that your eyes are probably going to get a little tired. Even so, try and do the best job you can... press the button as quickly as you can but only for the square with the hole in the top.
>
> "I'll be staying here while you do the test, but I can't talk to you once the test starts. Do you have any questions before we begin?
>
> "Ready, here we go... start watching the screen."

Start the test.

Observe and record if the subject is on task, and how the subject is reacting to the test. Do not prompt unless absolutely necessary; i.e., only if results will be invalid without prompting. Note if prompting was necessary. A behavioral observation form is provided in the appendices.

Observe for multiple responses to stimuli. This can be done by paying attention to the sound of the microswitch. While the test automatically records multiple responses, observation of the phenomenon for clinical correlation is advised.

When testing is completed the data will be saved. You will be returned to the main screen and ready for scoring/interpreting.

2.11 Instructions for Administering Auditory T.O.V.A.-A

2.11.1 Administration of Practice Test for the T.O.V.A.-A.

Slowly read (or paraphrase) the following:

> "This test measures your ability to pay attention. Two different kinds of notes will be heard. The notes will differ only in that one of them will be higher in pitch (DEMONSTRATE TARGET NOTE) than the other (DEMONSTRATE NONTARGET NOTE). I want you to press this button (indicate) every time you hear this sound (DEMONSTRATE TARGET SOUND)." Find out which hand they use for writing. Then continue: "I want you to hold this button in your writing hand with your thumb resting lightly on top, like this (indicate). Here... take the button. Let up when you hear the click; don't hold the button down very long. Push it down only once for each correct note.
>
> "Now we are going to play the notes, and your job is to press the button AS FAST AS YOU CAN every time you hear the high note (DEMONSTRATE). But the trick is that you are NOT to press the button when the low note is heard (DEMONSTRATE). Remember to press the button as fast as you can but only for the high note. The whole idea of this test is for you to be as fast, but also as accurate as you can. Try not to make any mistakes. But, if you do make a mistake...don't get upset, don't worry. Everyone can make a mistake on this test. Try and press the button as fast as you can but only for the high note (DEMONSTRATE). Don't be too fast – take enough time to hear which note it is. Don't guess. Once you've pressed the button, let up. Don't press it more than once when you hear the correct note. Any questions...?
>
> "Now we are going to have a short practice. When I press a key on the computer, the notes will begin. After I press the key, the numbers 3...2...1... are going to appear and then the first note will be heard. Remember, the whole idea is to be as fast AND accurate as you can be. Any questions...?"

2.12 Starting the Practice Test

Start the practice. The practice test lasts 3 minutes. Observe to be sure the subject is doing it correctly and use prompts freely early in the practice test. Instruct again if necessary. Rerun practice if necessary until subject demonstrates an understanding of the test instructions. If you wish, you can check practice results. If errors are excessive, repeat practice after discussing the instructions with the subject.

Record your observations of distractibility, attentiveness, mood, compliance, activity level, style of performance, medications and dosages taken in previous 12-24 hours, etc. A form for this purpose is provided in the appendices. These observations provide behavioral information to go with the data provided in the TOVA report.

2.13 Administering a Practice Test After the First Test

The visual T.O.V.A. and the auditory T.O.V.A.- A., both, offer practice tests to insure that the subject understands the testing conditions and instructions. The subject is to be fast AND accurate so as not to sacrifice speed for accuracy or vice versa.

Since a practice test (3 minutes) was administered before the T.O.V.A. and T.O.V.A.-A. norming data were obtained, it is recommended that it be administered before testing a subject for the first time. A quick verification of the practice summary data also ensures that the program is operating correctly before the subject starts a full session.

2.14 Administering the T.O.V.A.-A.

After practice is over (3 minutes), slowly read the following:

> "OK, now we are going to do the test for about 20 minutes. Do the best job you can. Also, you should know that you will probably get a little tired. Even so, try and do the best job you can... press the button as quickly as you can but only for the high note.
>
> "I'll be staying here while you do the test, but I can't talk to you once the test starts. Do you have any questions before we begin?
>
> "Ready, here we go... start listening."

Start the test.

Observe and record if the subject is on task, and how the subject is reacting to the test. Do not prompt unless absolutely necessary; i.e., only if results will be invalid without prompting. Record if prompted. A behavioral observation form is provided in the Appendices.

Observe for multiple responses to stimuli. This can be done by paying attention to the sound of the microswitch. While the test automatically records multiple responses, observation of the phenomenon for clinical correlation is advised.

When testing is completed the data will be saved. You will be returned to the main screen and ready for scoring/interpreting.

3 Normative Data

3.1 Overview

This chapter presents the information concerning the normative data. The chapter is divided into normative information for each test, visual and auditory. The actual normative data are found in the Appendices. The data are given in table format across variables, stratified by age and gender.

3.2 Normative Data for the Visual T.O.V.A.

Subjects:

Children - The subjects in the original normative data (Greenberg & Waldman, 1993) came from randomly selected classrooms in grades 1, 3, 5, 7 and 9. The schools were suburban public schools in or near Minneapolis, Minnesota. The ages of the children in this sample ranged from 6 to 16 years (see Table 2) and were primarily Caucasian (99%, 1% other). Subjects were excluded if they met any of the following criteria: a deviant classroom behavior rating defined by a score of greater than 2 standard deviations below average on the Conners Parent-Teacher Questionnaire, Abbreviated form; current use of psychoactive medication; or if they were receiving Special Education services. All testing was done in the mornings to control for possible diurnal effects.

Table 2: Age and Gender Distribution by Sample

Group	Original Sample	Additional Sample	Total Sample
Age 4 - 5			
Males	NA	36	36
Females	NA	36	36
Age 6 - 7			
Males	99	0	99
Females	100	1	101
Age 8 - 9			
Males	90	0	90
Females	99	0	99
Age 10 - 11			
Males	90	0	90
Females	82	0	82
Age 12 - 13			
Males	53	51	104
Females	59	59	118
Age 14 - 15			
Males	41	74	115
Females	56	50	106
Age 16 - 17			
Males	NA	40	40
Females	NA	47	47
Age 18 - 19			
Males	NA	57	57
Females	NA	120	120

Additional normative data was later collected from 571 subjects. This sample consisted of 73 children aged

Table 3: Age and Gender Distribution of Adult Sample

Group	Sample Size
Age 20 -29	
Male	19
Female	30
Age 30 - 39	
Male	4
Female	22
Age 40 -49	
Male	14
Female	19
Age 50 - 59	
Male	8
Female	16
Age 60 - 69	
Male	12
Female	24
Age 70 - 79	
Male	12
Female	39
Age 80+	
Male	8
Female	23

4 to 5, and 498 subjects ages 12 to 19 years (Greenberg & Crosby, 1992; also shown in Table 2). This sample consisted of children from an early-education screening project, children, public grade schools (in randomly selected classrooms), and a public high school. The early-education and grade school children were from suburban public schools, the high school was located in a rural Minnesota community, and were primarily Caucasian (99%, 1% other). Exclusion rules were the same as those described above for the original normative sample. The 4 and 5 year old subjects were administered a shorter version of T.O.V.A., consisting of only one quarter for each condition (stimulus infrequent and stimulus frequent), quarters #1 and #3. All testing was done in the mornings to control for possible diurnal effects.

Adults - The original T.O.V.A. adult normative sample consisted of 250 subjects, age 20 years and older. The sample consisted primarily of persons of Caucasian ethnicity (99%, 1% other) and was comprised of undergraduate students enrolled in three Minnesota liberal arts colleges, and persons residing in nearby communities. Subjects were excluded from the study based upon current use of psychoactive medication, history of CNS disorder, or history of CNS injury (see Table 3 for demographic information of sample).

Normative Data for Test Variables. Greenberg & Waldman (1993) noted mean score differences for gender across age-groups for percentage of omission errors, percentage of commission errors, and mean response time. Males showed a higher percentage of omission errors than females ($F\ (1,771) = 13.42$, $p < .001$). Between subjects effect of age did not differ by gender for omission errors. Males also displayed more commission errors than females ($F\ (1,771) = 65.61$, $p < .001$). The curvilinear decrease with age in percentage of commission errors differed significantly between the two halves. The interactions of both linear ($F\ (1,771) = 15.80$, $p < .001$) and quadratic ($F\ (1,771) = 27.48$, $p < .001$) components of age with test half were significant. While the decrease in commission errors with age in the first half was flat with linear and curvilinear components virtually absent, in the second half the curvilinear decrease was much more dramatic. In addition, the significant differences for males to have more commission errors than females was greater in the second than the first half ($F\ (1,771) = 57.45$, $p < .001$).

For Response Time, females showed a slower mean response time ($F(1,771) = 21.18$) $p < .001$), especially in younger ages, and a steeper linear decrease with age than males (slope = -.35 for females and -.29 for males; $F(1,770) = 9.70$, $p < .001$). Response time variability decreased curvilinearly with age ($F(1,771) = 174.41$, $p < .001$ for the linear trend); ($F(1,771) = 84.75$, $p < .001$ for the quadratic trend). Response time variability was greater ($F(1,771) = 68.74$, $p < .001$), and the age decrease was steeper and more curvilinear ($F(1,771) = 31.53$, $p < .001$ for the linear trend); ($F(1,771) = 18.67$, $p < .001$ for the quadratic trend), in the second half than in the first half (Greenberg & Waldman, 1993). Effects on response time variability also differed by quarter. Response time variability was greater ($F(1,773) = 82.96$, $p < .001$), and the linear decrease with age was steeper (slope = .33) for quarters 2 and 4 and -.28 for quarters 1 and 3; ($F(1, 773) = 32.90$, $p < .001$ for the linear trend), in quarters 2 and 4 than in quarters 1 and 3. No gender differences were found for response time variability (Greenberg & Waldman, 1993).

The means and standard deviations for percentage of omission errors, percentage of commission errors, response time, response time variability, and d prime across age groups by gender are provided in Appendices C and D. These tables represent the pool of the original sample, N = 775, (Greenberg & Waldman, 1993) and additional sample, N = 821, (Greenberg & Crosby, 1992A) for a total sample size of 1596 for ages ranging from 4 to 80 years (1346 children, 250 adults).

3.3 Normative Data for Auditory T.O.V.A.-A

Subjects:

Children - The subjects for the normative sample (N = 2551) were recruited from elementary and high schools in three metropolitan Minneapolis, Minnesota, suburban public schools, and were predominately Caucasian (99%, 1% other). Age and gender distribution are shown in Table 4. Subjects were excluded from the sample if they met any of the following: a deviant classroom behavior rating defined by a score of greater than 2 standard deviations above the mean on the Conners Parent-Teacher Questionnaire, Abbreviated form; current use of psychoactive medication, or receiving Special Education services. Ages of the sample ranged from 6 - 19 years. As with the visual T.O.V.A., all testing was done in the mornings to minimize diurnal effects.

It is important to note that the auditory stimulus version of the test has been normed on children aged 6 - 19 years. Our preliminary testing of the auditory version with 4 and 5 years olds indicated that this auditory task was too difficult for the children at this age, even when using the shorter (i.e., quarters 1 and 3 only) version.

Adults - Limited additional normative data is available for the adult sample in Table 5. Testing adult subjects is to be considered experimental for the auditory version. The normative study will be made available upon completion.

3.4 Normative Data for Test Variables

To maintain consistency between visual and auditory tests, two year age-groups were used (i.e., 6 to 7, 8 to 9, etc.). Age and gender differences for each variable were examined.

Similar to the visual stimulus test, significant main effects were found for age for all six performance indices. Further testing indicated that for commission, response time, and response time variability, all three contrasts were significant: quarter 1 vs. quarter 2 ($p < .01$ for commissions, $p < .001$ for response time and response time variability); quarter 3 vs. quarter 4 ($p < .001$ for all three variables); and quarter 1 and 2 vs. quarters 3 and 4 ($p < .001$ all three variables). A different set of contrasts was found to be significant for omission errors: quarter 1 vs. quarter 2: quarters 1 and 2 vs. quarters 3 and 4 ($p < .001$ for both contrasts). For d' (d prime), the following two comparisons were significant: quarters 3 vs. quarter 4; quarters 1 and 2 vs.

Table 4: Age and Gender Distribution by Sample

Group	Total Sample
Age 6	
Males	85
Females	90
Age 7	
Males	92
Females	82
Age 8	
Males	97
Females	108
Age 9	
Males	104
Females	100
Age 10	
Males	106
Females	107
Age 11	
Males	96
Females	104
Age 12	
Males	87
Females	94
Age 13	
Males	98
Females	91
Age 14	
Males	100
Females	101
Age 15	
Males	98
Females	90
Age 16	
Males	94
Females	87
Age 17	
Males	99
Females	107
Age 18	
Males	101
Females	101
Age 19	
Males	22
Females	10

Table 5: Age and Gender Distribution of Adult Sample

Group	Sample Size
Age 20 +	
Male	54
Female	75

quarters 3 and 4 ($p < .001$). Significant age effects were observed for omissions, commissions, response time, response time variability ($p < .001$ for each).

Results of analysis for effects of gender found that males had: (1) significantly higher commission errors ($p < .001$); and (2) shorter response times [i.e., lower mean response time scores] ($p < .001$). No main effects for gender were noted for omissions, response time variability and d prime.

Gender by quarter interactions were noted for commissions ($p < .001$), response time ($p < .001$), response time variability ($p < .01$) and d prime ($p < .01$).

The means and standard deviations for percent of omission errors, percent of commission errors, response time, response time variability and d' across age groups by gender are provided in the Appendices.

4 Reliability

4.1 Internal Reliability

Internal Reliability Chronbach alpha, split half and Kuder-Richardson reliability coefficients, traditionally reported as measures of a test's consistency, are not appropriate for timed tasks such as the T.O.V.A. (Anastasi, 1988). To calculate reliability coefficients for the test, Pearson product coefficients (r) were computed for all variables across both conditions. Pearson correlation coefficients (r) were computed for all variables across the two conditions, as shown in Tables 6 - 16 As can be seen in the tables, the two time epochs represent consistent measures within each condition.

Table 6: Within Condition 1 Reliability Coefficients

Variable	Q 1: Q 2	Q 3: Q 4
Omission	.72	.70
Commission	.79	.82
Response Time (ms)	.93	.93
RT Variability (ms)	.70	.86
D Prime	.52	.72

Condition 1 (Stimulus Infrequent): The reliability coefficients for the stimulus infrequent condition (quarters 1 and 2) support that the variables are consistent within each variable over the condition; yet, distinct between each variable.

For example, in Condition 1, the following r values for the within condition percentage of omission errors were found: $r = .72$; quarters 1 and 2 to first half, $r = .92$ and .93, respectively; quarters 1 and 2 to total omission, $r = .79$ and .85, respectively; and first half to total, $r = .88$.

Table 7: Within Condition 1 Omission Reliability Coefficients

Condition 1	Omission Reliability
Q1 : Q2	.72
Q1 : H1	.92
Q1 : Total	.79
Q2 : H1	.93
Q2 : Total	.85
H1 : Total	.88

The percentage of commission errors within condition coefficients are: between the two quarters, $r = .79$; quarters 1 and 2 to first half, $r = .95$ and .93 respectively; quarters 1 and 2 to total commissions, $r = .80$ and .71, respectively; and first half to total, $r = .80$.

Response time within condition values are: between quarters $r = .93$; quarters 1 and 2 to first half, $r = .98$ and .98, respectively; quarters 1 and 2 to response time total, $r = .90$ and .91, respectively, and first half to total, $r = .92$.

Response time variability within condition values are: between quarters, $r = .70$; quarters 1 and 2 to first half, $r = .89$ and .94, respectively; quarters 1 and 2 to total, $r = .80$ and .84; first half to total, $r = .92$.

D' values are: between quarters, $r = .52$; quarters 1 and 2 to first half, $r = .81$ and .82; quarters 1 and 2 to total, $r = .64$ and .65; and first half to total, $r = .72$.

Table 8: Within Condition 1 Commission Reliability Coefficients

Condition 1	Commission Reliability
Q1 : Q2	.79
Q1 : H1	.95
Q1 : Total	.88
Q2 : H1	.93
Q2 : Total	.80
H1 : Total	.71

Table 9: Within Condition 1 Response Time Reliability Coefficients

Condition 1	Response Time (ms) Reliability
Q1 : Q2	.93
Q1 : H1	.98
Q1 : Total	.90
Q2 : H1	.98
Q2 : Total	.91
H1 : Total	.89

Between variable coefficients support the contention that the variables capture different components of variance. The relationship between percentage of omission and percentage of commission coefficients, while statistically significant ($p < .01$), are not generally robust. The relationship between percentage of omissions to the other variables fails to demonstrate a robust level of commonness.

Percentage of commissions to response time comparisons failed to find statistical significance for all variable relationships (see Table 1 in the Appendices). Those that did find statistical significance were not robust with ranges from .05 to .12. Commission to response time variability relationships, while statistically significant ($p < .001$), supported a limited relationship between the two variables.

Response time and response time variability relationships were statistically significant ($p < .001$), and the data supported the relationship between the two variables, as one would predict. The within quarter relationships are generally stronger than the between quarter relationships between the two variables.

Condition 2 (Stimulus Frequent) Condition 2 data followed that of condition 1. Within variable coefficients were generally stronger than those between variables. Coefficient values for percentage of omission errors for quarters 3 and 4 found a coefficient $r = .70$. Percentage of omission errors comparing quarter 3 and 4 to second half, $r = .92$ and .92. Percentage of omissions quarter 3 and 4 to total, $r = .91$ and .91.

Coefficients for percentage of commission errors for quarters 3 and 4, $r = .82$, indicating consistent relationship. Coefficients for the remaining comparisons are as follows: quarters 3 and 4 to second half, .94 and .96; quarters 3 and 4 to total, $r = .90$ and .89; and second half to total, $r = .93$.

Response time quarters 3 and 4, coefficient $r = .93$. Coefficient values for the other response time comparisons are: quarters 3 and 4 to second half, $r = .98$ and .98; quarters 3 and 4 to total, $r = .98$ and .97, and second half to total, $r = .99$ (See Table 14.)

Response time variability coefficient values for quarters 3 and 4, $r = .87$. Coefficients for other response time variability comparisons are: quarters 3 and 4 to second half, $r = .95$ and .97; quarters 3 and 4 to total, $r = .95$ and .96, and second half to total $r = .99$.

Table 10: Within Condition 1 Response Time Variability Reliability Coefficients

Condition 1	Response Time (ms) Variability Reliability
Q1 : Q2	.70
Q1 : H1	.89
Q1 : Total	.80
Q2 : H1	.94
Q2 : Total	.84
H1 : Total	.92

Table 11: Within Condition 1 D Prime Reliability Coefficients

Condition 1	D Prime Reliability
Q1 : Q2	.52
Q1 : H1	.81
Q1 : Total	.56
Q2 : H1	.82
Q2 : Total	.55
H1 : Total	.72

D' reliability coefficient values for condition 2 are: between quarters 3 and 4, $r = .87$; quarters 3 and 4 to half 2, $r = .95$ and .97; quarters 3 and 4 to total, $r = .95$ and .96; and half 2 to total, $r = .99$.

Between variable reliability coefficients followed suit with those of condition 1. The between variable coefficients are not as robust as the within variable ones. Again, the variables across the condition are measuring a small degree of commonness. The exception is where one would expect, between response time and response time variability. These two variables showed the expected closeness of task measure with coefficients ranging from .70 response time quarter 3 to variability quarter 4 to .80 response time total to variability half 2.

Standard Error of Measurements: Standard error of measurements (SE_M) were calculated for the standard scores based upon the above reliability coefficients. A pooled weighted average standard deviation was calculated to determine the quarter to quarter combined standard deviation. This pooled weighted standard deviation was used in the calculation of the SE_M for each variable. Only those comparisons which would logically be made for the test data were calculated. SE_M for within condition within variable comparison were calculated, between condition were not calculated due to the nature of the test. Table 17, below, provides the pooled weighted average standard deviation and Sem.

Internal Consistency: Llorente, Amado, Voigt, Berretta, Fraley, Jensen & Heird (2001) examined the internal consistency of the T.O.V.A. The study utilized 49 strictly diagnosed Attention Deficit Hyperactive Disorder (ADHD) children. The mean age of the cohorts was 9.5 years with a standard deviation of 1.5 years. Age range of the participants was from 6 to 12 years.

The initial analysis used total number of correct target responses (errors of omission and commission) on half 1 and the total number of correct target responses on half 2. In addition, they used the same variables to compare response scores on half 1 and half 2 to the total number of correct responses for the entire test (total). Table 18 provides the Pearson product moment correlations (r_{xy}) derived using individual scores between initial performance and another performance done at 16 weeks (average time interval).

The data indicate a high level of internal consistency between the two halves. In addition, the data indicate high level of internal consistency between each half and the total. The data are consistent with the data obtained from our studies as cited above.

Table 12: Within Condition 2 Omission Reliability Coefficients

Condition 2	Omission Reliability
Q3 : Q4	.70
Q4 : H2	.92
Q3 : Total	.79
Q4 : H2	.93
Q4 : Total	.85
H2 : Total	.88

Table 13: Within Condition 2 Commission Reliability Coefficients

Condition 2	Commission Reliability
Q3 : Q4	.82
Q3 : H2	.94
Q3 : Total	.90
Q4 : H2	.96
Q4 : Total	.89
H2 : Total	.93

Test/Retest Reliability: In addition to examining internal consistency of the T.O.V.A., Llorente, Amado, Voigt, Berretta, Fraley, Jensen & Heird (2001) evaluated temporal stability and reproducibility of individual test scores. The study utilized 49 strictly diagnosed Attention Deficit Hyperactive Disorder (ADHD) children. The mean age of the cohorts was 9.5 years with a standard deviation of 1.5 years. Age range of the participants was from 6 to 12 years. The children were evaluated three times over four months.

Pearson product moment correlations (r_{xy}) were calculated across three time intervals for errors of omission, errors of commission, response time and response time variability. The coefficients are in Table 19. The coefficients indicate moderate test-retest correlation across several test periods. While the coefficients may be moderate, they are not unexpected in that the participants were children diagnosed with ADHD, rather than normal controls. Variability is expected within the ADHD group scores with less variability expected in normal control groups. To understand this further, the study authors then examined the repeatability of individual test scores within this same ADHD sample.

Llorente et al. (2001) used a Bland-Altman procedure to determine the limits of score agreement between the individual scores of each scale (omission, commission, response time and response time variability) between each of the visits (V_1-V_2, V_1-V_3, and V_2-V_3). Differences between the test scores from each of the two visits were used to evaluate the limits of agreement.

The data from the Bland-Altman procedure are provided in Table 20. The result of their analysis does indicate that the errors scores (omission and commission) had increased differences between test administrations. The response time and response time variability scores displayed less bias associated with increased differences, thus exhibiting greater reproducibility of individual scores. Llorente et al. conclude that the analysis yielded less agreement than observed for the entire sample (test-retest reliability coefficients). The variability found within the reproducibility analysis is most likely due to the nature of variability of attention and concentration found in ADHD itself. The authors also add that the T.O.V.A. test scores should be interpreted in context of a subject's history, neuropsychological test profile as well as neurobehavioral characteristics. This position is consistent with that proposed in the first edition of this manual.

To further understand the test-retest reliability Leark, Wallace & Fitzgerald (2004) investigated the matter

Table 14: Within Condition 2 Response Time (RT) Reliability Coefficients

Condition 2	RT (ms) Reliability
Q3 : Q4	.93
Q3 : H2	.98
Q3 : Total	.98
Q4: H2	.98
Q4 : Total	.97
H2 : Total	.99

Table 15: Within Condition 2 Response Time Variability Reliability Coefficients

Condition 2	RT Variability Reliability
Q3 : Q4	.87
Q3 : H2	.95
Q3 : Total	.95
Q4 : H2	.97
Q4 : Total	.96
H2 : Total	.99

using two different time intervals: 90 minutes and 1 week. The two intervals were selected for several reasons. Greenberg, Kindschi, Dupuy & Corman (1996) had recommended using the T.O.V.A. to monitor medication. The second time frame was chosen as it reflected what may occur in a typical clinical setting.

Study 1: 90-minute Test-Retest Interval

31 children, ages ranging from 6 through 14.2 years (overall M = 10.00 years, SD = 2.66 years) were administered the T.O.V.A. and then underwent a second administration at 90-minutes. Participants for the study were excluded if there was any history of central nervous system impairment, loss of consciousness, psychiatric disorder, or use of prescribed medication or over-the-counter medication affecting attention.

A two-tailed Pearson product moment correlation was utilized to determine the relationship between first and second administrations. The analysis yielded significant positive correlations overall T.O.V.A. scores (Table 21).

The correlation coefficients were then used to calculate the standard error of measurement (SE_M) for each T.O.V.A. score. The SE_M values are also located in Table 21.

To determine if there were practice effects, a series of paired Student t-tests were conducted over each of the four scores. Statistically significant mean score differences were found for the commission and response time scores. The commission scores were about 12 points higher on the second administration. The response time scores were slightly lower for the second administration. Each of the commission scores were within the normal limits range but do reflect actual differences obtained. The differences obtained on the response time are slight (about 4 points) yet reached statistical significance. The significant difference noted on the response time score is most likely related to the group variance within the second administration itself, as the SD is larger. Nonetheless, test users are encouraged to use caution when using the T.O.V.A. in 90-minute test intervals often reported in clinical settings.

The data indicate satisfactory test-retest reliability for the 90-minute interval. The use of at least one SE_M difference is highly recommended when comparing T.O.V.A. test scores for medication purposes. This will help account for test score fluctuations that may reflect random error rather than medication change. The

Table 16: Within Condition 2 D Prime Reliability Coefficients

Condition 2	RT Variability Reliability
Q3 : Q4	.87
Q3 : H2	.95
Q3 : Total	.95
Q4 : H2	.97
Q4 : Total	.96
H2 : Total	.99

Table 17: Table of Weighted Standard Deviation and SEm for Variable Over Condition

Variable	Q 1 : Q 2		Q 3 : Q 4	
	SD	SE_M	SD	SE_M
Omission	5.34	2.80	5.16	2.72
Commission	2.71	1.25	16.44	8.66
Response Time (ms)	109.11	29.23	104.35	54.99
Variability	38.75	21.33	62.34	32.85
D Prime	1.37	1.20	1.73	0.91

use of at least two SE_M scores will provide even a more stable predictor of test scores when using the medication titration method.

Study 2: 1-week interval

For this study 33 children (20 males, 13 females) were administered the T.O.V.A. at one week intervals (+ 2 days). The ages of the sample ranged from 6 to 14.5 years (M = 10.10 years, SD = 2.59). The grade range was from first through eighth grade (M = 4.33 grade level, SD = 2.5). The participants had to have normal or corrected vision, as well as the time for the testing session. The testing was conducted at the child's school (Southern California private and public schools). Participants for the study were excluded if there was any history of central nervous system impairment, loss of consciousness, psychiatric disorder, or use of prescribed medication or over-the-counter medication affecting attention. All tests were administered following standardized procedures. Each participant was administered the T.O.V.A. once then re-administered the test approximately seven days later at the same time of the day as the first administration.

A two-tailed Pearson product moment correlation was utilized to determine the relationship between the test variables over the two time intervals. The results of the analysis indicate positive and significant correlations between the two administrations across all four of the T.O.V.A. scores (Table 22). As with the 90-minute interval study, the correlations were then used to determine the standard error of measurement (SE_M) for each of the scores.

Practice effects were also examined using the same paired Student t-test method. As with the 90-minute interval study, statistically significant mean score differences were found for the commission mean scores. Similar to the 90-minute interval study, the commission score increased by about a 12 point margin. Non-significant mean score differences were found for the three remaining scores. Response time mean scores did not differ significantly as was found for the 90-minute interval.

The data from the study does indicate that the T.O.V.A. has highly stable test-retest reliability at one-week intervals with the healthy school aged children. The data from the Leark, Wallace & Fitzgerald study reflect more stable measures of reliability over the shorter time intervals. This finding is not unusual as Anastasi & Urbina (1997) have reported that test-retest coefficients are typically more stable over shorter time periods

Table 18: Total Number of Correct Target Responses (errors of omission and commission) internal consistency correlations for TOVA at Visit 3 (16 weeks [average] into study)

Test segment	(n)	(r_{xy})
Half 1 vs. Half 2	49	0.93**
Half 1 vs. Total	49	0.96**
Half 2 vs. Total	49	0.99**

** significant at .001 (two-tailed test)

From: Llorente, A. M., Amado, A.J., Voigt, R.G., Berretta, M.C., Fraley, J.K., Jensen, C.L. & Heird, W.C. (2001). Internal consistency, temporal stability, and reproducibility of the Test of Variables of Attention in children with attention-deficit hyperactive disorder. Archives of Clinical Neuropsychology, 16, 535-546.

Table 19: Test-Retest Reliability For Raw Scores Across Visits 1, 2 and 3

	Visit 1	Visit 2	Visit 3
Errors of Omission			
Visit 1	1.00		
Visit 2	0.51**	1.00	
Visit 3	0.61**	0.58**	1.00
Errors of Commission			
Visit 1	1.00		
Visit 2	0.71**	1.00	
Visit 3	0.58**	0.69**	1.00
Response Time			
Visit 1	1.00		
Visit 2	0.73**	1.00	
Visit 3	0.70**	0.82**	1.00
Response Time Variability			
Visit 1	1.00		
Visit 2	0.75**	1.00	
Visit 3	0.66**	0.72**	1.00

** Significant at the .0.1 level (two-tailed test).

From: Llorente, A. M., Amado, A.J., Voigt, R.G., Berretta, M.C., Fraley, J.K., Jensen, C.L. & Heird, W.C. (2001). Internal consistency, temporal stability, and reproducibility of the Test of Variables of Attention in children with attention-deficit hyperactive disorder. Archives of Clinical Neuropsychology, 16, 535-546.

than those reported within the Llorente et al. study.

4.2 Reliability Data for the T.O.V.A.-A. (Auditory)

Reliability: Like the visual version, the auditory version is a timed test. This makes traditional reliability coefficients, such as Chronbach alpha or split half, inappropriate (Anastasi, 1988). To calculate reliability coefficients for the test, Pearson product coefficients (r) were computed for all variables across both conditions. Tables 23 - 33 provide the Pearson product coefficients (r) for all variables across the two conditions, stimulus infrequent (quarters 1 and 2) and stimulus frequent (quarters 3 and 4). Since the table presents a large amount of data, two additional tables were prepared to divide the information by the two conditions. These additional tables present within condition correlations. Tables are presented for the stimulus infrequent condition (quarters 1 and 2), and for the stimulus frequent condition (quarters 3 and 4). Complete tables including between conditions are in the Appendices.

Condition 1 (Stimulus Infrequent): Condition 1 percentage of omission errors quarter 1 and 2 coefficient value found, $r = .8082$. The value indicates that the test measures percentage of omission errors between the two

Table 20: Bland-Altman Procedure to Determine Test-Retest Reliability

	Lower	Mean difference	Upper
Errors of omission			
Visit 1 - Visit 2	-97.3	-1.57	94.2
Visit 1 - Visit 3	-112.5	-13.6	85.2
Visit 2 - Visit 3	-110.6	-12.4	85.8
Errors of commission			
Visit 1 - Visit 2	-21.3	5.91	33.1
Visit 1 - Visit 3	-26.1	8.57	43.3
Visit 2 - Visit 3	-23.1	5.17	33.4
Response Time			
Visit 1 - Visit 2	-209.2	-27.7	153.8
Visit 1 - Visit 3	-245.4	-43.3	158.7
Visit 2 - Visit 3	-196.1	-24.5	147.2
Response Time Variability Visit 1 - Visit 2	-93.3	3.70	100.7
Visit 1 - Visit 3	-135	-9.04	116.9
Visit 2 - Visit 3	-135.4	-15.6	104.1

Llorente, A. M., Amado, A.J., Voigt, R.G., Berretta, M.C., Fraley, J.K., Jensen, C.L. & Heird, W.C. (2001). Internal consistency, temporal stability, and reproducibility of the Test of Variables of Attention in children with attention-deficit hyperactive disorder. Archives of Clinical Neuropsychology, 16, 535-546.

Table 21: Scores for the 90-Minute Interval (N = 31)

	First Time		Second Time			
T.O.V.A. Score	M	SD	M	SD	r	SE_M
Omission	95.95	15.40	96.95	14.68	.70	8.22
Commission	95.29	14.32	107.12*	11.54	.78	7.03
Response Time	96.66	15.43	92.36*	20.07	.84	6.00
Response Time Variability	99.94	16.43	101.48	20.12	.87	5.41

* $p < .05$

From: Leark, R. A., Wallace, D.R. & Fitzgerald, R (2004). Test-Retest Reliability and Standard Errors of Measurement for the Test of Variables of Attention (T.O.V.A.) with healthy school aged children. Assessment, 4, 285-289.

quarters over the condition consistently. The coefficient value of percentage of omission errors comparing quarter 1 and 2 to first half, $r = .94$ and .96. Coefficient value for percentage of omission errors comparing quarter 1 and 2 to total, $r = .73$ and .79. Coefficient value for first half to total, $r = .99$.

Percentage of commission errors coefficient value comparing quarter 1 and 2, $r = .87$. Like omission errors, commission errors across the two quarters for this test condition are measured with consistence. Coefficient value for percentage of commission errors comparing quarter 1 and 2 to first half, $r = .96$ and .97. Coefficient values for percentage of commission errors comparing quarter 1 and 2 to total, $r = .86$ and .88. Value of percentage of commission errors for first half to total, $r = .90$.

Response time (mean response time) comparing quarter 1 and 2, $r = .91$. The two quarters show a high degree of consistency across the two time epochs. Response time comparing quarter 1 and 2 to first half, $r = .98$ and .98. Response time for quarter 1 and 2 to total, $r = .85$ and .88. Coefficient value for first half to total, $r = .88$.

Response time (RT) Variability coefficient values for quarter 1 and 2, $r = .75$. The variability of mean response time is fairly consistent across the two time epochs over the same condition. Comparison of response time variability for quarter 1 and 2 to first half coefficient value, $r = .91$ and .95. Coefficient value for comparison of quarter 1 and 2 to total, $r = .80$ and .83. Finally, value of coefficient for first half to total,

Table 22: Scores For The 1-Week Interval (N = 33)

	First Time		Second Time			
T.O.V.A. Score	M	SD	M	SD	r	SE_M
Omission	90.39	21.85	91.42	21.86	.86	5.61
Commission	92.39	19.95	105.88	15.37	.74	7.65
Response Time	94.63	15.55	90.85	21.05	.79	6.87
Response Time Variability	97.70	18.32	98.64	20.94	.87	5.41

* $p < .01$

From: Leark, R. A., Wallace, D.R. & Fitzgerald, R (2004). Test-Retest Reliability and Standard Errors of Measurement for the Test of Variables of Attention (T.O.V.A.) with healthy school aged children. Assessment, 4, 285-289.

Table 23: Within Condition 1 Reliability Coefficients(Auditory)

Variable	Q 1: Q 2	Q 3: Q 4
Omission	.81	.94
Commission	.87	.83
Response Time (ms)	.91	.88
RT Variability	.75	.87
D Prime	.63	.74

r = .87.

D Prime coefficient values for condition 1: quarter 1 and 2, r = .63. Values for comparison of the remaining within variable within condition: quarters 1 and 2 to first half, r = .87 and .87; quarters 1 and 2 to total, r = .67 and .68; first half to total, r = .75.

Condition 2 (Stimulus Frequent): Within condition reliability coefficients for condition 2 found percentage of omission errors between quarters 3 and 4, r = .94. Like condition 1, the two time periods are measuring the same task consistently. Coefficient value for percentage of omission errors between quarters 3 and 4 and the second half score, r = .98 and .98. Reliability value for percentage of omission errors for quarters 3 and 4 to total score, r = .98 and .98. Value for percentage of omission errors for second half to total score, r = .99.

Percentage of commission errors between quarters 3 and 4 to reliability coefficient, r = .83. The two quarters measure with consistency. Reliability coefficient for percentage of commission errors for quarters 3 and 4 to the second half, r = .95 and .96. Reliability coefficient for percentage of commission errors for quarters 3 and 4 to total score, r = .78 and .71. Percentage of commission errors for second half to total, r = .77.

Mean response time for quarters 3 and 4, r = .88. The two time epochs are consistent in their measurement of mean response time. Remaining reliability coefficients for response time for condition 2: quarters 3 and 4 to second half score, r = .98 and .95; quarters 3 and 4 to total time, r = .97 and .94; and second half to total score, r = .99.

Variability (response time variability) reliability for quarters 3 to 4, r = .87. The two quarters over the condition measure response time variability consistently. The other coefficient values of variability over condition 2 are: quarters 3 and 4 to second half, r = .96 and .95; quarters 3 and 4 to total, r = .95 and .94; and second half to total, r = .99.

Reliability coefficient values for d prime reliability for condition 2 , quarters 3 to 4, r = .74. The remaining reliability coefficients for d prime over condition 2 are: quarters 3 and 4 to second half, r = .89 and .92; quarters 3 and 4 to total, r = .87 and .89; and second half to total, r = .97.

Table 24: Within Condition 1 Omission Reliability Coefficients(Auditory)

Condition 1	Omission Reliability
Q1 : Q2	.81
Q1 : H1	.94
Q1 : Total	.73
Q2 : H1	.96
Q2 : Total	.79
H1 : Total	.99

Table 25: Within Condition 1 Commission Reliability Coefficients(Auditory)

Condition 1	Commission Reliability
Q1 : Q2	.87
Q1 : H1	.96
Q1 : Total	.86
Q2 : H1	.97
Q2 : Total	.88
H1 : Total	.90

Standard Error of Measurement: Standard error of measurements (SE_M) were calculated for the standard scores based upon the above reliability coefficients. A pooled weighted average standard deviation was calculated to determine the quarter to quarter combined standard deviation. This pooled weighted standard deviation was used in the calculation of the SE_M for each variable. SE_M for within condition comparisons were calculated, between condition were not calculated due to the nature of the test. Only those comparisons which would logically be made for the test data were calculated. SE_M for within condition within variable comparison were calculated. Between conditions were not calculated due to the nature of the test. Table 34 provides the pooled weighted standard deviations and SE_M for the auditory version data.

Table 26: Within Condition 1 Response Time (ms) Reliability Coefficients(Auditory)

Condition 1	RT Reliability
Q1 : Q2	.91
Q1 : H1	.98
Q1 : Total	.85
Q2 : H1	.98
Q2 : Total	.88
H1 : Total	.88

Table 27: Within Condition 1 RT Variability Reliability Coefficients(Auditory)

Condition 1	RT Variability Reliability
Q1 : Q2	.75
Q1 : H1	.91
Q1 : Total	.80
Q2 : H1	.95
Q2 : Total	.83
H1 : Total	.87

Table 28: Within Condition 1 D Prime Reliability Coefficients(Auditory)

Condition 1	D Prime Reliability
Q1 : Q2	.63
Q1 : H1	.87
Q1 : Total	.67
Q2 : H1	.87
Q2 : Total	.68
H1 : Total	.75

Table 29: Within Condition 2 Omission Reliability Coefficients(Auditory)

Condition 2	D Prime Reliability
Q3 : Q4	.95
Q3 : H2	.98
Q3 : Total	.98
Q4 : H2	.98
Q4 : Total	.98
H2 : Total	.99

Table 30: Within Condition 2 Commission Reliability Coefficients(Auditory)

Condition 2	Commission Reliability
Q3 : Q4	.83
Q3 : H2	.95
Q3 : Total	.78
Q4 : H2	.96
Q4 : Total	.71
H2 : Total	.77

Table 31: Within Condition 2 Response Time (ms) Reliability Coefficients(Auditory)

Condition 2	RT Reliability
Q3 : Q4	.88
Q3 : H2	.98
Q3 : Total	.97
Q4 : H2	.95
Q4 : Total	.94
H2 : Total	.99

Table 32: Within Condition 2 RT Variability Reliability Coefficients(Auditory)

Condition 2	RT Variability Reliability
Q3 : Q4	.87
Q3 : H2	.96
Q3 : Total	.95
Q4 : H2	.95
Q4 : Total	.94
H2 : Total	.99

Table 33: Within Condition 2 D Prime Reliability Coefficients(Auditory)

Condition 2	D Prime Reliability
Q3 : Q4	.74
Q3 : H2	.89
Q3 : Total	.87
Q4 : H2	.92
Q4 : Total	.89
H2 : Total	.97

Table 34: Table of Weighted Standard Deviation and SEm for Variable Over Condition(Auditory)

Variable	Q 1 : Q 2		Q 3 : Q 4	
	SD	SE_M	SD	SE_M
Omission	5.34	2.34	5.16	1.31
Commission	2.54	0.93	16.44	6.78
Response Time (ms)	107.11	31.83	104.35	36.30
Variability	85.03	42.62	62.34	22.87
D Prime	1.73	1.05	1.73	0.88

5 Validity

5.1 Overview

Validity refers to a test's ability to adequately measure what it purports to measure and how well it does in measuring it. The T.O.V.A. was designed to measure variables that have been found to be important to differentiating ADHD subjects from normals.

5.2 Validity Data for the T.O.V.A. (visual)

Criterion validity: Criterion validity refers to the extent to which a measurement corresponds to an accurate measure of in interest, also known as the criterion. One example of criterion related validity was a study by Greenberg & Waldman (1993). They investigated ADHD, UADD (Undifferentiated ADD, DSM-III-R), Conduct Disorder (CD) and non-disordered control (NC) subjects performance on the visual stimulus version of the test. They analyzed group performance differences across the variables of in five different ways: 1.) group performance differences; 2.) group performance controlling for gender and age; 3.) group performance as a function of age; 4.) group performance differences as a function of test condition; and 5.) group performance differences as a function of test quarter.

On the first analysis, for measures of in attention, they found that the ADHD and ADD groups made more omission errors (t (896) = 4.10, p $\leq$ .001) and showed greater response time variability (t (896), p $\leq$ .001) than the CD and NC groups. The ADHD group made more omission errors (t (896) = 2.38, p $\leq$. 018) and showed greater response time variability (t (896) -3.97, p $\leq$ .001) than the UADD group No significant differences were found between CD and NC groups.

Differences between the ADHD and CD groups were found on measures of impulsivity. ADHD subjects made more commission errors (t (896) = 3.97, p $\leq$ .001) and more anticipatory errors (t (896) =3.65, p $\leq$ .001) than the UADD and NC groups. The UADD group made more commission errors than the NC (t (896) = 2.51, p $\leq$ .012). No significant differences were found on the anticipatory response variable. Response Time differences were noted with the ADHD group having significantly higher mean response times than the NC (p $\leq$ .001). The CD had higher mean response times than the NC (p $\leq$ .019), as well.

When controlling for age and gender, Greenberg and Waldman (1993) found that the ADHD and UADD groups made more omission errors (t (894) = 3.51, p $\leq$.001) and showed greater response time variability (t (894) = 6.07, p $\leq$ .007) than the CD and NC groups. The ADHD group showed greater response time variability than the UADD group (t (894) = 2.76, p $\leq$ .006). The CD group showed greater response time variability than the NC (t (894) = 4.92, p $\leq$ .001) but no differences were noted for omission errors. The group differences for inattention were similar after partialing out the effects of age and gender with the exception that CD groups showed greater response time variability to NC and only a trend for group differences was noted for omission errors for the ADHD and UADD groups. When controlling for age and gender, ADHD and CD groups made more commission errors (t (894) = 3.69, $\leq$ .001) and anticipatory errors (t (894), p $\leq$ .001) than the UADD and NC groups. UADD made more commission errors than the NC (t (894) = 2.48, $\leq$ .013), but no differences were found for anticipatory errors. Response time group differences were found with the CD group having higher mean response times (all p < .001). ADHD and UADD groups had higher mean response times than the NC (p $\leq$ .001).

When looking at the function of age, the differences between ADHD and UADD groups and the CD and NC groups in the number of omission errors varied as a function of age (t (894) = 3.92, p $\leq$ .001). The differences were larger in younger than in older children. Differences between ADHD and CD and the UADD and NC differences for anticipatory errors varied as a function of age (t (894) 1 = 1.97, p $\leq$ .001). More anticipatory errors were found in older than younger children. Mean response time differences were not found to very by age.

Test condition differences (stimulus infrequent, first half; stimulus frequent, second half) were examined. After controlling for age and gender, Greenberg and Waldman (1992c) found the indices of attention, impulsivity and mean response time different according to the differential response demands of the test. ADHD and UADD groups' greater omission errors (t (804) = 2.96, p $\leq$ .003) and response time variability (t (894) = 2.90, p = .004) relative to the CD and NC groups was more pronounced during the second half (stimulus frequent). The difference between the ADHD and UADD groups in the number of omission errors (t (894) = 1.98, p = .048) and the response time variability (t (894) = 2.30, p = 0.22) were also greater in the later half. None of the patient group differences in commission errors or mean response time difference significantly by condition.

To further examine effects of condition, group differences were analyzed by quarter, after controlling for age and gender. ADHD and UADD group differences were found for response time variability (t (894) = 2.92, p = 004). Greater response time variability was found in the second and forth quarters than in the first and third quarters. The Greenberg & Waldman (1992c) study concluded that ADHD and UADD groups were more inattentive, whereas the ADHD and CD groups were more impulsive, consistent with the DSM-IIIR conceptualization of the disorders. The ADHD group was more impulsive than the UADD group, and the UADD group was more impulsive than the NC group. Condition differences suggest that the response demands of the stimulus frequent condition tended to exacerbate inattention in those participants who already had problems in that domain. Figures 2 to 7 display these group differences.

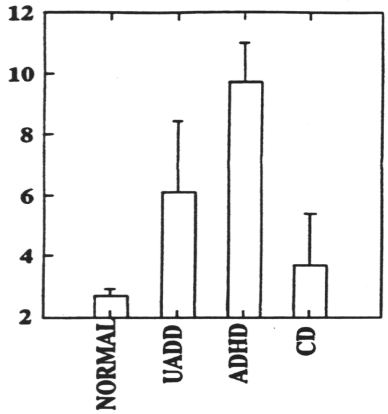

Figure 2: Group Differences by Total Omissions

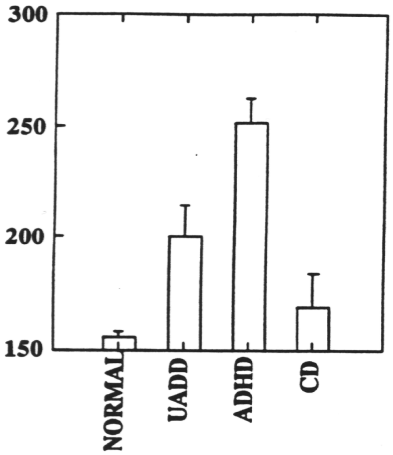

Figure 3: Group Differences in Total Response Time Variability (ms)

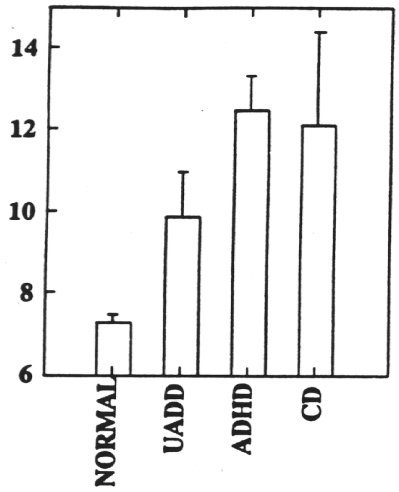

Figure 4: Group Differences in Commission Errors Total Commission Errors (%)

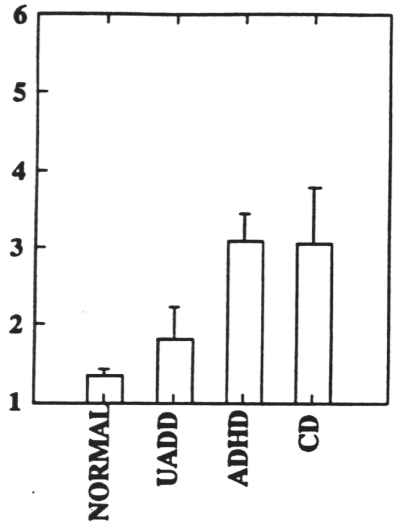

Figure 5: Groups Differences in Total Anticipatory Errors (%)

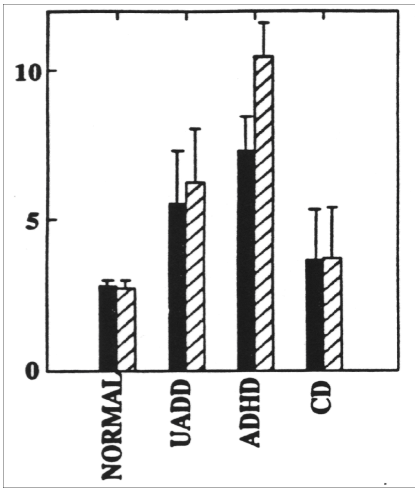

Figure 6: Group Differences in Omission Errors by Half

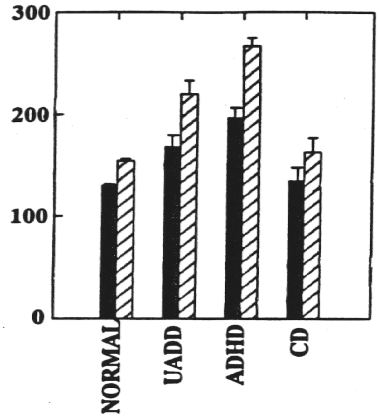

Figure 7: Group Differences in Response Time Variability By Half

Forbes (1998) reported that his sample of 117 children with ADHD/ADD differed significantly on omission errors, response time, response time variability and number of multiple responses [F (5,140) = 5.60, p <. 001) compared to a comparison group. The comparison group was comprised of age-matched children with oppositional defiant disorder, conduct disorder, adjustment disorders and learning disorders (n = 29). For this study, Forbes used *z* scores (standardized scores) in the calculations. Table 35 provides the data from this study.

Semrud-Clikeman & Wical (1999) evaluated attentional difficulties in children with complex partial seizures (CPS), children with ADHD, children with combined CPS and ADHD and normal controls. Each received the T.O.V.A. and those with ADHD also received the T.O.V.A. post medication. The baseline 3 (group) by 4 (T.O.V.A. scores) ANOVA yielded significant main effects for the T.O.V.A. [F (3, 82) = 6.906, p ≤ .001]. Post-hoc analysis indicated that the CPS/ADHD group performed the lowest (poor performance). The CPS and ADHD groups also performed poorer than normal control participants across all omission, commission, response time and response time variability (p ≤ .01). Post medication analysis revealed that the CPS/ADHD group improved following methylphenidate dosage (from -3.5 standard deviations to -1.5 standard deviations). The ADHD group mean T.O.V.A. scores were reported as normalized (no specific scores were reported within the article).

The study by Mautner, Thakkar, Kluwe & Leark (2002) also provided support for criterion related validity. Their study investigated the both the relationship of ADHD among children with neurofibromatosis type I

Table 35: Mean z scores on the T.O.V.A.

TOVA	ADHD/ADD (n=117)		Other (n=29)		F(df =1,144)
Score	M	SD	M	SD	
Omission	.74	3.50	.01	.35	7.10*
Commission	1.03	2.34	.28	1.08	2.83
Response Time	1.37	1.29	.41	1.30	12.71**
Response Time Variability	2.58	2.31	.58	.99	20.67**
# Multiple Responses	1895	27.89	4.59	6.38	7.54*

* p <.01 **p < .001

From: Forbes, G.B. (1998). Clinical utility of the Test of Variables of Attention (TOVA) in the diagnosis of Attention Deficit Hyperactivity Disorder. Journal of Clinical Psychology, 54(4), 461-476.

Table 36: T.O.V.A. Mean Scores

T.O.V.A.	Nf1-ADHD		Nf1 no ADHD		ADHD		Normal	
Score	M	SD	M	SD	M	SD	M	SD
Omission	97.10	17.12	104.04	5.96	77343	23.09	104.29	5.47
Commission	68.50	25.19	104.73	8.04	98.21	9.30	104.14	7.98
RT	76.65	20.92	104.54	7.90	79.00	13.69	105.79	8.89
RTV	80.25	20.92	105.08	6.31	73.29	29.87	109.36	11.06

RT = Response Time, RTV = Response Time Variability.

From: Mautner, V.F., Thakkar, S., Kluwe, L. & Leark, R.A. (2002). Treatment of ADHD in neurofibromatosis type 1. Developmental Medicine & Child Neurology, 44 (3) 164-170.

(nf1) and the treatment of those children. The four groups included those with nf1, nf1 with ADHD, ADHD without nf1, and normal control participants. The T.O.V.A. scores were poorer in the nf1 with ADHD and ADHD groups than the nf1 no ADHD and normal controls (Table 36).

Sensitivity & Specificity: Sensitivity refers to the test's ability to correctly identify true ADHD cases, while, specificity refers to the test's ability to correctly identify normal individuals. The higher a test's sensitivity, the greater the ability to function as a diagnostic or screening tool as it would detect those likely to have ADHD. The higher the test's specificity, the less likely it would be for the test to incorrectly classify a normal as not normal. In other words, a high specificity would decrease false positives. There is a balance between sensitivity and specificity, when one value increases, the other decreases. The cost of errors in either direction (missing ADHD cases due to lower sensitivity, or, conversely, over-diagnosing ADHD due to low specificity) must be carefully weighed.

To study this for the T.O.V.A., Greenberg & Crosby (1992B) examined 73 subjects (62 males, 11 females), all diagnosed by senior faculty level university psychiatrists or psychologists independent of the study. The subjects were screened for co-existing psychiatric problems such as depression, conduct disorder or oppositional defiant disorder through the use of history, interview, psychological testing (not including the T.O.V.A.) and teacher rating scales (CPTQ-A and ACTeRs). Only those with a diagnosis of ADHD alone were included in the study. The diagnosis was made independent of test performance. The subjects had all been referred to the Clinic for Attention Deficit Disorders at the University of Minnesota. The subjects' scores for each of the five measures were converted to standard scores (z score) based upon normative data for age and gender. A one-way MANOVA was then used to compare z scores for the ADHD sample to the normative sample, and univariate tests of significance were also performed. For this study, two alternate approaches to classification were used, discriminant analysis and equal weighting of standardized scores using summed standardized scores. For both approaches, a random sample of one-half of the ADHD and the normative samples were selected. Analysis performed yielded 2 distinct cut-off points to achieve "false positive" rates

of 10% (0.90 specificity) and 20% (0.80 specificity). The identical cutoff points were then applied to the remaining sample and sensitivity indices recomputed.

Initial discriminant analysis, with prior probabilities set to sample size, found that anticipatory errors failed to contribute significantly to the regression equation, due largely to a substantial correlation ($r = .55$) to errors of commission. Thus, a subsequent analysis with the four variables (errors of omission, errors of commission, response time and response time variability) was done. The discriminant analysis of the first randomly selected sample (384 normals, 36 ADHD) revealed that the four variables were significantly able to predict group membership (canonical correlation = .56; Wilks' lambda = .68; $p < .001$). All four variables were significantly correlated to the discriminant function with values ranging from .42 (errors of commission) to .98 (response time variability). The .80 specificity cutoff point for the first sample was .34, and those scoring above this value were considered target cases. The resulting sensitivity based on this cutoff was .69. The .90 specificity cutoff point for this sample was .79 with a corresponding sensitivity of .67.

Discriminant function scores were then computed for the remaining sample using the regression weights from the first analysis. The cutoff points, determined from the first analysis, were applied to this sample. The .80 specificity (cutoff = .34) produced a sensitivity of .73 and specificity of .73; the .90 specificity (cutoff = .79) yielded a sensitivity of .68 and specificity of .85. Figure 8 demonstrates the sensitivity and specificity analysis graphically.

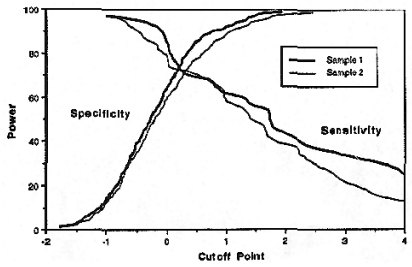

Figure 8: Sensitivity and Specificity: Discriminant Analysis. From *Specificity And Sensitivity Of The Test Of Variables Of Attention* (Greenberg & Crosby, 1992C)

For the second model of classification, equal weighting scores were computed for the first sample (384 normals, 36 AHDH). These was done by summing standardized scores (z) for each of the four variables. Cutoff points for 0.80 and 0.90 specificity were determined, yielding cutoff points of 1.94 and 3.42, respectively. A sensitivity rate of .76 was achieved for the 0.80 cutoff, and, .60 for the 0.90 cutoff.

The second sample equal weighting classification analysis was done using the established cutoff points. The 0.80 specificity cutoff yielded an overall sensitivity of .72 and specificity of .85; the 0.90 specificity yielded overall sensitivity of .61 and specificity of .94. Figure 9 demonstrates the standardized scores of the sensitivity and specificity graphically.

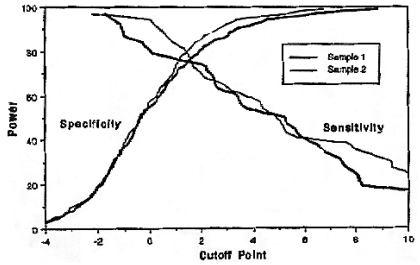

Figure 9: Sensitivity and Specificity: Summed Standardized Scores*

Table 37: Comparison of Classification Methods

Method	1st Sample Sensitivity	1st Sample Specificity*	2nd Sample Sensitivity	2nd Sample Specificity
Discriminant Analysis Equal Weighting	.69	.80	.73	.73
	.67	.90	.68	.85
	.76	.80	.72	.85
	.60	.90	.61	.94

*Specificity rates for Sample 1 chosen a priori. Specificity And Sensitivity Of The Test Of Variables Of Attention (Greenberg & Crosby, 1992C)

*Specificity And Sensitivity Of The Test Of Variables Of Attention (Greenberg & Crosby, 1992C)

Comparison of the two approaches is presented in Table 37. The sensitivity for the initial sample is higher for the discriminant analysis at the 0.90 specificity level. Somewhat surprisingly, the sensitivity for the equal weighting approach is higher at the 0.80 specificity level. The findings suggest that both weighted scoring via discriminant analysis and equal weighting via summed standardized scores produced respectable and similar levels of sensitivity and specificity.

Greenberg & Crosby (1992C) recommend a cutoff point of 1.94 for nonclincal screening settings (such as schools or work places). This resulted in a sensitivity of .72 and specificity of .85 (based upon sample two), yielding a minimum of false positives (28%). Rating scales could further reduce this "false positive" rate. For clinical settings, a cutoff of 3.42 is recommended. This resulted in sensitivity of .61 and specificity of .94 with a minimal number of "false positives" (6%). The higher rate of false negatives (39%) would be reduced by clinical history, rating scales and other psychological tests.

A second study, (Greenberg & Crosby, 1992C) examined sensitivity and specificity in 105 children (86 males, 19 females; ages 6 to 15) with carefully diagnosed ADHD (diagnosis made by senior faculty level university psychiatrists or psychologists independent of the study). These subjects were also reported in the Greenberg & Crosby (1992A) study. The normative sample was comprised of 954 age similar children (471 males, 483 females).

The first series of analysis was carried out using Receiver Operator Characteristic (ROC) Analysis (Murphy, Berwick, Weinstein, Borus, Budman, & Klerman, 1987). ROC analysis can be used to calculate the overall predictive performances of a score by assessing the score's diagnostic accuracy (true positives vs false negatives) over a continuum of scores. For this study, the scores for the omission errors, commission errors, mean response time, response time variability (variability), d prime and beta for first half, second half and total were converted to z scores (to control for effects of age and gender). Then a ROC analysis was conducted on each of the three scores for each variable to identify the scores that yielded the highest overall predictive performance. Next, a ROC analysis was conducted on combinations of "highly predictive" scores. These combinations represented theoretical elements of attention that are most strongly implicated in ADHD. The following combination score proved to have superior overall predictive performance: Mean Response Time (1st half) + D Prime (2nd half) + Variability (total).

Thus, the formula used to calculate the ADHD Score is:

ADHD Score = Response Time z score (half 1) + D' z score (half 2) + Variability z score (total)

The last step of the procedure involved creating a series of contingency tables so that the sensitivity and specificity associated with each value of the combination score could be evaluated. Through examination of the tables, a cutoff score was identified that resulted in the highest overall test performance (equal diagnostic sensitivity and specificity). The cutoff score that was chosen yielded a sensitivity of .80 (i.e., false negatives

Table 38: Caffeine Effects in Children*

	Placebo		2.5mg/k Caffeine		5.0 mg/k Caffeine		ANOVA			Random Regression		P
	X	SD	X	SD	X	SD	F	df		Est. Caf		
OmisErr	7.9	17.8	4.0	13.5	1.5	3.2	2.86	2,38	.070	-	1.55	.005
ComErr	1.7	2.7	1.3	1.9	1.7	2.9	0.56	2,38	.577	0.02	-	.866
RT	498.3	130.7	490.4	93.2	478.3	106.8	0.32	2,38	.726	-	2.67	.619
V-RT	159	61.4	135	52.6	121.2	46.4	8.33	2,38	.001	-	8.48	<.01

* from: Bernstein, Carroll, Crosby, Perwien, Go, & Benowitz (1994). "Caffeine Effects on Learning, Performance, And Anxiety in Normal Aged School Children". Journal of the American Academy Child Adolescent Psychiatry, 33:3, March/April.

@ 20%) and a specificity of .80 (i.e., false positives @ 20%).

The ROC analysis differs from the discriminant function analysis in that the latter produces prediction equations with item weights that often vary from sample to sample. The ROC analysis creates an analysis both theoretically based and yet able to be cross validated across diverse groups of individuals. Thus, ROC, the more conservative measure, is the more appropriate analysis since CPT norm samples are not representative of the general population.

Comparison of the two studies (discriminate function and ROC), yields overall discrimination abilities at minimum of .80 sensitivity and .80 specificity for the test across both analyses.

In another study, Teichner, Ito, Glod, & Barber (1996) examined the movement abnormalities in seated children with ADHD while engaged in a derivative of the T.O.V.A. Movement patterns of 18 boys with ADHD (9.3 + 2.4 yrs) and 11 normal controls (8.6 + 1.8 yrs) were recorded using an infrared motion analysis system that tracked the position of four markers 50 times per second to a resolution of 0.04 mm. Their results found that boys with ADHD moved their head 2.3 times more often than normal children ($p < .002$); moved 3.4 times as far ($p < .01$); covered a 3.8 fold greater area ($p < .001$); and had a more linear and less complex movement pattern ($p < .00004$). ADHD boys responded more slowly (response time) and had higher response time variability scores than the controls.

Bernstein, Carroll, Crosy, Perwien, Go, and Benowitz (1994) examined the acute effects of caffeine on learning, performance and anxiety in normal prepubertal children. 21 children were examined in a double-blind, placebo-controlled crossover design, studied during four sessions, each 1 week apart, under four conditions: baseline; placebo; 2.5mg/kg caffeine; and 5.0 mg/kg caffeine. Using randomized order of placebo and two dosages of caffeine, the children were tested in tests of attention, manual dexterity, short-term memory and processing speed. The T.O.V.A. was found to be sensitive to caffeine dosage on two of the four test variables. Table 38 presents this information.

Greenberg & Waldman (1993) investigated ADHD, UADD (Undifferentiated ADD, DSM III-R), CD (Conduct Disordered), and nondisordered control (NC) subjects performance on the visual stimulus version of the test. The researchers analyzed group performance differences across the variables in five different ways: group performance differences; group performance controlling for gender and age; group performance as function of age; group performance differences as a function of test condition; and group performance differences as a function of test quarter.

On the first analysis, for measures of inattention, they found that the ADHD and ADD groups made more omission errors ($t\ (896) = 4.10$, $p < .001$), and showed a greater response time variability ($t\ (896) = 594$, $p < .001$) than the CD and NC groups. The ADHD group made more omission errors ($t\ (896) = 2.38$, $p < .018$) and showed greater response time variability ($t\ (896) = 3.62$, $p < .001$) than the UADD group. No significant differences were found between the CD and NC groups.

Differences between the ADHD and CD groups were found on measures of impulsivity. ADHD subjects

made more commission errors (t (896) = 3.97, p < .001) and more anticipatory errors (t (896) = 3 .65, p < .001) than the UADD and NC groups. The UADD group made more commission errors than the NC (t (896) = 2.51, p < .012). No significant differences were found on the anticipatory response variable.

Response time differences were noted with the ADHD group having significantly higher mean response times than the NC (p < .001). The CD had higher mean response times than the NC (p < .018), as well.

When controlling for age and gender, Greenberg and Waldman (1993), again, found that again, the ADHD and UADD groups made more omission errors (t (894) = 3.51, p < .001) and showed greater response time variability (t (894) = 6.07, p < .001) than the CD and NC groups. The ADHD showed greater response time variability than the UADD group (t (894) = 2.76, p < .006). The CD group showed greater response time variability than the NC (t (894) = 4.92, p < .001) but no differences were noted for omission errors. The group differences for inattention were similar after partialing out the effects of age and gender with the exception that CD group showed greater response time variability to NC and only a trend for group differences was noted for omission errors for the ADHD and UADD groups.

Again, when controlling for age and gender, ADHD and CD groups made more commission errors (t (894) = 3.69, p < .001) and anticipatory errors (t (894) = 3.19, p < .001) than the UADD and NC groups. UADD made more commission errors than the NC (t (894) = 2.48, p < .013), but no differences were found for anticipatory errors. Response time group differences were found with the CD group having higher mean response times (all p < .001). ADHD and UADD groups had higher mean response times than NC (p < .001).

When looking at the function of age, the differences between ADHD and UADD groups and the CD and NC groups in the number of omission errors varied as a function of age (t (894) = 3.92, p < .001). The differences were larger in younger than in older children. Differences between ADHD and CD and the UADD and NC differences for anticipatory errors varied as a function of age (t (894) = 1.97, p < .001). More anticipatory errors were found in older than in younger children. Mean response time group differences were not found to vary by age.

Test condition differences (stimulus infrequent, first half; stimulus frequent, second half) were examined. After controlling for age and gender, Greenberg & Waldman (1992C), found the indices of attention, impulsivity and mean response time differed according to the differential response demands of the test. ADHD and UADD groups' greater omission errors (t (894) = 2.96, p = .003) and response time variability (t (894) = 2.90, p = .004) relative to the CD and NC groups was more pronounced during the second half, stimulus frequent. The difference between the ADHD and UADD groups in the number of omission errors (t (894) = 1.98,)p = .048) and the response time variability (t (894) = 2.30), p = 0.22) were also greater in the later half. None of the patient group differences in commission errors or mean response time differed significantly by condition.

To further examine effects of condition, group differences were analyzed by quarter, after controlling for age and gender. ADHD and UADD group differences were found for response time variability (t (894) = 2.92, p = .004). Greater response time variability was found in the second and fourth quarters than in the first and third quarters. ADHD and UADD groups and CD and NC group differences were found for response time variability differed by test half and quarter (t (894) = 2.97, p = 0.14).

Greenberg & Waldman (1992C) concluded that the ADHD and UADD groups were more inattentive, whereas the ADHD and CD groups were more impulsive, consistent with the DSM III-R conceptualization of the disorders. The ADHD group was more impulsive than the UADD group, and the UADD was more impulsive than the NC group. Condition differences suggest that the response demands of the stimulus frequent condition tended to exacerbate inattention in those patients who already have problems in that domain. Figures 2 to 7 display these group differences.

Factor Data: Data for the percentage of omission errors, percentage of commission errors, mean response time, response time variability and d prime over both conditions were entered into a principle components

Table 39: Visual Factor Data

Variable	Factor 1	Factor 2	Factor 3	Variable	Factor 1	Factor 2	Factor 3	Variable	Factor 1	Factor 2	Factor 3
Var. Total	.915			RT Q1	.748			Com Q3		-.707	
Var Half2	.892			D Half2	-.735			Com Half2		-.699	
Var Q4	.869			D Q4	-.719			RT Jhalf2	.664		
Var Q3	.860			RT Total	.709			RT Q4	.635		
Var Half1	.842			D Half1	-.965			Com Q4		-.635	
Var Q2	.798			D Q1	-.669			Com Q1		-.587	
RT Q2	.791			RT Q3	.666			Om Total		.721	
RT Half1	.783			D Q2	-.661			Om Half1		.717	
D Total	-.761			D Q3	-.653			Om Q3		.702	
Var Q1	.759			Com Total		-.750		Om Half2		.690	
								Om Q1		.673	

Table 40: Classification Results

	Predicted Group Membership			
	Normal		ADHD	
Original Group	Percent	Count	Percent	Count
Normal	93.2	41	6.8	3
ADHD	25	11	75	33

From: Leark, R.A., Dixon, D. Allen, M. & Llorente, A. (2002). Cross-validation of the diagnostic hit rates and performance differences between ADHD and normative groups of children on the Test of Variables of Attention. Poster paper presented at the 20th Annual Meeting of the National Academy of Neuropsychology, Orlando, FL.

varimax rotation factor analysis (N=1468). Three significant factors emerged: Factor 1.) response time (mean response time, response time variability) and d prime (hit to miss ratio); Factor 2.) percentage of commission errors; and Factor 3.) percentage of omission errors. Visual factor loadings for each are presented in Table 39.

The factor data supports the contention that the test is measuring distinct variables: response time, impulsivity and inattention.

Discriminant Analysis: In a separate analysis from the data reported above, Forbes (1998) reported the T.O.V.A. correctly classified 80% of the ADHD group and 72% of the other group. This result was obtained by using criteria on any one or more T.O.V.A. scores exceeding 1.5 standard deviations below expectation. This data is similar to that reported within the sensitivity and specificity section (see above).

Another study of the discriminant abilities of the T.O.V.A. was reported by Leark, Dixon, Allen & Llorente (2002) used 44 ADHD children and 44 aged matched subjects randomly selected from the T.O.V.A. normative sample. Their analysis used raw test data to classify subjects using group (ADHD, normative) as the criteria. This analysis yielded an overall 84.1% original group classification rate. The normal group was correctly classified 93.2% of the time. The ADHD group was correctly classified at 75% (Table 40).

These studies along with the sensitivity and specificity data indicate that the T.O.V.A. to be highly predictive in correctly classifying those with attention problems. As with all tests, we do not encourage the use of the T.O.V.A. to be used alone in the clinical diagnosis of ADHD. History, interviews, behavior rating scales are all essential components of an ADHD workup.

Relationship of T.O.V.A. (visual) to measures of intelligence: In an earlier edition of the T.O.V.A. Clinical Guide (Greenberg, Kindschi, Dupuy & Corman, 1996) as well as in workshops, Greenberg, et al. had suggested that scores to the T.O.V.A. were related to measures of intelligence. The nature of these suggestions

Table 41: Correlation Data Between WISC-III and T.O.V.A.

WISC-III	Omission	Commission	RT	RTV
FSIQ	-.440*	-.006	-.161	-.249
PIQ	-.458*	-.507	-.141	-.161
VIQ	-.202	-.003	-.221	-.274
PC	.113	.156	.154	.170
PA	-.502**	-.082	-.073	-.252
BD	-.198	.031	-.208	-.216
OA	-.540**	-.074	-.279	-.315
CD	.125	.141	.171	.182
SS	.009	.207	.126	.077
INF	-.462*	-.150	-.121	-.284
SIM	-.313	-.024	-.138	-.137
ARI	-.265	.011	-.170	-.206
VOC	-.205	.041	-.017	-.120
COM	-.126	.107	.058	.000
DS	-.078	.047	-.256	-.131

* p <.05, ** p < .01. RT = Response Time, RTV = Response Time Variability, PC = Picture Completion, PA = Picture Arrangement, BD = Block Design, OA = Object Assembly, CD = Coding, SS = Symbol Search, INF = Information SIM = Similarities, ARI = Arithmetic, VOC = Vocabulary, COM = Comprehension, DS = Digit Span.

From: Chae, P. K. (1999) Correlation study between WISC-III scores and TOVA performance. *Psychology in the Schools*, 36(3), 179-175.

came at the clinical experience of the author (Greenberg). These also made rational sense towards test interpretation strategies especially in light of interpreting test scores related to medication titration. However, these suggestions were just that, suggestions and did not have statistical support for them. Since then, several studies have been reported which indicate that the T.O.V.A. test scores are not influenced by the intelligence of the examinee.

For example, Chae (1999) compared T.O.V.A. (visual) test scores to the performance of 44 children referred for ADHD symptoms on the Wechsler Intelligence Scale for Children, 3rd revision (WISC-III). The children were not on medication during any of the testing. The results of his analysis are reported in Table 41. Non-significant correlations were shown between the total scores for the T.O.V.A. commission, response time and response time variability and the WISC-III Full Scale IQ (FSIQ), Verbal IQ (VIQ) and Performance IQ (PIQ). A negative correlation was found between the omission score and the PIQ and FSIQ. A negative but non-significant correlation was also shown between omission score and the VIQ.

The trend towards negative correlation between omission score and PIQ performance was further analyzed using the subtests that comprise the PIQ. This analysis yielded a significant negative correlation between total omission score and Picture Arrangement (-.502, p < .01) and Object Assembly (-.540, p < .01). No other significant correlations were found between PIQ subtests and T.O.V.A. performance. The same trend toward negative correlation was noted on the correlation between VIQ subtests and omission total scores. The only significant correlation between total T.O.V.A. scores and VIQ subtests was found between omission and the Information subtest (-.462, p <.01). The data from Chae's study indicates that the T.O.V.A. scores are related only slightly to intellectual processing. In particular, for these ADHD participants as their omission scores increased (poorer sustained attention) the performance on the WISC-III declined.

Using college aged participants, Weyandt, Mitzlaff & Thomas (2002) compared age-matched controls to referrals to a college ADHD clinic. Each was administered the T.O.V.A. and the Wechsler Adult Intelligence Scale-Revised (WAIS-R). Their analysis (Table 42) yielded non-significant correlation coefficients between

Table 42: Correlation Coefficients Between T.O.V.A. Scores and WAIS-R

T.O.V.A. Score	FSIQ	VC	PO	FD
Omission	-.075	-.055	-.156	-.001
Commission	.130	.152	.022	.050
RT	.059	.023	-.121	.016
RTV	.023	-.030	-.121	.068

Note: All correlation coefficients were non-significant. RT = Response Time, RTV = Response Time Variability, FSIQ = Full Scale IQ, VC = Verbal Comprehension, PO = Perceptional Organization, FD = Freedom from Distractibility.

From: Weyandt, L.L., Mitzlaff, L. & Thomas, L. (2002). The relationship between intelligence and performance on the Test of Variables of Attention (TOVA). *Journal of Learning Disabilities*, 35(2), 114-120.

T.O.V.A. scores and WAIS-F FSIQ. Further, an additional analysis yielded non-significant correlation coefficients between the T.O.V.A. scores and the WAIS-R factor derived summary scores: Verbal Comprehension (VC), Perceptual Organization (PO) and Freedom from Distractibility (FD). Weyandt, Mitzlaff & Thomas concluded that intelligence is unrelated to performance on continuous performance tests.

Fake Bad Test Bias: Leark, Dixon, Hoffman & Huynh (2001) investigated how intentionally faking bad would affect T.O.V.A. test performance. Two groups of age-matched college control participants were used with counter-balanced test order. One group was administered the T.O.V.A. under standard administration, followed by a second administration with standardized instructions to subtly fake bad. The other group took the initial administration with the instruction to subtly fake bad, then the standard administration of the test. The analysis of test-order yielded non-significant findings indicating that the instruction to fake bad provided the difference. Given there were non-significant effects for test-order, the two groups were then combined into fake bad (FB) and normal conditions (NC). Group mean score differences were analyzed using student t-tests for all four of the T.O.V.A. scores over each quarter, half and the total score. The analysis yielded significant mean score differences between the two groups with the FB group having excessively higher scores nearly across all quarters, halves and total score (Table 43). The study affirmed that the test is subject to intentional fake bad test bias. Professionals are encouraged to evaluate for malingered or intentional fake bad response bias when excessively high scores are obtained on the test.

5.3 Validity Data for the T.O.V.A.-A.

Factor Data: As was done with the visual version of the test, the percentage of omission errors, percentage of commission errors, mean response time, response time variability and d prime across both conditions by quarter, halves and totals were entered into a principal components factor analysis with a varimax rotation (N=2,551). The factor analysis yielded five loadings accounting for 86% of the variance. These five factors were: Factor 1) response time (mean response time and response time variability); Factor 2) percentage of commission errors stimulus frequent condition (quarters 3 & 4, 2nd half) and D Prime; and, Factor 3) percentage of omissions stimulus frequent condition (quarter 3, quarter 4 & second half; Factor 4) percentage of commission errors stimulus infrequent (quarters 1 & 2, 1st half); and, Factor 5) percentage of omission errors stimulus infrequent condition (quarter 1, quarter 2 and first half). Table 44 illustrates factor data for T.O.V.A.-A.

In comparison to visual test version, the auditory version factor data partial out commission errors across the two conditions. Stimulus frequent percentage of commission errors emerged separate from stimulus infrequent percentage of commission errors. This separation was not found for percentage of omission errors across the conditions.

Table 43: Table of Raw Score Means for Normal Condition (NC) and Fake Bad (FB) Instructions

		Omission		Commission		RT		RTV		D Prime	
		NC	FB	NC	FB	NC	FB	NC	FB	NC	FB
Q1	M	8.49	22.66*	1.92	11.24t	441.78	530.00	111.44	201.55**	6.67	3.82**
	SD	22.27	26.51	4.59	18.92	175.32	190.08	114.20	134.68	2.73	2.97
Q2	M	9.26	26.32*	1.56	10.06t	444.22	602.11**	114.91	223.24**	6.74	3.53**
	SD	23.76	29.74	4.02	17.59	179.52	238.56	139.57	107.82	2.54	2.69
Q3	M	6.35	24.77*	12.86	26.24t	370.56	491.50	106.78	215.71**	4.73	2.14**
	SD	19.72	27.84	12.09	18.82	125.21	236.05	106.78	133.69	1.97	1.90
Q4	M	6.57	25.52*	11.46	24.61t	361.28	471.38**	105.16	207.12**	4.81	2.16**
	SD	18.33	26.3	11.03	16.6	126.98	188.79	100.62	119.38	2.13	1.91
H1	M	8.87	24.49*	1.74	10.68t	442.22	566.67	113.16	220.38**	6.30	3.44**
	SD	22.89	27.47	4.26	18.21	174.97	212.82	119.33	119.68	2.50	2.63
H2	M	6.46	25.14*	12.11	25.37t	365.17	481.89**	108.18	217.14**	4.47	2.00**
	SD	19.84	26.94	10.89	16.09	122.63	210.62	101.91	123.52	1.78	1.75
Total	M	6.99	25.00*	3.99	13.77t	381.00	500.39**	115.50	227.11**	4.89	2.46**
	SD	19.63	26.83	5.18	16.91	127.85	205.37	105.12	118.13	1.81	1.84

RT = Response Time, RTV = Response Time Variability, * Paired Mann-Whitney U test, p <.003 Bonferroni corrected, ** Paired Student's t test, p <.03 Bonferroni corrected, t Paired Mann-Whitney U test, p <.02 Bonferroni corrected.

From: Leark, R.A., Dixon, D., Hoffman, T., & Huynh, D. (2001). Fake bad test response bias effects on the Test of Variables of Attention. *Archives of Clinical Neuropsychology*, 17, 335-342.

Table 44: Auditory Factor Data for the T.O.V.A.-A.

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
RT Total	.937				D' Q4		-.800			
RT Half 2	.915				D' Total		-.782			
RT Q4	.895				D' Q3		-.779			
RT Q3	.894				Com Q3		.751			
RTQ2	.844				Om Half 2			.852		
RT Half 1	.842				Om Q3			.843		
RT Q1	.796				Om Total			.839		
Var Total	.727				Om Q4			.834		
Var Half 2	.702				Com Half 1				.955	
Var Q3	.682				Com Q2				.927	
Var Q4	.677				Com Q1				.918	
Var H1	.672				Com Total				.813	
Var Q2	.633				Om Half 1					.653
Var Q1	.605				Om Q1					.629
D' Half 2		-.835			Om Q2					.615
Com Half 2		.814			D' Half1					-.597
Com Q4		.802								

Table 45: Comparison of the T.O.V.A. and T.O.V.A.-A.Tests(Adjusted Mean plus/minus 1 SD)*

Variable	Visual (N=1331)	Auditory (N=2551)	F Value, Significance
Omission	2.06±5.49	3.99±10.92	F(1,3878) = 41.89, p <.001
Commission	5.73±5.11	2.41±5.23	F(1,3878) = 419.66, p <.001
Response Time	445.00±117.93	586.28 ±139.31	F(1,3878) = 1601.14, P <.001
Variability	137.67±62.78	183.46±79.85	F(1,3878) = 556.94, P <.001
D Prime	4.79±1.45	5.29±1.86	F(1,3878) = 105.58, P <.001

*Results of analyses of covariance controlling for age and gender.

5.4 Construct Validity

An analysis of covariance (ANCOVA) controlling for age and gender was performed to compare total variable scores between tests (see Table 45). A higher mean of percentage of omission errors was found with the auditory test, having twice as high of omission errors than visual (3.99 ±10.92; 2.06 ±5.49). Mean percentage of commission errors were higher for the visual test (5.73 ±5.11; 2.41 ±5.23). Mean response times were faster for the visual test (445.00 ms ±117.93; 586.28 ms ±139.31). Response time variability was greater for the auditory than the visual (183.46 ±79.85; 137.61 ±62.78). All mean score between test differences were significant ($p < .001$).

To understand the uniqueness of the T.O.V.A.-A., Dixon & Leark (1999) compared the performances of 30 college aged participants on the T.O.V.A.-A. and two measures from the Halstead Reitan Neuropsychological Battery (HRNB). The HRNB has two measures purported to measure sustained attention. These are the Seashore Rhythm Test (SRT) and the Speech Sounds Perception Test (SSPT). The SRT requires the participant to differentiate between pairs of rhythmic beats over thirty trials. There are no breaks within the test and the stimuli are presented at a fairly rapid pace. The instructions require the individual to identify if the pairs are the same or different. The SSPT is comprised of sixty spoken vowel consonant nonsensical word blends, all of which are variations of the "ee" sound. The stimuli are played over a cassette tape with volume adjustment to user's preference. Reitan maintains (1985) that the test requires the maintenance of sustained attention through the 60 items. Given that the T.O.V.A.-A., SSPT and SRT require differing presentation of stimuli, only the Omission scores were used. Speed of processing is not a variable of either the SRT or the SSPT. Thus, response time and response time variability were not used for this study. A correlation analysis was done which yielded significant correlations between omission scores and SRT. However, the Omission Quarter 4 scores were not significantly correlated with SRT. None of the commission scores reached statistically significant correlation with the SRT. The SSPT was not significantly correlated the neither the omission nor commission scores of the T.O.V.A.-A., (Table 46). Dixon & Leark noted that the correlation between the omission scores of the T.O.V.A.-A. and the SRT made rational sense in that both instruments require immediate and sustained attention to task. The failure to find a statistically significant correlation between the SSPT and the T.O.V.A.-A. also makes rational sense in that the two tasks present stimuli in non-related methods. The correlation between the SRT and T.O.V.A.-A supports the sustained attention construct of the omission score.

Table 46: Correlation Coefficients Between Seashore Rhythm Test (SRT) and T.O.V.A.-A. Omission Scores

Omission Score	SRT
Q1	.42*
Q2	.43*
Q3	.44*
Q4	.27ns
H1	.42*
H2	.38*
Total	.48*

* p = .05, ns = non-significant correlation.

From: Dixon, D. & Leark, R.A. (1999). *Construct Validation of the Test of Variables of Attention - Auditory: Comparison to Reitan's Model of Attention.* Poster presentation at the American Association for the Advancement of Sciences 168th Annual Conference. Anaheim, CA January.

6 Interpretation

6.1 Overview

This chapter presents an overview of the interpretation of the T.O.V.A. test. Basic interpretation guidelines for determination of invalid profiles (cases), use of the ADHD Score, and other information important to test interpretation are also addressed. This chapter does not provide information relevant to printing the test results from your computer. Information on using the T.O.V.A. software program and generating T.O.V.A. reports is found in the *T.O.V.A. Clinical Manual* (2007).

6.2 Determination for Valid Test Profile

Several general guidelines exist for determining whether or not a test profile is valid. For test interpretation purposes, a case is usually *invalid* if it meets at least one of the following:

1. Response time (RT) equals 0 (zero) for any one quarter, half or total.

If a Response Time of 0 (zero) is recorded for any quarter, half or total, the test is considered to be invalid. A RT of 0 (zero) may indicate: 1) The subject had not pressed the microswitch/scorebox button during the examination; or 2) The microswitch/scorebox was not been properly connected to the computer. Literally, the zero response time score indicates that no responses were recorded. When this occurs, the test cannot accurately calculate any true omissions or true commissions, as the button on the microswitch has not been pressed (or if not connected properly, no response was recorded even if the button was pressed). Omissions will be artificially elevated, commissions artificially reduced, and response time variability eliminated.

2. Response Time Variability (V) equals 0 (zero) for any one quarter, half or total.

Either the subject did not press the button on the microswitch/scorebox during the test, or the microswitch/scorebox was not been properly connected to the computer. Theoretically, it is improbable that the subject was able to sustain a consistent response time without any variance to the mean response time. Thus, as with Rule 1, the test is considered invalid.

3. Test Interrupted.

While the test can be interrupted by the examiner during the test, the remainder of the test, once restarted, is considered invalid. Stopping a continuous performance test violates the standardization followed in the normative study. We recommend that the subject be retested on a different morning. We do not recommend restarting a test on the same day due to the fact that this was not done during the normative sampling.

4. Excessive Anticipatory Responses ($\geq 10\%$).

If an anticipatory response score equal to or greater than 10% is recorded for a quarter, all variables for that specific quarter may be invalid and must be interpreted cautiously. Anticipatory responses artificially decrease omission errors and response time, and increase commission errors and variability. See the *T.O.V.A. Clinical Manual* (2007) for interpretation guidelines.

5. Omission Error for any quarter, half or total equals 100%.

If the percentage of omission errors for any one quarter, half or total equals 100%, the subject missed majority of the targets for that quarter, half or total test. If this occurs, it is likely that the subject may not have correctly understood the test directions, or the subject may not have cooperated for the task.

6. Commission errors for any quarter, half or total equals 100%.

If the percentage of commission errors for any one quarter, half or total equals 100% this indicates that the subject has pressed the button for all of the nontargets for that time period. If this occurs, it is likely that 1.) the subject may not have correctly understood the test instructions; 2.) the subject may not have cooperated; or 3.) the microswitch/scorebox may not have been functioning properly.

6.3 Analyzing Test Data

From a report generated by the T.O.V.A. software program, first examine the totals for significant findings. Then examine and compare halves to determine whether there are significant findings and their clinical implications.

1) **Review Half 1**. This is the "boring" task (stimulus infrequent condition), and the "under aroused" have difficulty maintaining attention and control. If this half is symptomatic, Notes to the Clinician will include statements about increasing toward-task stimulation, decreasing time on-task, introducing activity, etc.

2) **Review Half 2**.This is the active or high response demand task (stimulus frequent condition), and the "over stimulated" have difficulty. Of course, everyone (normals included) tends to be faster and make many more commission errors than in half 1. If this half is symptomatic, Notes to the Clinician will contain statements about decreasing distractions and pace, etc.

3) **If results both half 1 and 2 are significantly below average** or if the person has difficulty with both halves, the Notes to the Clinician will contain suggestions for interventions for both conditions.

4) **Review results quarter by quarter.** The quarters within and across halves should be examined next. If there is a significant change (worsening) within a half, the possibility of a short (5-6 minute) attention span in that kind of task or possibly a 12-15 minute attention span overall should be considered, if the change is between quarters 3 and 4. If it appears that quarter 3 is worse than quarter 4, look for a change-of-set problem at the beginning of quarter 3 by examining the response by response option. This could be indicative of excessive obsessive-compulsive traits or anxiety. (See the *T.O.V.A. Clinical Manual* for more information.).

If it appears that quarter 1 is worse than quarter 2, this could be indicative of excessive anxiety. Look for game (or test taking) strategy influences or changes. For some individuals being fast is more important than making fewer errors, and visa-versa. Some individuals may dramatically slow down to reduce errors in half 2 while others may speed up, as if losing control. The T.O.V.A. program will label significant discrepancies between commission errors and response time in the section "Notes to the Clinician" so the results could be interpreted and the person can be debriefed. For example, if someone were deliberately slow to avoid errors, the response time could be significantly deviant and the error rate significantly better than average. However, it would not necessarily follow that the person had an attention problem (or depression). If there is an absence of an apparent test taking strategy, sometimes the protocol looks disorganized or erratic with no discernible consistency or pattern. It may reflect the presence of a significant mental illness or the performance of a strategist who changes strategy frequently and attempts to "beat" the test. It would be helpful to debrief the subject.

5) **If significantly high omission errors** (i.e. standard scores 80 or less), the Notes to the Clinician should have a prompt, look for clusters of omission errors in the response by response option to determine whether narcolepsy, seizures, etc., might be possible.

The response by response option allows the examination of each response recorded throughout the test. It can be viewed on screen or printed out as needed.

The four columns of information presented are:

1)Target or non-target

2) Response type:

Correct response, correct non-response, omission, commission, post-commission response, user interrupt, and button error.

3) Response time (ms)

Note: A significantly deviant performance does not necessarily make a diagnosis of ADHD.

6.4 Scoring

The software electronically records all subject responses, nonresponses, and response times of the microswitch. A sample report protocol is presented in the Appendices. All variables are presented, with summary of raw scores, calculated standard deviation scores and z scores for quarters, halves, and totals.

The scoring process is a sub-menu driven option within the software, easily performed after the testing is complete. The software saves unscored and scored data on the computer hard drive (by default unless another drive is selected).

6.5 Interpretation Rules

1. O + C + RT + V ≥ -3.6 std dev and O + RT + V ≥ -2.6

2. O or RT or V > -2 std dev (< 70 std score)

3. O + RT + V ≥ -3 std dev

4. If O + RT + V > -2 and < -3 std dev, borderline condition

5. If RT ≥ -2 std dev ($\leq$ 70 std score), and O and V each > -1 std dev (<85 std score), and C < -2 std dev (>70 std score)

6. If RT ≥ -2 std dev ($\leq$ 70 std score), O and V each < -1 std dev (> 85 std score), and C < -2 std dev (> 70 std score), compatible with depression and/or attention deficit

7. If any two (O, RT, V) ≥ -1.5 std dev ($\leq$ 77.5 std score)

8. If any two (O, RT, V) > -1 and < -1.5 std dev (77.5 - 84 std score), borderline condition

9. If $\geq$ 13 years old, and C ≥ -2 std dev ($\leq$ 70 std score)

10. If >13 years old, and C ≥ -1.5 and <-2 std dev (77.5 - 71 std score), and O, RT, and/or V ≥ -1.5 std dev (<77.5 std score)

11. If ?$\geq$ 13 years old, and C ≥ -1.5 std dev ($\leq$ 77.5 std score), and two others are > -1 and < -1.5 std dev (84 - 77.5 std score)

(O = omission errors, C = commission errors, RT = response time, V = variability)

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8 Appendices

8.1 Appendix A: Sample T.O.V.A. 7.3 Protocol

T.O.V.A.® Visual Continuous Performance Test Report

for Example Subject

The T.O.V.A. (Test Of Variables of Attention) is a continuous performance test used by health care professionals to help in the diagnosis and treatment of attention problems in children and adults, ages 4 to 80+. The results of a T.O.V.A. test are compared to the largest available group of same age, same gender normal individuals, and also to people with attention problems.

The T.O.V.A. provides useful information about a person's ability to accurately respond to an attention task. It is designed to augment and NOT to take the place of an evaluation done by a trained health care professional.

Attention problems may be caused by a number of conditions, including depression, anxiety, stress, learning problems, sleep disorders, head injuries, drug abuse, as well as excessive caffeine or nicotine. For more information about attention problems (including ADD and ADHD), please see the T.O.V.A. web site at http://www.tovatest.com/.

The T.O.V.A. measures attention during a 21.6 minute task. It records the speed, accuracy and consistency of responses to a series of squares presented in two second intervals. These measurements are then compared to the results of a large group of people of average intelligence who did not have any attention problems. This comparison determines whether the test results are "within normal range" or not. The T.O.V.A. also compares results to a large group of people diagnosed with ADHD, to help determine if deviant results may be caused by ADHD as opposed to other attention problems. The T.O.V.A. report is based on these two comparisons as well as other statistical measures.

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T.O.V.A. results are confidential. We recommend use of a release of information form when sharing T.O.V.A. results with others.

For more information on the T.O.V.A. test and interpretation, including the monitoring of treatment, visit our web site at http://www.tovatest.com/.

Figure 10: T.O.V.A. 7.3 Interpretation (Table Of Contents)

T.O.V.A.® Interpretation (Form 1)

Name:	Example Subject		Test Date: 05/31/05	Version:	7.2B3844
Subject:	01 0010	Gender: Male	Birth Date: 03/19/71	Serial:	001000
Session:	01	Age: 34y 02m 12d	Test Time: 08:42 AM	Test Type:	Visual

The T.O.V.A. (Test Of Variables of Attention) test is a computerized visual continuous performance test for the evaluation of attention and impulsivity in children and adults. This test provides reliable and relevant screening and diagnostic information about attention and impulsivity that is not otherwise available. The T.O.V.A. is also used to document treatment effectiveness (e.g., determine optimal medication dose) and monitor the course of treatment over time.

T.O.V.A. Interpretation

Overall, this T.O.V.A. is suggestive of an attention problem, including ADHD/ADD.

The test results (see Form 3) and the ADHD Score (see Form 4) are not within normal limits.

- Additional Interpretation Notes

There are no additional notes.

For more information on the T.O.V.A. test and interpretation, including the monitoring of treatment, visit our web site at http://www.tovatest.com/.

- Validation Notes:

All quarters are valid and interpretable.

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Figure 11: T.O.V.A. 7.3 Interpretation (Form 1)

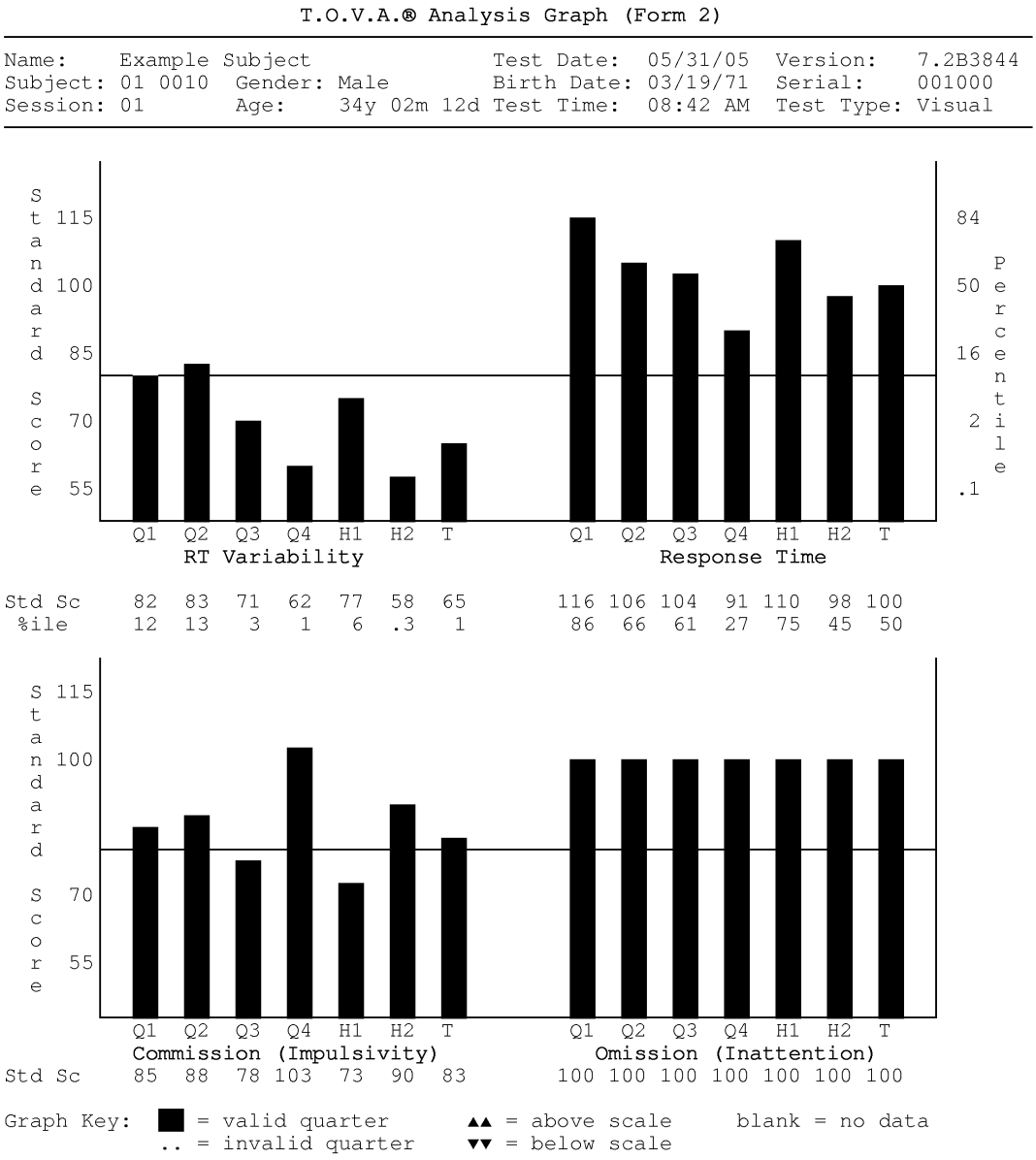

Figure 12: T.O.V.A. 7.3 Interpretation (Form 2)

T.O.V.A.® Analyzed Data (Form 3)

Name: Example Subject Test Date: 05/31/05 Version: 7.2B3844
Subject: 01 0010 Gender: Male Birth Date: 03/19/71 Serial: 001000
Session: 01 Age: 34y 02m 12d Test Time: 08:42 AM Test Type: Visual

These results, compared to the normal same-gender, same-age, and average intelligence group, are reported as standard deviations (std dev) and standard scores (std scores). The higher (more positive) the score, the better. Std devs and std scores indicate the deviance from the norm (e.g., the extent of a problem). Normal results for std devs are -1.00 or higher (more positive) and normal results for std scores are 85 or higher. Note: 1 std dev = 15 std score points.

Analysis Table	Quarter				Half		Total
	1	2	3	4	1	2	
RT Variability msec	59b	66b	93*	91*	66*	99*	93*
Std Deviation (Z)	-1.16b	-1.12b	-1.92*	-2.48*	-1.51*	-2.79*	-2.28*
Standard Score	82b	83b	71*	62*	77*	58*	65*
Response Time msec	317	360	317	393	339	355	352
Std Deviation (Z)	1.10	0.41	0.32	-0.54	0.73	-0.12	0.05
Standard Score	116	106	104	91	110	98	100
d' (DPrime)	6.68	6.68	5.35	5.86	6.68	5.56	6.18
Std Deviation (Z)	<-4	-1.50	-1.35	-0.33	-1.79	-0.63	-0.86
Standard Score	<40	77	79	94	73	90	87
Commission Errors	0.79%	0.79%	13.89%*	5.56%	0.79%*	9.72%	2.78%b
Std Deviation (Z)	-1.00	-0.75	-1.44*	0.24	-1.75*	-0.63	-1.10b
Standard Score	85	88	78*	103	73*	90	83b
Omission Errors	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Std Deviation (Z)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Standard Score	100	100	100	100	100	100	100

[ ] = Invalid Quarter b = Borderline result * = Significantly Deviant Result

The T.O.V.A. test results (below) are a quarter by quarter analysis of the test. These results, in combination with the ADHD Score (below and on Form 4) determine the T.O.V.A. Interpretation (see Form 1).

Test Results	N	N	*	*	*	*	*

Test Results Key: N = Within normal limits assuming average intelligence
* = Not within normal limits B = Borderline ? = Not interpretable

ADHD Score = -2.18

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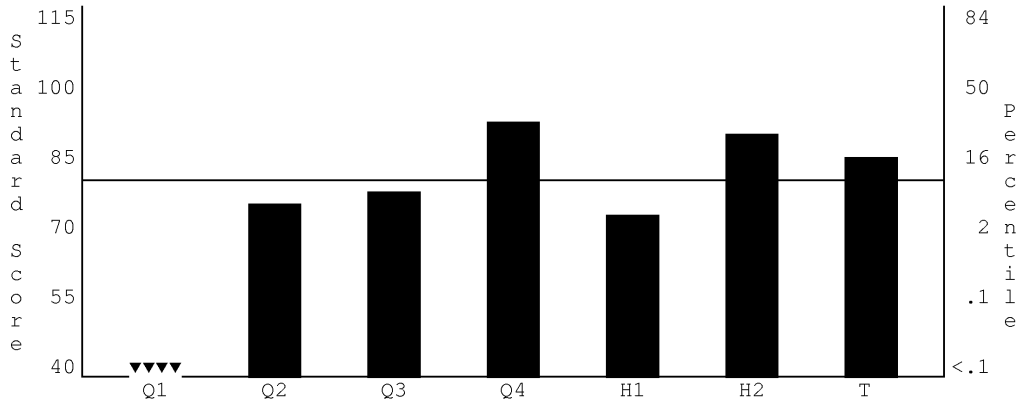
Figure 13: T.O.V.A. 7.3 Interpretation (Form 3)

T.O.V.A.® Signal Detection Data (Form 4)

Name:	Example Subject		Test Date: 05/31/05	Version:	7.2B3844
Subject:	01 0010	Gender: Male	Birth Date: 03/19/71	Serial:	001000
Session:	01	Age: 34y 02m 12d	Test Time: 08:42 AM	Test Type:	Visual

D Prime

d' (D Prime), a measure from signal detection theory, reflects how successfully a person continues to respond to the target and not respond to the nontarget over the length of the test. The higher the score, the more correctly the subject performed the task at hand.



Std Sc	<40	77	79	94	73	90	87
%ile	<.1	6	8	34	4	25	19

Graph Key: ▬ = valid quarter ▲▲▲▲ = above scale blank = no data
.... = invalid quarter ▼▼▼▼ = below scale

The T.O.V.A. ADHD Score

The ADHD Score is a comparison of the subject's responses to those of an ADHD group. An ADHD Score of -1.80 or less (more negative) fits the profile of the ADHD sample. A score of more than -1.80 (more positive) does not fit the ADHD profile. When comparing ADHD Scores (such as with medication challenges), the higher the ADHD Score the better the performance. Thus, the ADHD Score can be used as an indicator of response to treatment.

Response Time (Half 1)	0.73
D Prime (Half 2)	-0.63
Variability (Total)	-2.28
ADHD Score	-2.18

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Figure 14: T.O.V.A. 7.3 Interpretation (Form 4)

T.O.V.A.® Information and Results (Form 5)

Name: Example Subject Test Date: 05/31/05 Version: 7.2B3844
Subject: 01 0010 Gender: Male Birth Date: 03/19/71 Serial: 001000
Session: 01 Age: 34y 02m 12d Test Time: 08:42 AM Test Type: Visual

Medication	Dosage	Med-Test Interval
Challenge:	0.00 mg	0.0 hours
Med. #2:	0.00 mg	0.0 hours
Med. #3:	0.00 mg	0.0 hours

Weight: 0.0 lbs Height: 0 in.

Comments: Baseline

Tester:
ISI: 2000 msec Ontime: 0200 msec Offtime: 0300 msec Anticipatory: 0150 msec
Test Format: 1(Std) Test Version: 7.2B9 Test Serial: 16292

Results Table (Tabulated Raw data)		Quarter 1	2	3	4	Half 1	2	Total
RT Variability	msec	59	66	93	91	66	99	93
Response Time	msec	317	360	317	393	339	355	352
D Prime		6.68	6.68	5.35	5.86	6.68	5.56	6.18
Commission Errors	%	0.79%	0.79%	13.89%	5.56%	0.79%	9.72%	2.78%
(Impulsivity)	#	1	1	5	2	2	7	9
Omission Errors	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
(Inattention)	#	0	0	0	0	0	0	0
Anticipatory Resp.s	%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Nontargets	#	0	0	0	0	0	0	0
Targets	#	0	0	0	0	0	0	0
Multiple Responses	#	0	0	1	1	0	2	2
Correct Responses	#	36	36	126	126	72	252	324
Correct Nonresp.s	#	125	125	31	34	250	65	315
Post-Commissions	#	1	1	5	2	2	7	9
Response Time	msec	340	534	381	440	437	398	406
Variability	msec	0	0	150	135	97	148	139
User Interrupts		0	0	0	0	0	0	0
Hardware Errors		0	0	0	0	0	0	0

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Figure 15: T.O.V.A. 7.3 Interpretation (Form 5)

T.O.V.A.® Notes to the Clinician (Form 6)

Name:	Example Subject	Test Date:	05/31/05	Version:	7.2B3844
Subject:	01 0010	Gender: Male	Birth Date:	03/19/71	Serial:	001000
Session:	01	Age: 34y 02m 12d	Test Time:	08:42 AM	Test Type:	Visual

Clinical Notes:

NOTE: The clinician needs to take into account factors that may result in a "false negative" or a "false positive" result. These factors may include psychiatric and medical conditions including sleep disorders, medication(s) (e.g., prescribed, over the counter, homeopathic or illicit), caffeine and nicotine, and highly developed eye-hand coordination skills (e.g., computer games experience, trained athletes). In addition, the interpretation assumes average intelligence. Since an attention problem may also be secondary to auditory (not visual) processing difficulties, a T.O.V.A.-A. (auditory) test can be performed. Since a percentage of false negatives and positives occur with all tests, the clinician must rely on all of the relevant information, not just the T.O.V.A.

The T.O.V.A. test can be administered after a single challenge dose of medication to measure response to treatment. The T.O.V.A. test can also be used to evaluate different doses of medication and to monitor medication efficacy over time. Please see the T.O.V.A. Clinical Guide.

Although adult norms are based on a small number of subjects, the results very closely approximate the predicted (theoretical) curves for age and gender. Preliminary data indicate that T.O.V.A. performance does not significantly vary between the ages of 19 and 60. Thus, interpretations from this norming base can be considered reliable.

Figure 16: T.O.V.A. 7.3 Interpretation (Form 6)

8.2 Appendix B: Sample Legacy T.O.V.A. 7.0 Protocol

T.O.V.A(R) Visual Continuous Performance Test Report

The T.O.V.A. (R) (Test Of Variables of Attention) test is a computerized visual continuous performance test for the diagnosis and treatment of children and adults with attentional disorders. This highly reliable test provides relevant screening and diagnostic information about attention that is not otherwise available. The T.O.V.A. is used to accurately predict treatment effuectiveness,
determine optimal dosage, and monitor the course of treatment.

Whether this protocol is interpreted as within normal limits or not, the clinician needs to take into account several factors that may result in a "false negative" or "false positive" result, including IQ, computer game experience, and the possibility that an attentional problem may be secondary to auditory (not visual) processing difficulties. In the latter case, T.O.V.A.-A (auditory) test can be performed. Since a percentage of false negatives and positives occur with all tests, the clinician must rely on all of the relevant information, not just the T.O.V.A.

T.O.V.A. results are confidential. We recommend use of a release of information form when sharing T.O.V.A. results with others.

Table of Contents:

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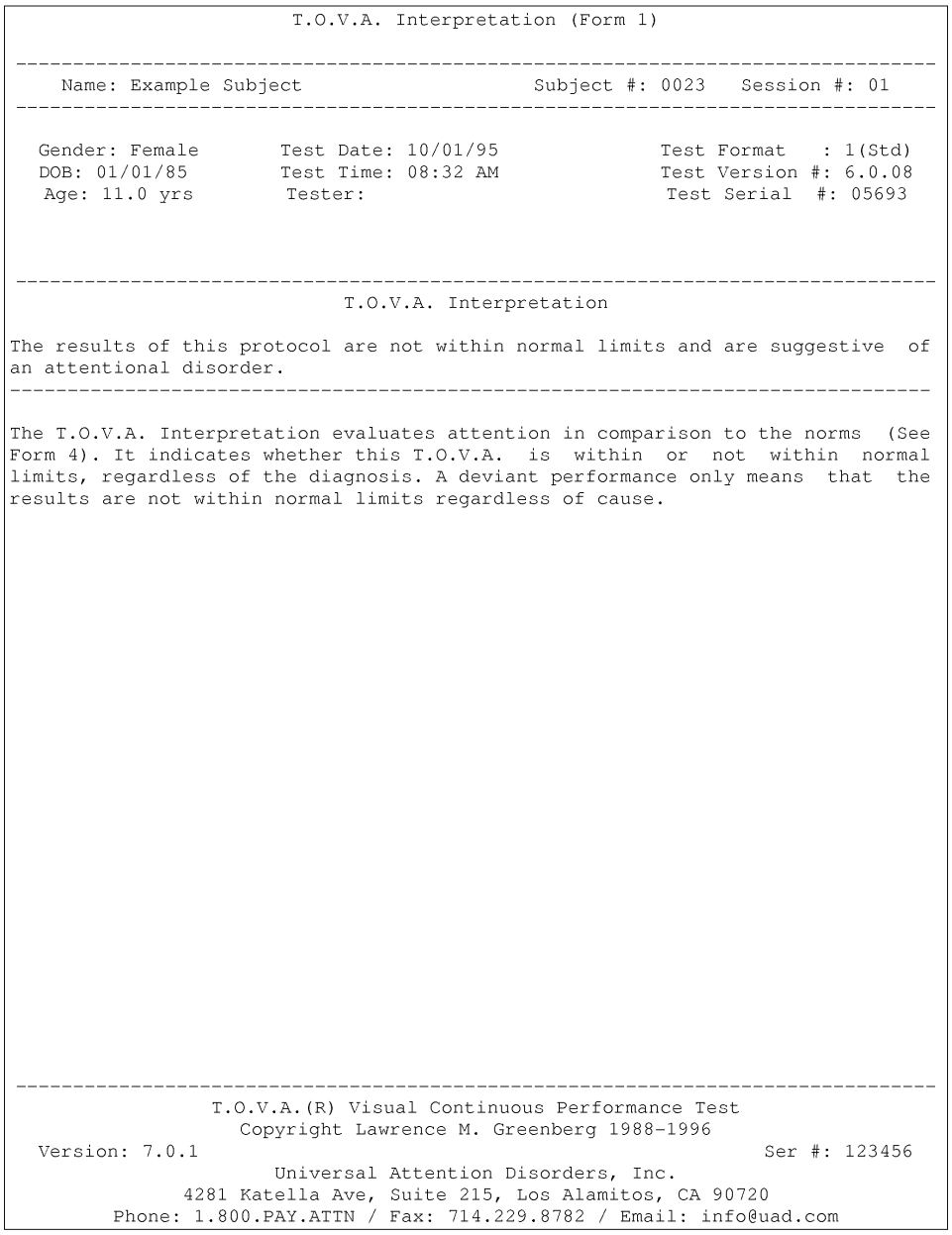
4281 Katella Ave, Suite 215, Los Alamitos, CA 90720
Phone: 1.800.PAY.ATTN / Fax: 714.229.8782 / Email: info@uad.com

Figure 17: T.O.V.A. 7.0 Interpretation (Table Of Contents)



T.O.V.A. Interpretation (Form 1)

Name: Example Subject Subject #: 0023 Session #: 01

Gender: Female Test Date: 10/01/95 Test Format : 1(Std)
DOB: 01/01/85 Test Time: 08:32 AM Test Version #: 6.0.08
Age: 11.0 yrs Tester: Test Serial #: 05693

T.O.V.A. Interpretation

The results of this protocol are not within normal limits and are suggestive of an attentional disorder.

The T.O.V.A. Interpretation evaluates attention in comparison to the norms (See Form 4). It indicates whether this T.O.V.A. is within or not within normal limits, regardless of the diagnosis. A deviant performance only means that the results are not within normal limits regardless of cause.

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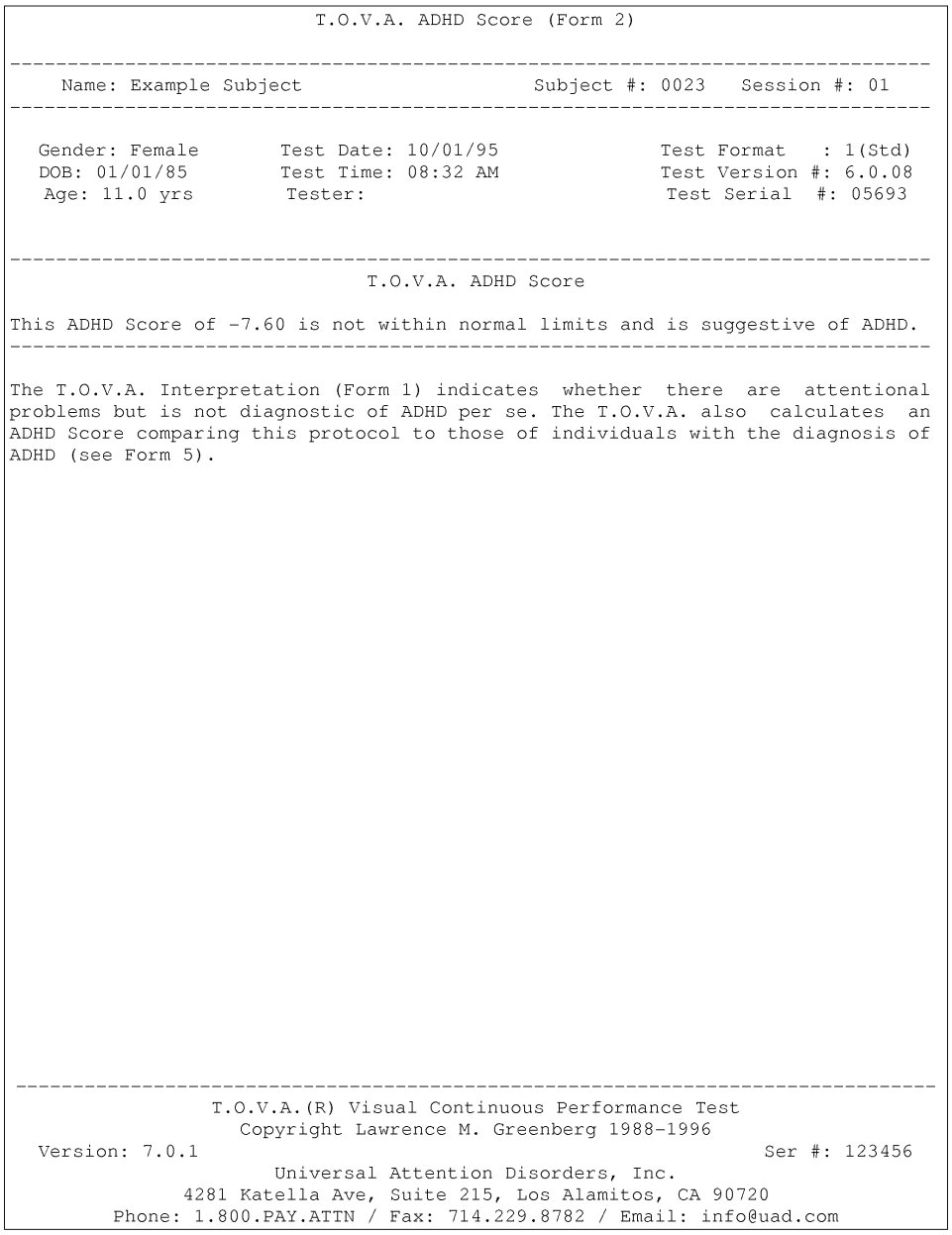
Figure 18: T.O.V.A. 7.0 Interpretation (Form 1)



T.O.V.A. ADHD Score (Form 2)

Name: Example Subject Subject #: 0023 Session #: 01

Gender: Female Test Date: 10/01/95 Test Format : 1(Std)
DOB: 01/01/85 Test Time: 08:32 AM Test Version #: 6.0.08
Age: 11.0 yrs Tester: Test Serial #: 05693

T.O.V.A. ADHD Score

This ADHD Score of -7.60 is not within normal limits and is suggestive of ADHD.

The T.O.V.A. Interpretation (Form 1) indicates whether there are attentional problems but is not diagnostic of ADHD per se. The T.O.V.A. also calculates an ADHD Score comparing this protocol to those of individuals with the diagnosis of ADHD (see Form 5).

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Figure 19: T.O.V.A. 7.0 Interpretation (Form 2)

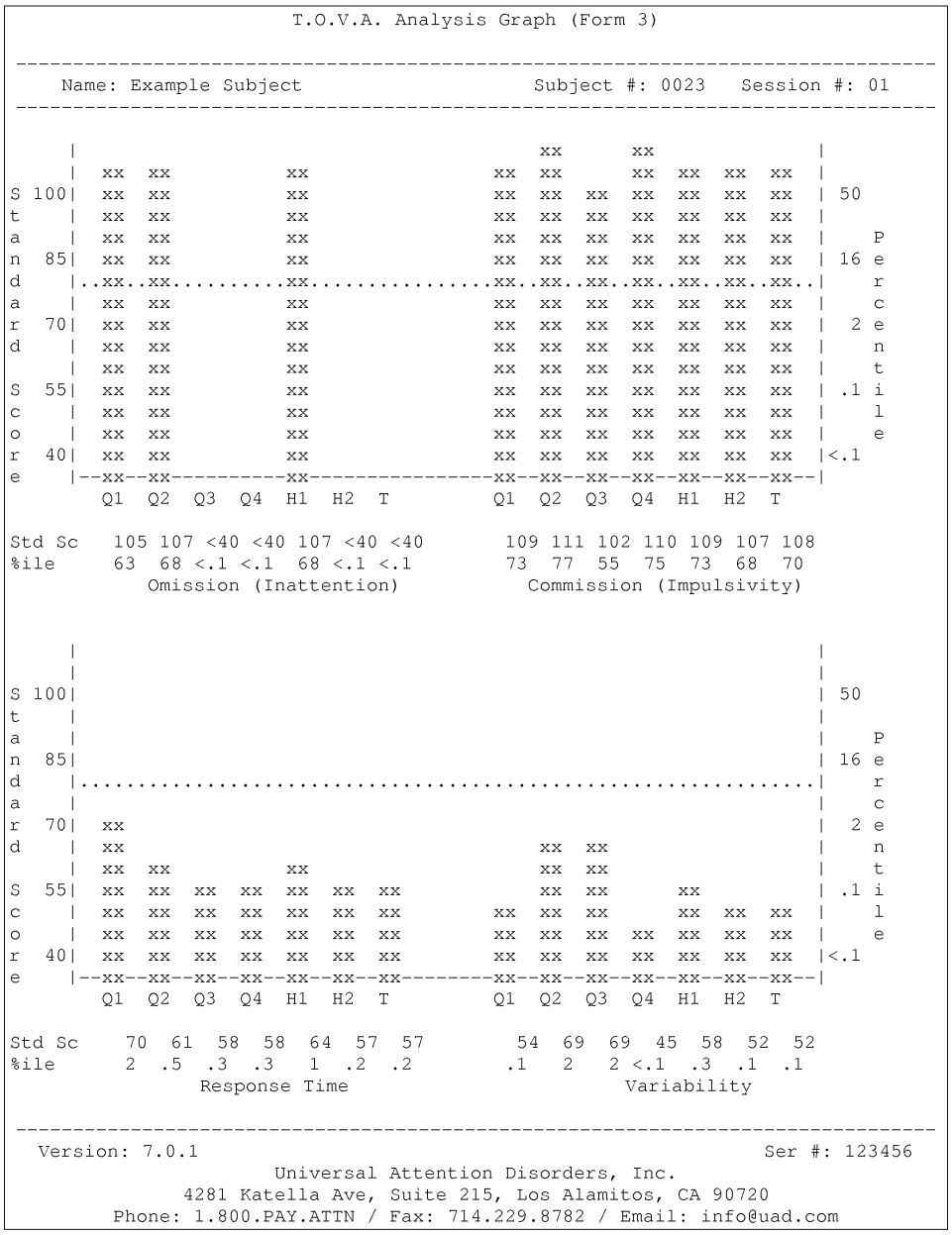

Figure 20: T.O.V.A. 7.0 Interpretation (Form 3)

T.O.V.A. Analyzed Data (Form 4)

Name: Example Subject Subject #: 0023 Session #: 01

Gender: Female Test Date: 10/01/95 Test Format : 1(Std)
DOB: 01/01/85 Test Time: 08:32 AM Test Version #: 6.0.08
Age: 11.0 yrs Tester: Test Serial #: 05693

These results, compared to the normal same-gender, same-age, and average IQ group, are reported as standard deviations (std dev) and standard scores (std scores). A standard deviation indicates the extent of a problem (or deviance from the norm). The more negative the std dev, the greater the problem. Conversely, a more positive std dev indicates a better than average performance. Normal range is -1.00 to +1.00. The std score (1 std dev = 15 std score points) also compares these results to the norm. Normal range is 85 to 115. Scores above 115 are better than average, and scores below 85 are less than average.

Analysis Table	Quarter				Half		Total
	1	2	3	4	1	2	
Omission Errors %	0.00%	0.00%	11.11%*	16.67%*	0.00%	13.89%*	10.80%*
Std Deviation (Z)	0.35	0.49	<-4*	<-4*	0.44	<-4*	<-4*
Standard Score	105	107	<40*	<40*	107	<40*	<40*
Commission Errors %	0.79%	0.00%	19.44%	16.67%	0.40%	18.06%	4.32%
Std Deviation (Z)	0.58	0.76	0.14	0.68	0.58	0.46	0.55
Standard Score	109	111	102	110	109	107	108
Response Time msec	586*	677*	618*	607*	631*	613*	618*
Std Deviation (Z)	-2.02*	-2.58*	-2.78*	-2.79*	-2.37*	-2.86*	-2.88*
Standard Score	70*	61*	58*	58*	64*	57*	57*
RT Variability msec	207*	195*	196*	298*	206*	250*	240*
Std Deviation (Z)	-3.05*	-2.06*	-2.04*	-3.65*	-2.80*	-3.17*	-3.16*
Standard Score	54*	69*	69*	45*	58*	52*	52*

[ ] = Invalid Quarter * = Significantly Deviant Result
! ! = Excessive Commission Quarter b = Borderline result

Analysis Validation Notes

There are no invalid quarters.

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Figure 21: T.O.V.A. 7.0 Interpretation (Form 4)

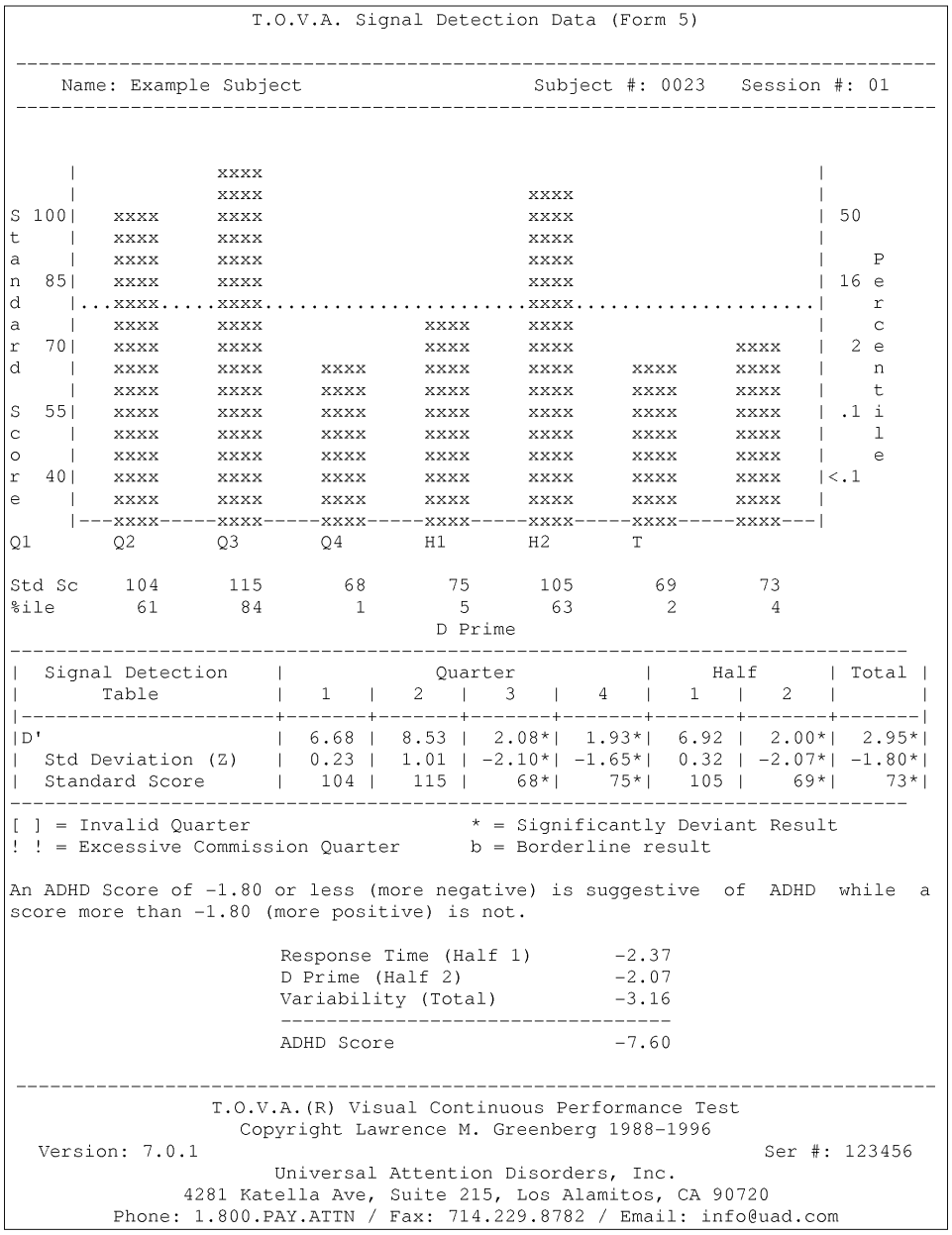

Figure 22: T.O.V.A. 7.0 Interpretation (Form 5)

T.O.V.A. Information and Results (Form 6)

Name: Example Subject Subject #: 0023 Session #: 01

Gender: Female Test Date: 10/01/95 Test Format : 1(Std)
DOB: 01/01/85 Test Time: 08:32 AM Test Version #: 6.0.08
Age: 11.0 yrs Tester: Test Serial #: 05693

ISI:02000msec Ontime:00200msec Anticipatory:00200msec Offtime:00300msec

Medication	Dosage	Med-Test Interval
Challenge:	0.00 mg	0.0 hours
Med. #2:	0.00 mg	0.0 hours
Med. #3:	0.00 mg	0.0 hours

Weight: 0.0 kg Height: 0 cm

Results Table (Tabulated Raw data)		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Half 1	Half 2	Total
Omission Errors	%	0.00%	0.00%	11.11%	16.67%	0.00%	13.89%	10.80%
(Inattention)	#	0	0	14	21	0	35	35
Commission Errors	%	0.79%	0.00%	19.44%	16.67%	0.40%	18.06%	4.32%
(Impulsivity)	#	1	0	7	6	1	13	14
Response Time	msec	586	677	618	607	631	613	618
RT Variability	msec	207	195	196	298	206	250	240
Correct Responses	#	36	36	111	101	72	212	284
Correct Nonresp.s	#	125	126	29	30	251	59	310
Anticipatory Resp.s	%	0.00%	0.00%	0.62%	2.47%	0.00%	1.54%	0.77%
NonTargets	#	0	0	0	0	0	0	0
Targets	#	0	0	1	4	0	5	5
Multiple Responses	#	0	0	0	1	0	1	1
User Interrupts		0	0	0	0	0	0	0
Hardware Errors		0	0	0	0	0	0	0
Post-Commissions	#	1	0	7	6	1	13	14
Response Time	msec	611	0	855	602	611	738	729
Variability	msec	0	0	236	234	0	267	259
D Prime		6.68	8.53	2.08	1.93	6.92	2.00	2.95

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Figure 23: T.O.V.A. 7.0 Interpretation (Form 6)

T.O.V.A. Notes to the Clinician (Form 7)

Name: Example Subject Subject #: 0023 Session #: 01

The T.O.V.A. test can be administered after a single challenge dose of medication to reliably predict response to treatment. The T.O.V.A. test can also be used to titrate the dose of medication in terms of the attentional variables and to monitor medication efficacy over time. (Please see the T.O.V.A. Manual.)

In Quarter 1, Quarter 2, Quarter 3 and Quarter 4 errors of commission (impulsivity/disinhibition) were low and the response time was slow. The subject may have adopted a cautious response strategy to minimize errors, resulting in slow time. Consider retesting after instructing the subject to equally balance accuracy and speed.

The omission errors (inattention) in this protocol are excessive (<-2.0 std dev/quarter) in Quarter 3 and Quarter 4. Excessive omission errors can be associated with neurological and/or neuropsychological impairment, including sleep disorders.

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Figure 24: T.O.V.A. 7.0 Interpretation (Form 7)

8.3 Appendix C: T.O.V.A. 7.x Calculations

Table 47: T.O.V.A. 7.x Calculations: per quarter, half and total

Omissions:	Percentage (000.00%)	$\frac{\#\text{ Omissions}}{\#\text{ Targets}-\#\text{ Anticipatories}} \times 100\%$
	Standard Deviation (0.00)	$\frac{\text{Subject's \% Omissions}-\text{Norm Table \% Omissions}}{\text{Norm Table \% Omissions Standard Deviation}}$
	Standard Score (000)	$100 - (\text{Subject's \% Omissions Std. Dev.} \times 15)$
Commissions:	Percentage (000.00%)	$\frac{\#\text{ Commissions}}{\#\text{ Targets - }\#\text{ Anticipatories}} \times 100\%$
	Standard Deviation (0.00)	$\frac{\text{Subject's \% Commissions}-\text{Norm Table \% Commissions}}{\text{Norms Table \% Commissions Standard Deviation}}$
	Standard Score (000)	$100 - (\text{Subject's \% Commissions Std. Dev.} \times 15)$
Response Time:	Mean (000 ms)	$\frac{\sum(\text{Correct Response Times})}{\#\text{ Correct Responses}}$
	Standard Deviation (0.00)	$\frac{\text{Subject's mean RT}-\text{Norm Table Mean RT}}{\text{Norm Table RT Standard Deviation}}$
	Standard Score (000)	$100 - (\text{Subject's RT Std. Dev.} \times 15)$
Variability:	Mean (000 ms)	$\sqrt{\frac{\sum_{i=0}^{n} x_i - (\text{Mean Correct RT})^2}{\#\text{ Correct Responses}}}$
	Standard Deviation (0.00)	$\frac{\text{Subject's Variability}-\text{Norm Table Variability}}{\text{Norm Table Variability Standard Deviation}}$
	Standard Score (000)	$100 - (\text{Subject's Variability Std. Dev.} \times 15)$
Limits:	Standard Deviation: Standard Score:	Values limited to $-5 \leq$ Standard Deviation ≤ 5 Thus by formula, $25 \leq$ Standard Score ≤ 175.
Miscellaneous:	Quarters: 1 and 2 3 and 4	Targets,NonTargets: 36,126 126,36
T Scores:		50 + (Standard Deviation + 10)

8.4 Appendix D: Mac version 1.3 Calculations

Table 48: Mac v1.3 Calculations: per quarter, half and total

Omissions:	Percentage (000.00%)	$\frac{\#\text{ Omissions}}{\#\text{ Targets}-\#\text{ Anticipatories}} \times 100\%$
	Number	# Omissions Errors
Commissions:	Percentage (000.00%)	$\frac{\#\text{ Commissions}}{\#\text{ NonTargets}-\#\text{ NonTarget Anticipatories}} \times 100\%$
	Number	# Commissions Errors
Correct Responses:	Percentage (000.00%)	$\frac{\#\text{ Correct Responses}}{\#\text{ Targets}} \times 100\%$
	Number	# Correct Responses
	Mean (000 ms)	$\frac{\sum \text{Correct Response Times}}{\#\text{ Correct Responses}}$
	Variability (000 ms)	$\sqrt{\frac{\sum_{i=0}^{n} x_i - \text{Mean Correct RT}^2}{\#\text{ Correct Responses}}}$
Correct Nonresponses:	Percentage (000.00%)	$\frac{\#\text{ correct NonResponses}}{\#\text{ NonTargets}} \times 100\%$
	Number	# Correct NonResponses
Anticipatories:	Percentage (000.00%)	$\frac{\#\text{ Anticipatories}}{\#\text{ Total Stimuli}} \times 100\%$
	Number	# Anticipatory Errors
Multiples:	Number	# Multiple Errors
Post Commission Responses:	Number	# Post Commission Responses
	Mean (000 ms)	$\frac{\sum \text{Post Commission Response Times}}{\#\text{ Post Commission Responses}}$
	Variability (000 ms)	$\sqrt{\frac{\sum_{i=0}^{n} x_i - \text{Mean PC RT}^2}{\#\text{ Post Commissions}}}$
User Interrupts:	Number	#
Button Errors:	Number	#

8.5 Appendix E: Visual Norms

Table 49: Norms Summary (See end of this section for reference key.)

Years of Age	Omission Errors(%): Inattention $Mean \pm SD$	Commission Errors(%): Impulsivity $Mean \pm SD$	Response Time (ms) $Mean \pm SD$	Variability (SD, ms) $Mean \pm SD$	D PRIME: Hit/ False Alarm Rate $Mean \pm SD$]
Age 4					
Male (N=24)	28.81 ± 20.51	17.34 ± 12.54	783.42 ± 87.71	330.08 ± 65.98	1.68 ± 0.69
Female (N=26)	33.38 ± 21.06	10.75 ± 7.46	826.69 ± 104.27	325.46 ± 91.67	1.86 ± 0.84
Age 5					
Male (N=66)	14.17 ± 11.90	10.27 ± 6.92	723.69 ± 147.40	262.94 ± 63.33	2.59 ± 0.65
Female (N=80)	14.95 ± 12.92	6.91 ± 7.05	767.90 ± 126.78	260.4 ± 55.69	2.93 ± 0.98
Age 6					
Male (N=19)	8.95 ± 7.80	10.37 ± 6.85	604.32 ± 120.24	236.95 ± 54.41	2.96 ± 0.94
Female (N=23)	8.87 ± 9.77	6.78 ± 4.16	667.00 ± 74.27	248.04 ± 38.79	3.10 ± 0.70
Age 7					
Male (N=61)	6.54 ± 7.55	10.97 ± 8.47	558.70 ± 108.12	223.15 ± 54.93	3.19 ± 1.04
Female (N=61)	4.00 ± 4.30	6.89 ± 5.02	608.28 ± 99.87	215.87 ± 47.89	3.84 ± 1.20
Age 8					
Male (N=36)	2.17 ± 2.94	8.61 ± 5.23	487.19 ± 86.14	176.92 ± 47.66	4.22 ± 1.24
Female (N=38)	1.87 ± 2.46	6.61 ± 4.28	544.34 ± 79.54	192.79 ± 37.89	4.31 ± 1.19
Age 9					
Male (N=57)	4.35 ± 14.22	9.39 ± 6.52	458.56 ± 80.75	161.74 ± 43.81	4.25 ± 1.44
Female (N=55)	1.07 ± 1.50	6.53 ± 4.17	498.80 ± 71.53	164.82 ± 38.17	4.71 ± 1.23
Age 10					
Male (N=33)	2.45 ± 6.87	7.70 ± 3.20	402.15 ± 58.04	137.39 ± 39.30	4.60 ± 1.29
Female (N=34)	.53 ± .90	5.65 ± 4.23	438.47 ± 74.24	138.32 ± 38.78	5.39 ± 1.41
Age 11					
Male (N=55)	1.93 ± 7.28	8.69 ± 5.34	379.33 ± 66.01	123.82 ± 33.70	4.69 ± 1.48
Female (N=60)	.68 ± 1.26	6.65 ± 4.16	412.80 ± 71.07	130.95 ± 34.36	5.06 ± 1.17
Age 12					
Male (N=37)	.68 ± 1.15	6.34 ± 3.82	389.92 ± 73.81	125.05 ± 37.09	4.97 ± 1.15
Female (N=49)	.53 ± .92	4.59 ± 4.16	410.29 ± 80.96	122.33 ± 40.89	5.34 ± 1.26
Age 13					
Male (N=66)	.67 ± 1.44	4.93 ± 3.93	379.74 ± 60.77	108.35 ± 33.71	5.16 ± 1.22
Female (N=69)	.55 ± 1.39	3.81 ± 2.85	379.71 ± 56.85	103.09 ± 29.61	5.14 ± 1.14
Age 14					
Male (N=46)	.31 ± .47	3.97 ± 3.31	383.43 ± 65.82	104.70 ± 35.07	5.32 ± 1.05
Female (N=36)	$.27^{10}$ ± .65	2.95 ± 2.60	383.36 ± 62.93	100.39 ± 34.64	5.71 ± 1.12
Age 15					
Male (N=61)	.69 ± 1.31	3.64 ± 2.82	361.15 ± 53.54	96.59 ± 27.34	5.25 ± 1.19
Female (N=58)	.41 ± .82	3.45 ± 3.39	374.41 ± 61.85	90.93 ± 22.71	5.63 ± 1.42

Table 50: Norms - Summary, continued (See end of this section for reference key.)

Age 16					
Male (N=22)	$.77 \pm 1.42$	4.19 ± 4.54	354.82 ± 51.97	91.59 ± 25.77	5.16 ± 1.36
Female (N=29)	$.72 \pm 1.42$	2.87 ± 2.46	379.62 ± 60.33	100.83 ± 32.13	5.56 ± 1.31
Age 17					
Male (N=18)	$.27^{10} \pm .30$	2.79 ± 3.11	377.89 ± 45.92	95.94 ± 27.72	5.63 ± 1.51
Female (N=18)	$.38 \pm .75$	2.21 ± 2.26	376.72 ± 48.55	89.56 ± 20.04	5.88 ± 1.08
Age 18					
Male (N=32)	$.35 \pm .42$	3.86 ± 3.04	373.94 ± 64.20	89.84 ± 29.15	5.18 ± 1.04
Female (N=66)	$.35 \pm .80$	3.21 ± 2.87	402.44 ± 60.60	86.58 ± 23.18	5.49 ± 1.08
Age 19					
Male (N=25)	$.07 \pm .18^{10}$	2.17 ± 1.52	404.04 ± 56.86	82.92 ± 20.07	6.24 ± 1.00
Female (N=54)	$.58 \pm 1.81$	3.73 ± 3.38	403.52 ± 49.63	86.06 ± 23.46	5.44 ± 1.14
Age 20 - 29					
Male (N=19)	$.37 \pm .72$	4.81 ± 3.48	383.58 ± 52.36	83.53 ± 20.86	5.30 ± 1.08
Female (N=30)	$.55 \pm 1.21$	2.29 ± 2.66	421.07 ± 71.26	88.63 ± 29.06	5.89 ± 1.25
Age 30 - 39					
Male (N=4)	$.00 \pm .01^{10}$	1.62 ± 1.05	355.25 ± 72.94	64.00 ± 12.83	6.49 ± 0.36
Female (N=22)	$.14 \pm .25^{10}$	1.77 ± 1.56	369.77 ± 53.53	81.36 ± 24.57	6.05 ± 0.96
Age 40 - 49					
Male (N=14)	$.02 \pm .08^{10}$	2.76 ± 1.80	331.93 ± 31.25	66.14 ± 11.60	6.29 ± 0.84
Female (N=19)	$.06 \pm .13^{10}$	1.88 ± 2.01	405.32 ± 66.85	81.89 ± 21.06	6.21 ± 0.85
Age 50 - 59					
Male (N=8)	$.19 \pm .28^{10}$	2.16 ± 1.22	442.88 ± 46.85	75.38 ± 11.55	5.71 ± 1.02
Female (N=16)	$.15 \pm .32^{10}$	1.85 ± 2.33	432.06 ± 41.57	79.56 ± 17.37	6.20 ± 1.22
Age 60 - 69					
Male (N=12)	$.10 \pm .24^{10}$	1.95 ± 2.22	447.17 ± 35.92	86.50 ± 22.93	6.19 ± 0.91
Female (N=24)	$.22 \pm .31^{10}$	2.69 ± 2.53	442.75 ± 57.71	81.67 ± 16.73	5.76 ± 1.23
Age 70 - 79					
Male (N=12)	1.47 ± 2.22	4.17 ± 3.32	476.75 ± 55.65	107.08 ± 33.85	4.77 ± 1.35
Female (N=39)	$.73 \pm 1.71$	2.55 ± 2.03	480.23 ± 50.35	97.87 ± 26.33	5.21 ± 1.01
Age 80 and up					
Male (N=8)	2.47 ± 2.47	5.83 ± 3.87	502.25 ± 68.44	128.88 ± 21.68	3.80 ± 0.58
Female (N=23)	2.12 ± 3.11	3.50 ± 3.64	509.57 ± 63.09	115.00 ± 48.39	4.63 ± 1.21

Table 51: Visual Norms - Omissions (%)(See end of this section for reference key.)

Years of Age	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Half 1	Half 2	Total
Age 4							
Male (N=24)	32.75 ± 18.04		27.68 ± 22.54				28.81 ± 20.51
Female (N=26)	41.56 ± 27.96		31.04 ± 20.30				33.38 ± 21.06
Age 5							
Male (N=66)	16.09 ± 12.60		13.62 ± 12.61				14.17 ± 11.90
Female (N=80)	15.96 ± 16.26		14.66 ± 13.83				14.95 ± 12.92
Age 6							
Male (N=19)	4.84 ± 5.58	9.53 ± 9.07	7.21 ± 7.79	12.11 ± 11.24	7.11 ± 6.61	9.58 ± 8.66	8.95 ± 7.80
Female (N=23)	7.91 ± 11.24	9.26 ± 12.23	7.52 ± 7.73	10.39 ± 12.42	8.61 ± 11.52	8.96 ± 9.88	8.87 ± 9.77
Age 7							
Male (N=61)	5.10 ± 11.19	7.98 ± 12.13	5.18 ± 6.41	8.10 ± 9.60	6.46 ± 11.32	6.59 ± 7.57	6.54 ± 7.55
Female (N=61)	3.97 ± 6.62	3.70 ± 4.18	3.38 ± 4.51	4.97 ± 5.80	3.74 ± 4.32	4.11 ± 4.82	4.00 ± 4.30
Age 8							
Male (N=36)	1.89[4] ± 3.05	2.72[4] ± 4.05	1.61 ± 2.09	2.53 ± 4.53	2.31 ± 3.19	1.97 ± 3.09	2.17 ± 2.94
Female (N=38)	1.74 ± 2.34[4]	2.34[4] ± 3.05	1.18 ± 1.86	2.53 ± 4.57	1.97 ± 1.95	1.82 ± 2.79	1.87 ± 2.46
Age 9							
Male (N=57)	4.81 ± 15.59	3.51 ± 13.29	4.42 ± 16.36	4.49 ± 14.42	4.09 ± 13.43	4.35 ± 14.59	4.35 ± 14.22
Female (N=55)	1.44[4] ± 3.70	1.33 ± 2.07[4]	.76[2] ± 1.22	1.42 ± 2.45	1.29 ± 2.39	1.04[6] ± 1.60	1.07 ± 1.50
Age 10							
Male (N=33)	3.42 ± 8.06	3.36 ± 9.08	3.12 ± 12.52	1.30 ± 2.08	3.33 ± 8.06	2.18 ± 7.00	2.45 ± 6.87
Female (N=34)	.65 ± 2.00[4]	.764 ± 2.10	.41 ± .78[2]	.68[2] ± 1.01	.71 ± 1.71	.41 ± .78[6]	.53 ± .90
Age 11							
Male (N=55)	1.75[4] ± 7.18	2.55 ± 8.17	2.04 ± 10.61	1.85 ± 4.43	2.07 ± 7.67	1.91 ± 7.30	1.93 ± 7.28
Female (N=60)	1.13[4] ± 3.15	1.02[4] ± 2.05	.45[2] ± .87	.75[2] ± 1.32	1.00 ± 2.22	.52 ± 1.03[6]	.68 ± 1.26
Age 12							
Male (N=37)	.53 ± 1.95[4]	.98[4] ± 1.83	.58[2] ± .88	.93 ± 1.71	.70 ± 1.54	.72 ± 1.24[6]	.68 ± 1.15
Female (N=49)	.61 ± 1.39[4]	.83 ± 1.61[4]	.44[2] ± .85	.57[2] ± 1.49	.72 ± 1.27	.50 ± 1.03[6]	.53 ± .92
Age 13							
Male (N=66)	.68 ± 1.97[4]	.76 ± 1.48[4]	.56[2] ± 1.43	.86 ± 1.85	.71 ± 1.50	.67 ± 1.56[6]	.67 ± 1.44
Female (N=69)	.33 ± 1.05[4]	.61[4] ± 2.02	.57[2] ± .92	.63[2] ± 2.26	.47 ± 1.43	.56 ± 1.41[6]	.55 ± 1.39
Age 14							
Male (N=46)	.37 ± 1.12[4]	.36 ± .95[4]	.32[2] ± .79	.25 ± .53[2]	.35[8] ± .73	.29 ± .53[6]	.31 ± .47
Female (N=36)	.08 ± .46[4]	.16 ± .67[4]	.41[2] ± 1.03	.30 ± .77[2]	.10 ± .36[8]	.31 ± .82[6]	.27[10] ± .65
Age 15							
Male (N=61)	.47 ± 1.76[4]	1.89[4] ± 6.04	.66[2] ± 1.07	.39[2] ± 1.24	1.18 ± 3.33	.53 ± 1.02[6]	.69 ± 1.31
Female (N=58)	.29 ± 1.00[4]	.58 ± 1.14[4]	.36 ± .72[2]	.57[2] ± 1.58	.42 ± .78	.40 ± .97[6]	.41 ± .82

Table 52: Visual Norms - Omissions (%), continued(See end of this section for reference key.)

Age 16							
Male (N=22)	$.63 \pm 1.19^{4}$	$.63 \pm 1.70^{4}$	$.76^{2} \pm 1.26$	$.87 \pm 2.27$	$.63 \pm 1.11$	$.81^{6} \pm 1.69$	$.77 \pm 1.42$
Female (N=29)	$.86^{4} \pm 2.98$	$.77 \pm 2.34^{4}$	$.77^{2} \pm 1.64$	$.63^{2} \pm 1.15$	$.81 \pm 2.61$	$.70 \pm 1.27^{6}$	$.72 \pm 1.42$
Age 17							
Male (N=18)	$.46 \pm 1.07^{4}$	$.00 \pm .00^{4}$	$.35 \pm .49^{2}$	$.22 \pm .46^{2}$	$.23^{8} \pm .53$	$.29 \pm .30^{6}$	$.27^{10} \pm .30$
Female (N=18)	$.62 \pm 1.52^{4}$	$.15 \pm .65^{4}$	$.13 \pm .30^{2}$	$.62^{2} \pm 1.55$	$.39 \pm .80$	$.37 \pm .90^{6}$	$.38 \pm .75$
Age 18							
Male (N=32)	$.17 \pm .68^{4}$	$.17 \pm .68^{4}$	$.37 \pm .49^{2}$	$.42 \pm .75^{2}$	$.17^{8} \pm .59$	$.40 \pm .48^{6}$	$.35 \pm .42$
Female (N=66)	$.21 \pm .74^{4}$	$.29 \pm .99^{4}$	$.31 \pm .60^{2}$	$.43^{2} \pm 1.48$	$.25^{8} \pm .69$	$.37 \pm .99^{6}$	$.35 \pm .80$
Age 19							
Male (N=25)	$.00 \pm .01^{4}$	$.11 \pm .56^{4}$	$.10 \pm .26^{2}$	$.06 \pm .32^{2}$	$.068 \pm .28^{8}$	$.08 \pm .20^{6}$	$.07 \pm .18^{10}$
Female (N=54)	$.21 \pm .73^{4}$	$.62 \pm 1.84^{4}$	$.54^{2} \pm 2.05$	$.71^{2} \pm 2.47$	$.41 \pm 1.16$	$.62^{6} \pm 2.23$	$.58 \pm 1.81$
Age 20 - 29							
Male (N=19)	$.29 \pm .88^{4}$	$.29 \pm .88^{4}$	$.33^{2} \pm .97$	$.46^{2} \pm 1.00$	$.29^{8} \pm .58$	$.40 \pm .88^{6}$	$.37 \pm .72$
Female (N=30)	$.56 \pm 1.85^{4}$	$.37 \pm .96^{4}$	$.26^{2} \pm .82$	$.87 \pm 2.14$	$.46 \pm 1.17$	$.57 \pm 1.34^{6}$	$.55 \pm 1.21$
Age 30 - 39							
Male (N=4)	$.00 \pm .01^{4}$	$.00 \pm .01^{4}$	$.00 \pm .01^{2}$	$.00 \pm .01^{2}$	$.00 \pm .01^{8}$	$.00 \pm .01^{6}$	$.00 \pm .01^{10}$
Female (N=22)	$.25 \pm .82^{4}$	$.13 \pm .59^{4}$	$.11 \pm .28^{2}$	$.14 \pm .31^{2}$	$.19^{8} \pm .49$	$.13 \pm .23^{6}$	$.14 \pm .25^{10}$
Age 40 - 49							
Male (N=14)	$.00 \pm .01^{4}$	$.00 \pm .01^{4}$	$.06 \pm .21^{2}$	$.00 \pm .01^{2}$	$.00^{8} \pm .018$	$.03 \pm .11^{6}$	$.02 \pm .08^{10}$
Female (N=19)	$.00 \pm .01^{4}$	$.15 \pm .64^{4}$	$.13 \pm .30^{2}$	$.00 \pm .01^{2}$	$.07 \pm .32^{8}$	$.06 \pm .15^{6}$	$.06 \pm .13^{10}$
Age 50 - 59							
Male (N=8)	$.35 \pm .98^{4}$	$.35 \pm .98^{4}$	$.10 \pm .28^{2}$	$.20 \pm .56^{2}$	$.35^{8} \pm .64$	$.15 \pm .30^{6}$	$.19 \pm .28^{10}$
Female (N=16)	$.17 \pm .69^{4}$	$.00 \pm .01^{4}$	$.25 \pm .63^{2}$	$.10 \pm .40^{2}$	$.09 \pm .35^{8}$	$.17 \pm .35^{6}$	$.15^{10} \pm .32$
Age 60 - 69							
Male (N=12)	$.00 \pm .01^{4}$	$.00 \pm .01^{4}$	$.20 \pm .49^{2}$	$.07 \pm .23^{2}$	$.00 \pm .01^{8}$	$.13 \pm .31^{6}$	$.10 \pm .24^{10}$
Female (N=24)	$.35 \pm .94^{4}$	$.23 \pm .78^{4}$	$.33 \pm .66^{2}$	$.07 \pm .22^{2}$	$.29^{8} \pm .71$	$.20 \pm .39^{6}$	$.22^{10} \pm .31$
Age 70 - 79							
Male (N=12)	$.23 \pm .80^{4}$	1.16 ± 2.50^{4}	1.19 ± 1.81	2.18 ± 3.42	$.69 \pm 1.26$	1.69 ± 2.56	1.47 ± 2.22
Female (N=39)	$.21 \pm .75^{4}$	1.21 ± 2.69^{4}	$.81 \pm 1.63$	$.65^{2} \pm 2.20$	$.71 \pm 1.52$	$.73^{6} \pm 1.82$	$.73 \pm 1.71$
Age 80 and up							
Male (N=8)	3.13 ± 3.77	3.47 ± 4.39	2.58 ± 1.93	1.88 ± 2.61	3.30 ± 3.92	2.23 ± 2.15	2.47 ± 2.47
Female (N=23)	$1.57^{4} \pm 3.63$	1.21 ± 2.34^{4}	1.83 ± 3.11	2.83 ± 5.82	1.39 ± 2.78	2.33 ± 3.73	2.12 ± 3.11

Table 53: Visual Norms - Commissions (%)(See end of this section for reference key.)

Years of Age	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Half 1	Half 2	Total
Age 4							
Male (N=24)	12.60 ± 14.18		33.91 ± 18.61				17.34 ± 12.54
Female (N=26)	6.23 ± 8.16		26.60 ± 14.60				10.75 ± 7.46
Age 5							
Male (N=66)	5.33 ± 6.79		27.55 ± 15.95				10.27 ± 6.92
Female (N=80)	3.85 ± 7.82		17.64 ± 12.01				6.91 ± 7.05
Age 6							
Male (N=19)	4.26 ± 5.49	3.05 ± 4.77	29.74 ± 16.47	39.95 ± 18.07	3.63 ± 5.16	34.84 ± 16.58	10.37 ± 6.85
Female (N=23)	2.39 ± 3.87	1.91 ± 3.33	20.17 ± 11.73	27.70 ± 14.26	2.00 ± 3.25	23.96 ± 11.52	6.78 ± 4.16
Age 7							
Male (N=61)	4.61 ± 7.57	3.66 ± 8.57	31.38 ± 18.61	41.16 ± 18.24	4.03 ± 7.86	36.25 ± 17.33	10.97 ± 8.47
Female (N=61)	2.72 ± 4.67	1.39 ± 2.33	21.05 ± 14.55	28.98 ± 16.67	1.95 ± 3.46	25.02 ± 14.41	6.89 ± 5.02
Age 8							
Male (N=36)	3.72 ± 4.60	1.72 ± 2.84	24.81 ± 12.98	35.42 ± 17.19	2.58 ± 3.74	30.08 ± 13.91	8.61 ± 5.23
Female (N=38)	1.92 ± 2.55	.82 ± 1.61	23.00 ± 16.39	29.34 ± 15.26	$1.34^{5} \pm 1.95$	26.18 ± 14.80	6.61 ± 4.28
Age 9							
Male (N=57)	3.60 ± 4.30	2.35 ± 4.15	28.14 ± 17.83	37.82 ± 21.11	2.89 ± 4.11	32.74 ± 18.82	9.39 ± 6.52
Female (N=55)	1.89 ± 2.94	1.02 ± 1.79	20.15 ± 13.54	30.24 ± 16.28	1.38 ± 2.31	25.24 ± 14.08	6.53 ± 4.17
Age 10							
Male (N=33)	1.97 ± 1.40	.88 ± 1.11	26.45 ± 12.67	34.06 ± 12.99	1.27 ± 1.04	30.15 ± 11.38	7.70 ± 3.20
Female (N=34)	2.00 ± 2.61	$.76^{1} \pm 1.21$	18.59 ± 14.88	22.71 ± 15.56	1.26 ± 1.83	20.59 ± 14.08	5.65 ± 4.23
Age 11							
Male (N=55)	2.62 ± 2.65	1.65 ± 2.12	28.67 ± 19.01	36.18 ± 19.40	2.09 ± 2.27	32.42 ± 18.49	8.69 ± 5.34
Female (N=60)	2.05 ± 2.17	1.07 ± 1.40	21.65 ± 14.81	28.22 ± 16.88	1.42 ± 1.73	24.85 ± 14.71	6.65 ± 4.16
Age 12							
Male (N=37)	1.15 ± 1.51	$.78^{1} \pm 1.29$	23.60 ± 14.95	27.35 ± 15.93	$.91 \pm 1.28^{5}$	25.50 ± 14.01	6.34 ± 3.82
Female (N=49)	.83 ± 1.10	$.56^{1} \pm .86$	16.16 ± 15.25	21.15 ± 18.78	$.57 \pm .89^{5}$	18.70 ± 16.50	4.59 ± 4.16
Age 13							
Male (N=66)	1.57 ± 2.16	$.76^{1} \pm .89$	17.80 ± 14.09	19.22 ± 17.18	$1.15^{5} \pm 1.40$	18.46 ± 14.45	4.93 ± 3.93
Female (N=69)	$.77^{1} \pm 1.05$	$.54^{1} \pm .84$	14.47 ± 12.52	16.29 ± 12.76	$.64 \pm .86^{5}$	15.37 ± 12.21	3.81 ± 2.85
Age 14							
Male (N=46)	.78 ± 1.08	$.68^{1} \pm .90$	15.36 ± 12.96	15.30 ± 14.33	$.72 \pm .85^{5}$	15.35 ± 12.81	3.97 ± 3.31
Female (N=36)	$.58^{1} \pm 1.01$	$.37^{1} \pm .671$	10.98 ± 9.18	12.48 ± 11.78	$.46 \pm .69^{5}$	11.77 ± 9.92	2.95 ± 2.60
Age 15							
Male (N=61)	$.72^{1} \pm 1.23$	$.45^{1} \pm .83$	14.27 ± 10.65	14.80 ± 12.22	$.56 \pm .92^{5}$	14.56 ± 10.74	3.64 ± 2.82
Female (N-58)	$.73^{1} \pm 1.08$	$.24 \pm .54^{1}$	13.38 ± 14.04	14.89 ± 13.89	$.45 \pm .66^{5}$	14.12 ± 13.41	3.45 ± 3.39

Table 54: Visual Norms - Commissions (%), continued. (See end of this section for reference key.)

Age 16							
Male (N=22)	1.19 ± 1.76	.61[1] ± .88	15.15 ± 15.78	16.29 ± 18.47	.90 ± 1.24[5]	15.72 ± 16.58	4.19 ± 4.54
Female (N=29)	.57[1] ± .95	.36 ± .62[1]	9.87 ± 9.32	12.74 ± 10.69	.47 ± .75[5]	11.30 ± 9.24	2.87 ± 2.46
Age 17							
Male (N=18)	.71[1] ± 1.36	.26 ± .54[1]	9.72 ± 12.14	12.04 ± 13.10	.49 ± .90[5]	10.88 ± 12.17	2.79 ± 3.11
Female (N=18)	.62[1] ± 1.00	.31 ± .48[1]	6.48 ± 7.13	10.19 ± 10.74	.46 ± .64[5]	8.33 ± 8.52	2.21 ± 2.26
Age 18							
Male (N=32)	.55 ± .74[1]	.69[1] ± 1.14	14.41 ± 13.00	16.84 ± 15.18	.62 ± .64[5]	15.19 ± 12.54	3.86 ± 3.04
Female (N=66)	.48 ± .68[1]	.44[1] ± .79	12.16 ± 12.50	13.43 ± 12.82	.46 ± .61[5]	12.82 ± 12.15	3.21 ± 2.87
Age 19							
Male (N=25)	.41 ± .61[1]	.16 ± .32[1]	8.33 ± 5.50	9.22 ± 8.44	.29 ± .31[5]	8.78 ± 6.36	2.17 ± 1.52
Female (N=54)	.71[1] ± 1.05	.51[1] ± .93	14.40 ± 14.72	14.87 ± 13.49	.61 ± .85[5]	14.63 ± 13.38	3.73 ± 3.38
Age 20 - 29							
Male (N=19)	.75 ± .72[1]	.75[1] ± .93	18.71 ± 13.70	19.30 ± 16.16	.75 ± .66[5]	19.01 ± 14.22	4.81 ± 3.48
Female (N=30)	.37 ± .74[1]	.40[1] ± .93	9.26 ± 10.43	8.70 ± 11.60	.38 ± .62[5]	8.98 ± 10.58	2.29 ± 2.66
Age 30 - 39							
Male (N=4)	.00 ± .01[1]	.20 ± .40[1]	6.94 ± 4.81	6.94 ± 5.78	.10 ± .20[5]	6.94 ± 4.39	1.62 ± 1.05
Female (N=22)	.14 ± .31[1]	.61[1] ± 1.75	5.18 ± 5.24	8.08 ± 7.90	.38 ± .87[5]	6.63 ± 5.84	1.77 ± 1.56
Age 40 - 49							
Male (N=14)	.51 ± .59[1]	.28 ± .39[1]	9.33 ± 7.11	12.70 ± 9.42	.40 ± .35[5]	11.01 ± 7.32	2.76 ± 1.80
Female (N=19)	.84 ± 1.82	.67[1] ± 1.80	6.14 ± 4.95	5.56 ± 4.44	.75[5] ± 1.78	5.85 ± 4.28	1.88 ± 2.01
Age 50 - 59							
Male (N=8)	.60[1] ± .92	.30 ± .41[1]	6.25 ± 5.51	10.07 ± 6.95	.45 ± .39[5]	8.16 ± 5.11	2.16 ± 1.22
Female (N=16)	.74[1] ± 1.80	.20 ± .54[1]	5.73 ± 6.21	7.64 ± 8.70	.47 ± 1.12[5]	6.68 ± 6.96	1.85 ± 2.33
Age 60 - 69							
Male (N=12)	.60[1] ± .96	.26 ± .52[1]	7.41 ± 10.14	7.18 ± 7.05	.43 ± .60[5]	7.29 ± 8.27	1.95 ± 2.22
Female (N=24)	.63[1] ± .84	.33 ± .57[1]	10.30 ± 10.05	10.53 ± 11.38	.48 ± .63[5]	10.42 ± 10.13	2.69 ± 2.53
Age 70 - 79							
Male (N=12)	1.46 ± 2.03	1.26 ± 1.71	13.89 ± 9.02	14.12 ± 10.01	1.36[5] ± 1.75	14.00 ± 8.95	4.17 ± 3.32
Female (N=39)	1.00 ± 1.24	.49 ± .72[1]	9.54 ± 7.69	8.19 ± 7.73	.74 ± .84[5]	8.87 ± 7.05	2.55 ± 2.03
Age 80 and up							
Male (N=8)	.99 ± .92	1.49 ± 1.56	20.83 ± 12.60	22.92 ± 17.43	1.24 ± .94[5]	21.88 ± 14.71	5.83 ± 3.87
Female (N=23)	1.62 ± 2.71	.76[1] ± 1.45	10.75 ± 11.70	12.44 ± 10.36	1.19[5] ± 2.03	11.59 ± 10.37	3.50 ± 3.64

Table 55: Visual Norms - Response Times (ms)

Years of Age	Quarter				Half		Total
	1	2	3	4	1	2	
Age 4							
Male (N=24)	896.79 ± 114.19		725.42 ± 74.63				783.42 ± 87.71
Female (N=26)	911.85 ± 150.15		801.38 ± 102.03				826.69 ± 104.27
Age 5							
Male (N=66)	805.88 ± 158.20		699.76 ± 149.94				723.69 ± 147.40
Female (N=80)	834.94 ± 134.51		748.91 ± 131.64				767.90 ± 126.78
Age 6							
Male (N=19)	642.53 ± 111.13	696.37 ± 144.04	584.63 ± 123.85	586.11 ± 121.16	669.05 ± 121.66	585.11 ± 120.83	604.32 ± 120.24
Female (N=23)	706.17 ± 94.35	764.48 ± 114.98	648.22 ± 79.10	648.09 ± 83.97	735.13 ± 96.26	647.74 ± 78.43	667.00 ± 74.27
Age 7							
Male (N=61)	609.13 ± 103.16	652.57 ± 123.35	543.30 ± 116.95	534.39 ± 112.93	630.62 ± 108.85	538.87 ± 110.85	558.70 ± 108.12
Female (N=61)	655.16 ± 102.72	691.89 ± 105.57	591.02 ± 103.20	587.25 ± 113.71	673.51 ± 99.51	589.25 ± 106.33	608.28 ± 99.87
Age 8							
Male (N=36)	530.44 ± 75.32	566.61 ± 87.97	475.36 ± 90.45	463.39 ± 101.67	548.61 ± 77.61	469.42 ± 92.25	487.19 ± 86.14
Female (N=38)	589.03 ± 83.95	615.39 ± 90.16	522.34 ± 90.57	533.74 ± 89.86	602.50 ± 80.48	527.95 ± 86.62	544.34 ± 79.54
Age 9							
Male (N=57)	512.70 ± 73.40	547.75 ± 79.09	439.81. ± 85.77	433.86 ± 97.86	530.37 ± 73.67	437.67 ± 88.09	458.56 ± 80.75
Female (N=55)	552.42 ± 77.01	583.89 ± 79.39	476.69 ± 72.17	481.64 ± 86.88	568.25 ± 73.36	478.96 ± 76.25	498.80 ± 71.53
Age 10							
Male (N=33)	440.91 ± 59.25	476.58 ± 63.75	385.67 ± 61.71	387.18 ± 69.62	458.82 ± 57.90	386.15 ± 61.48	402.15 ± 58.04
Female (N=34)	488.21 ± 67.69	506.62 ± 83.11	424.06 ± 74.68	419.53 ± 90.49	497.38 ± 73.11	421.74 ± 78.61	438.47 ± 74.24
Age 11							
Male (N=55)	424.82 ± 57.55	452.64 ± 68.79	365.25 ± 69.53	358.25 ± 76.57	439.45 ± 61.47	362.15 ± 71.52	379.33 ± 66.01
Female (N=60)	458.60 ± 62.94	486.07 ± 73.95	401.58 ± 77.84	389.98 ± 77.60	472.75 ± 66.69	395.82 ± 75.66	412.80 ± 71.07
Age 12							
Male (N=37)	432.86 ± 63.18	442.76 ± 81.61	382.84 ± 80.15	368.97 ± 81.40	437.81 ± 69.14	376.14 ± 78.21	389.92 ± 73.81
Female (N=49)	463.90 ± 78.84	467.73 ± 77.58	394.33 ± 81.08	395.39 ± 94.64	465.82 ± 75.85	394.96 ± 85.47	410.29 ± 80.96
Age 13							
Male (N=66)	412.23 ± 57.49	433.98 ± 74.54	368.89 ± 65.22	365.70 ± 66.32	423.15 ± 62.50	367.41 ± 62.90	379.74 ± 60.77
Female (N=69)	420.65 ± 62.87	445.68 ± 72.40	365.54 ± 58.18	363.35 ± 61.97	433.17 ± 65.30	364.43 ± 58.42	379.71 ± 56.85
Age 14							
Male (N=46)	403.48 ± 58.24	426.83 ± 76.63	371.15 ± 64.68	378.04 ± 80.91	415.15 ± 64.36	374.67 ± 69.30	383.43 ± 65.82
Female (N=36)	424.97 ± 69.54	442.58 ± 72.56	371.42 ± 67.33	366.94 ± 62.95	433.58 ± 69.89	369.28 ± 63.24	383.36 ± 62.93
Age 15							
Male (N=61)	390.61 ± 56.57	414.74 ± 70.48	345.66 ± 53.17	353.41 ± 64.31	402.36 ± 60.35	349.51 ± 56.41	361.15 ± 53.54
Female (N-58)	412.38 ± 56.93	423.31 ± 61.71	363.34 ± 66.87	360.84 ± 66.66	417.91 ± 57.80	362.09 ± 65.38	374.41 ± 61.85

Table 56: Visual Norms - Response Times (ms), continued

Age 16							
Male (N=22)	391.64 ± 48.46	406.18 ± 59.30	346.32 ± 56.84	338.86 ± 58.50	398.82 ± 51.18	342.45 ± 55.47	354.82 ± 51.97
Female (N=29)	410.17 ± 51.56	430.69 ± 53.35	364.79 ± 68.77	371.69 ± 71.75	420.10 ± 50.90	368.28 ± 68.50	379.62 ± 60.33
Age 17							
Male (N=18)	426.44 ± 45.92	434.61 ± 48.61	364.78 ± 54.52	360.83 ± 52.52	430.50 ± 46.46	362.94 ± 51.90	377.89 ± 45.92
Female (N=18)	411.89 ± 44.03	418.56 ± 45.98	366.94 ± 52.43	365.00 ± 56.89	415.06 ± 43.63	365.83 ± 52.75	376.72 ± 48.55
Age 18							
Male (N=32)	406.91 ± 68.20	423.16 ± 73.43	363.50 ± 65.88	361.81 ± 72.04	415.31 ± 69.38	362.91 ± 66.95	373.94 ± 64.20
Female (N=66)	431.68 ± 53.86	445.55 ± 66.97	392.74 ± 65.02	393.11 ± 66.39	438.06 ± 59.57	392.53 ± 63.94	402.44 ± 60.60
Age 19							
Male (N=25)	438.04 ± 55.96	441.12 ± 50.34	394.96 ± 59.55	391.88 ± 66.82	439.12 ± 50.06	393.36 ± 60.80	404.04 ± 56.86
Female (N=54)	422.54 ± 41.50	444.63 ± 60.57	393.13 ± 47.43	397.33 ± 62.98	433.22 ± 49.89	394.69 ± 54.13	403.52 ± 49.63
Age 20 - 29							
Male (N=19)	414.68 ± 47.36	428.37 ± 62.11	377.21 ± 51.14	370.63 ± 59.22	420.58 ± 55.47	372.79 ± 54.80	383.58 ± 52.36
Female (N=30)	445.50 ± 59.80	470.63 ± 77.15	409.90 ± 74.12	411.07 ± 81.33	457.80 ± 65.80	410.50 ± 74.80	421.07 ± 71.26
Age 30 - 39							
Male (N=4)	386.00 ± 62.90	388.00 ± 69.02	341.50 ± 77.52	351.00 ± 77.19	386.75 ± 65.76	346.00 ± 76.62	355.25 ± 72.94
Female (N=22)	401.59 ± 52.29	413.36 ± 64.35	364.64 ± 57.13	357.55 ± 65.78	405.91 ± 57.01	365.09 ± 66.59	369.77 ± 53.53
Age 40 - 49							
Male (N=14)	360.71 ± 37.63	367.43 ± 41.36	327.79 ± 34.25	318.57 ± 32.18	364.00 ± 38.72	323.29 ± 32.20	331.93 ± 31.25
Female (N=19)	443.89 ± 85.19	452.32 ± 78.17	401.16 ± 68.60	385.26 ± 64.33	448.16 ± 80.71	393.11 ± 65.32	405.32 ± 66.85
Age 50 - 59							
Male (N=8)	452.75 ± 49.90	477.38 ± 65.23	432.50 ± 48.77	439.88 ± 45.03	465.25 ± 57.18	436.13 ± 45.45	442.88 ± 46.85
Female (N=16)	472.88 ± 46.75	480.81 ± 60.94	428.00 ± 49.93	410.19 ± 39.62	476.81 ± 52.21	419.06 ± 42.10	432.06 ± 41.57
Age 60 - 69							
Male (N=12)	450.67 ± 44.15	474.75 ± 33.90	432.25 ± 36.86	452.17 ± 59.43	471.08 ± 51.46	442.83 ± 40.29	447.17 ± 35.92
Female (N=24)	466.17 ± 47.06	478.83 ± 48.21	438.50 ± 66.75	430.08 ± 62.23	472.54 ± 45.39	434.33 ± 62.87	442.75 ± 57.71
Age 70 - 79							
Male (N=12)	493.00 ± 54.26	501.08 ± 53.03	456.83 ± 52.80	485.25 ± 72.08	496.92 ± 52.95	470.75 ± 59.38	476.75 ± 55.65
Female (N=39)	500.10 ± 56.73	519.28 ± 69.56	475.05 ± 57.90	468.56 ± 54.06	510.03 ± 61.43	471.72 ± 51.73	480.23 ± 50.35
Age 80 and up							
Male (N=8)	541.25 ± 31.30	540.13 ± 37.49	487.75 ± 75.53	495.00 ± 88.28	540.13 ± 31.76	491.38 ± 80.46	502.25 ± 68.44
Female (N=23)	522.17 ± 51.18	532.30 ± 61.40	494.74 ± 70.13	515.22 ± 77.57	527.26 ± 55.54	504.87 ± 70.71	509.57 ± 63.09

Table 57: Visual Norms - Variability (ms)

Years of Age	Quarter				Half		Total
	1	2	3	4	1	2	
Age 4							
Male (N=24)	280.88 ± 69.79		334.29 ± 73.84				330.08 ± 65.98
Female (N=26)	254.42 ± 88.97		331.81 ± 100.49				325.46 ± 91.67
Age 5							
Male (N=66)	228.68 ± 63.68		263.20 ± 74.57				262.94 ± 63.33
Female (N=80)	217.40 ± 69.44		264.23 ± 62.44				260.4 ± 55.69
Age 6							
Male (N=19)	170.58 ± 48.78	212.37 ± 79.58	221.26 ± 53.09	261.05 ± 71.52	198.84 ± 60.20	242.32 ± 58.90	236.95 ± 54.41
Female (N=23)	192.74 ± 64.03	212.09 ± 66.69	239.13 ± 48.97	258.52 ± 46.37	210.74 ± 56.80	250.70 ± 40.60	248.04 ± 38.79
Age 7							
Male (N=61)	168.75 ± 52.74	184.26 ± 67.28	212.59 ± 61.39	236.33 ± 69.74	181.72 ± 54.83	227.54 ± 59.96	223.15 ± 54.93
Female (N=61)	166.95 ± 46.95	175.38 ± 50.43	203.90 ± 56.53	230.02 ± 66.30	176.69 ± 40.63	218.79 ± 55.08	215.87 ± 47.89
Age 8							
Male (N=36)	145.75 ± 55.27	151.61 ± 47.17	162.11 ± 53.94	185.17 ± 55.85	154.28 ± 43.82	176.47 ± 52.58	176.92 ± 47.66
Female (N=38)	149.21 ± 47.83	156.08 ± 46.52	173.76 ± 45.25	207.53 ± 52.04	160.18 ± 34.54	193.92 ± 43.81	192.79 ± 37.89
Age 9							
Male (N=57)	127.07 ± 48.50	135.88 ± 44.90	146.65 ± 48.46	164.93 ± 54.82	135.70 ± 40.64	158.58 ± 48.76	161.74 ± 43.81
Female (N=55)	126.65 ± 41.17	133.40 ± 45.24	149.27 ± 41.65	172.22 ± 52.65	135.22 ± 37.11	163.60 ± 43.55	164.82 ± 38.17
Age 10							
Male (N=33)	107.09 ± 34.15	116.06 ± 36.90	122.33 ± 39.41	142.85 ± 57.76	116.27 ± 30.08	135.61 ± 46.21	137.39 ± 39.30
Female (N=34)	122.00 ± 40.99	114.26 ± 38.44	127.09 ± 41.47	135.59 ± 50.41	122.79 ± 31.66	134.38 ± 44.50	138.32 ± 38.78
Age 11							
Male (N=55)	101.89 ± 34.33	105.98 ± 40.43	110.96 ± 34.47	124.36 ± 47.27	107.33 ± 34.19	119.35 ± 38.34	123.82 ± 33.70
Female (N=60)	108.77 ± 32.18	114.98 ± 38.61	118.47 ± 37.96	131.40 ± 45.66	114.83 ± 32.65	127.37 ± 38.73	130.95 ± 34.36
Age 12							
Male (N=37)	103.92 ± 39.45	110.97 ± 50.52	114.22 ± 40.87	124.35 ± 45.16	110.57 ± 43.21	121.84 ± 40.93	125.05 ± 37.09
Female (N=49)	111.14 ± 52.75	100.39 ± 39.25	110.14 ± 43.82	120.76 ± 45.96	109.10 ± 42.76	117.73 ± 44.21	122.33 ± 40.89
Age 13							
Male (N=66)	89.41 ± 31.40	93.86 ± 38.91	100.21 ± 35.21	107.61 ± 40.91	95.39 ± 34.64	106.33 ± 36.42	108.35 ± 33.71
Female (N=69)	79.70 ± 29.14	92.32 ± 36.08	94.19 ± 32.66	100.22 ± 32.75	89.67 ± 30.47	98.83 ± 31.10	103.09 ± 29.61
Age 14							
Male (N=46)	79.89 ± 23.84	81.41 ± 27.27	99.28 ± 37.30	105.70 ± 41.70	84.39 ± 25.94	105.39 ± 39.15	104.70 ± 35.07
Female (N=36)	79.89 ± 32.68	78.92 ± 22.62	94.81 ± 39.52	97.97 ± 42.41	81.72 ± 25.34	98.39 ± 39.25	100.39 ± 34.64
Age 15							
Male (N=61)	74.41 ± 26.99	82.16 ± 35.97	88.75 ± 27.82	94.89 ± 31.94	82.31 ± 30.53	93.89 ± 28.53	96.59 ± 27.34
Female (N-58)	70.71 ± 19.69	72.95 ± 21.10	86.43 ± 28.68	88.88 ± 28.50	73.79 ± 18.56	89.28 ± 26.59	90.93 ± 22.71

Table 58: Visual Norms - Variability (ms), continued

Age 16							
Male (N=22)	70.00 ± 21.72	81.77 ± 38.97	82.55 ± 24.27	89.18 ± 37.82	79.27 ± 27.89	88.23 ± 28.70	91.59 ± 25.77
Female (N=29)	81.28 ± 26.84	76.10 ± 22.98	90.72 ± 33.58	101.38 ± 45.17	81.14 ± 22.41	98.41 ± 37.46	100.83 ± 32.13
Age 17							
Male (N=18)	87.17 ± 47.37	83.33 ± 47.36	84.78 ± 22.72	91.56 ± 25.83	86.78 ± 45.63	89.50 ± 22.28	95.94 ± 27.72
Female (N=18)	74.72 ± 28.62	63.78 ± 17.93	83.33 ± 22.85	89.44 ± 32.48	71.11 ± 21.48	88.61 ± 24.59	89.56 ± 20.04
Age 18							
Male (N=32)	77.28 ± 36.32	74.09 ± 39.22	80.09 ± 29.40	86.75 ± 34.28	78.13 ± 35.75	86.16 ± 30.31	89.84 ± 29.15
Female (N=66)	64.74 ± 18.93	69.11 ± 19.52	81.03 ± 28.34	84.92 ± 27.06	70.08 ± 17.14	85.24 ± 26.68	86.58 ± 23.18
Age 19							
Male (N=25)	68.68 ± 16.74	69.48 ± 34.41	74.64 ± 20.52	79.36 ± 28.48	72.52 ± 25.00	79.88 ± 23.27	82.92 ± 20.07
Female (N=54)	62.50 ± 15.59	66.37 ± 27.91	80.56 ± 20.11	87.74 ± 33.39	67.70 ± 21.42	85.93 ± 26.30	86.06 ± 23.46
Age 20 - 29							
Male (N=19)	64.79 ± 26.78	70.58 ± 20.78	78.79 ± 17.20	80.84 ± 29.13	69.84 ± 22.77	81.11 ± 22.02	83.53 ± 20.86
Female (N=30)	64.60 ± 20.77	74.10 ± 33.94	81.20 ± 28.39	87.73 ± 39.15	74.13 ± 28.14	86.93 ± 33.09	88.63 ± 29.06
Age 30 - 39							
Male (N=4)	48.75 ± 9.00	50.00 ± 14.09	63.00 ± 15.64	61.25 ± 11.76	49.50 ± 11.09	63.00 ± 12.96	64.00 ± 12.83
Female (N=22)	67.32 ± 30.38	63.27 ± 25.75	76.68 ± 24.25	75.45 ± 24.15	69.41 ± 25.96	80.32 ± 26.37	81.36 ± 24.57
Age 40 - 49							
Male (N=14)	52.86 ± 12.46	52.50 ± 10.76	64.07 ± 14.37	64.14 ± 15.40	54.14 ± 7.59	65.21 ± 11.97	66.14 ± 11.60
Female (N=19)	69.21 ± 27.82	63.95 ± 19.45	79.37 ± 20.50	75.74 ± 22.28	69.11 ± 20.59	79.37 ± 19.83	81.89 ± 21.06
Age 50 - 59							
Male (N=8)	62.00 ± 19.68	60.50 ± 24.73	70.13 ± 8.89	79.00 ± 15.66	63.38 ± 21.31	75.88 ± 10.48	75.38 ± 11.55
Female (N=16)	68.06 ± 26.07	67.88 ± 27.30	76.75 ± 20.55	67.56 ± 17.13	70.81 ± 23.40	74.69 ± 17.88	79.56 ± 17.37
Age 60 - 69							
Male (N=12)	83.17 ± 36.61	75.00 ± 28.87	77.08 ± 19.77	82.00 ± 21.80	82.50 ± 29.77	84.42 ± 25.19	86.50 ± 22.93
Female (N=24)	66.13 ± 20.95	69.88 ± 21.84	76.29 ± 15.59	80.08 ± 26.82	70.54 ± 18.55	80.00 ± 20.06	81.67 ± 16.73
Age 70 - 79							
Male (N=12)	86.92 ± 31.18	77.08 ± 26.62	94.33 ± 31.02	117.92 ± 48.92	83.50 ± 26.79	110.33 ± 38.62	107.08 ± 33.85
Female (N=39)	83.64 ± 34.23	77.69 ± 28.94	99.26 ± 34.41	91.54 ± 27.30	84.46 ± 27.45	97.15 ± 26.78	97.87 ± 26.33
Age 80 and up							
Male (N=8)	114.38 ± 32.15	102.13 ± 16.56	124.75 ± 35.62	128.75 ± 29.24	110.75 ± 17.52	128.38 ± 29.51	128.88 ± 21.68
Female (N=23)	84.83 ± 27.75	78.57 ± 25.77	108.52 ± 50.81	123.52 ± 63.45	83.30 ± 24.68	118.78 ± 55.67	115.00 ± 48.39

Table 59: Visual Norms - D Prime (Perceptual Sensitivity)

Years of Age	Quarter				Half		Total
	1	2	3	4	1	2	
Age 4							
Male (N=24)	1.99 + 1.07		1.18 + 0.63				1.68 + 0.69
Female (N=26)	2.25 + 1.64		1.38 + 0.86				1.86 + 0.84
Age 5							
Male (N=66)	3.18 + 1.15		1.99 + 0.86				2.59 + 0.65
Female (N=80)	3.78 + 1.67		2.40 + 1.05				2.93 + 0.98
Age 6							
Male (N=19)	5.05 ± 1.68	4.70 ± 2.24	2.37 ± 0.96	1.74 ± 1.03	4.45 ± 1.79	2.02 ± 0.97	2.96 ± 0.94
Female (N=23)	4.31 ± 1.39	4.85 ± 1.90	2.91 ± 1.34	2.22 ± 0.95	4.62 ± 1.56	2.40 ± 0.91	3.10 ± 0.70
Age 7							
Male (N=61)	4.77 ± 1.59	4.59 ± 1.89	2.77 ± 1.43	2.18 ± 1.44	4.44 ± 1.62	2.37 ± 1.20	3.19 ± 1.04
Female (N=61)	5.40 ± 1.74	5.77 ± 1.95	3.53 ± 1.40	2.84 ± 1.34	5.31 ± 1.82	3.06 ± 1.31	3.84 ± 1.20
Age 8							
Male (N=36)	5.47 ± 1.66	5.94 ± 1.99	3.78 ± 1.28	3.43 ± 1.44	5.41 ± 1.79	3.64 ± 1.36	4.22 ± 1.24
Female (N=38)	5.98 ± 1.55	6.41 ± 1.85	4.14 ± 1.30	3.65 ± 1.33	5.64 ± 1.66	3.74 ± 1.29	4.31 ± 1.19
Age 9							
Male (N=57)	5.52 ± 1.86	6.06 ± 1.85	3.79 ± 1.48	3.27 ± 1.58	5.49 ± 1.75	3.54 ± 1.46	4.25 ± 1.44
Female (N=55)	6.36 ± 1.67	6.43 ± 1.50	4.35 ± 1.31	3.84 ± 1.45	6.05 ± 1.64	4.01 ± 1.33	4.71 ± 1.23
Age 10							
Male (N=33)	5.66 ± 1.59	6.70 ± 1.72	4.07 ± 1.21	3.74 ± 1.30	5.86 ± 1.65	3.83 ± 1.31	4.60 ± 1.29
Female (N=34)	6.63 ± 1.21	7.21 ± 1.72	4.88 ± 1.35	4.34 ± 1.43	6.73 ± 1.51	4.65 ± 1.32	5.39 ± 1.41
Age 11							
Male (N=55)	6.21 ± 1.56	6.30 ± 2.04	4.15 ± 1.48	3.67 ± 1.62	6.01 ± 1.88	3.84 ± 1.57	4.69 ± 1.48
Female (N=60)	6.34 ± 1.42	6.79 ± 1.72	4.61 ± 1.20	4.09 ± 1.30	6.43 ± 1.49	4.43 ± 1.17	5.06 ± 1.17
Age 12							
Male (N=37)	7.04 + 1.46	6.96 ± 1.71	4.35 ± 1.44	4.26 ± 1.49	6.62 ± 1.47	4.22 ± 1.41	4.97 ± 1.15
Female (N=49)	7.09 ± 1.50	7.18 ± 1.42	4.93 ± 1.39	4.84 ± 1.50	7.04 ± 1.51	4.64 ± 1.29	5.34 ± 1.26
Age 13							
Male (N=66)	6.60 ± 1.53	6.92 ± 1.64	4.82 ± 1.45	4.72 ± 1.66	6.31 ± 1.53	4.61 ± 1.43	5.16 ± 1.22
Female (N=69)	7.30 ± 1.38	7.39 ± 1.35	4.80 ± 1.58	4.89 ± 1.45	6.98 ± 1.40	4.53 ± 1.33	5.14 ± 1.14
Age 14							
Male (N=46)	7.24 ± 1.06	7.19 ± 1.37	5.08 ± 1.17	5.17 ± 1.39	6.77 ± 1.20	4.83 ± 1.14	5.32 ± 1.05
Female (N=36)	7.72 ± 1.04	7.75 ± 1.13	5.29 ± 1.48	5.47 ± 1.64	7.45 ± 1.07	5.06 ± 1.26	5.71 ± 1.12
Age 15							
Male (N=61)	7.41 ± 1.47	7.34 ± 1.53	4.84 ± 1.64	5.08 ± 1.38	6.92 ± 1.55	4.68 ± 1.32	5.25 ± 1.19
Female (N-58)	7.31 ± 1.36	7.66 ± 1.36	5.20 ± 1.58	5.23 ± 1.88	7.10 ± 1.44	5.10 ± 1.58	5.63 ± 1.42

Table 60: Visual Norms - D Prime (Perceptual Sensitivity), continued

Age 16							
Male (N=22)	6.82 ± 1.87	7.27 ± 1.47	4.85 ± 1.88	5.04 ± 1.81	6.59 ± 1.80	4.58 ± 1.53	5.16 ± 1.36
Female (N=29)	7.41 ± 1.48	7.56 ± 1.52	5.28 ± 1.53	5.03 ± 1.62	7.27 ± 1.49	4.88 ± 1.38	5.56 ± 1.31
Age 17							
Male (N=18)	7.33 ± 1.51	8.09 ± 0.85	5.47 ± 1.97	5.81 ± 2.09	7.36 ± 1.32	5.00 ± 1.74	5.63 ± 1.51
Female (N=18)	7.23 ± 1.51	7.77 ± 0.99	6.07 ± 1.55	5.46 ± 1.68	7.05 ± 1.27	5.60 ± 1.57	5.88 ± 1.08
Age 18							
Male (N=32)	7.46 ± 1.03	7.24 ± 1.16	4.76 ± 1.36	4.98 ± 1.79	6.93 ± 0.98	4.48 ± 1.17	5.18 ± 1.04
Female (N=66)	7.55 ± 1.22	7.60 ± 1.23	5.14 ± 1.37	5.26 ± 1.33	7.20 ± 1.26	4.92 ± 1.20	5.49 ± 1.08
Age 19							
Male (N=25)	7.82 ± 0.97	8.07 ± 1.04	5.77 ± 1.08	5.90 ± 1.19	7.56 ± 1.03	5.64 ± 1.17	6.24 ± 1.00
Female (N=54)	7.29 ± 1.16	7.45 ± 1.37	5.22 ± 1.52	5.13 ± 1.52	6.98 ± 1.28	4.88 ± 1.36	5.44 ± 1.14
Age 20 - 29							
Male (N=19)	7.03 ± 1.42	7.21 ± 1.28	4.94 ± 1.14	4.88 ± 1.28	6.77 ± 1.36	4.75 ± 1.15	5.30 ± 1.08
Female (N=30)	7.78 ± 1.29	7.63 ± 1.44	5.85 ± 1.50	5.75 ± 1.82	7.30 ± 1.35	5.50 ± 1.51	5.89 ± 1.25
Age 30 - 39							
Male (N=4)	8.53 ± 0.01	8.07 ± 0.93	5.81 ± 0.34	6.35 ± 1.47	8.13 ± 0.81	5.84 ± 0.44	6.49 ± 0.36
Female (N=22)	7.98 ± 1.13	7.92 ± 1.30	6.30 ± 1.42	5.66 ± 1.25	7.58 ± 1.47	5.55 ± 0.94	6.05 ± 0.96
Age 40 - 49							
Male (N=14)	7.57 ± 1.00	7.87 ± 0.92	6.01 ± 1.47	5.67 ± 0.92	7.32 ± 0.81	5.64 ± 1.04	6.29 ± 0.84
Female (N=19)	7.58 ± 1.06	7.67 + 1.27	5.82 ± 0.92	6.37 ± 1.17	7.29 ± 1.10	5.77 ± 0.87	6.21 ± 0.85
Age 50 - 59							
Male (N=8)	7.45 ± 1.70	7.54 ± 1.07	6.19 ± 1.05	5.38 ± 1.03	6.73 ± 1.52	5.32 ± 0.94	5.71 ± 1.02
Female (N=16)	7.71 ± 1.11	8.27 ± 0.72	6.10 ± 1.76	6.25 ± 1.53	7.79 ± 1.01	5.61 ± 1.38	6.20 ± 1.22
Age 60 - 69							
Male (N=12)	7.69 ± 1.05	8.04 ± 0.88	6.09 ± 1.76	5.89 ± 1.18	7.62 ± 0.97	5.75 ± 1.30	6.19 ± 0.91
Female (N=24)	7.25 ± 1.35	7.76 ± 1.36	5.54 ± 1.44	5.71 ± 1.17	7.13 ± 1.42	5.40 ± 1.27	5.76 ± 1.23
Age 70 - 79							
Male (N=12)	7.19 ± 1.57	6.64 ± 1.89	4.54 ± 1.79	4.53 ± 1.58	6.43 ± 1.85	4.17 ± 1.46	4.77 ± 1.35
Female (N=39)	7.17 ± 1.29	7.03 ± 1.54	4.92 ± 1.35	5.64 ± 1.46	6.55 ± 1.42	4.78 ± 1.13	5.21 ± 1.01
Age 80 and up							
Male (N=8)	5.62 ± 2.06	5.56 ± 1.64	2.94 ± 0.62	4.02 ± 2.07	5.13 ± 1.66	3.04 ± 0.71	3.80 ± 0.58
Female (N=23)	6.51 ± 1.51	7.04 ± 1.92	4.75 ± 1.68	4.22 ± 1.74	6.32 ± 1.72	4.05 ± 1.35	4.63 ± 1.21

Table 61: REFERENCE KEY

Ref. #	Type	Description
1	Q1/Q2 commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.794% (1 error / 126 stimuli).*
2	Q3/Q4 omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.794% (1 error / 126 stimuli).*
3	Q3/Q4 commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 2.778% (1 error / 36 stimuli).*
4	Q1/Q2 omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 2.778% (1 error / 36 stimuli).*
5	H1 commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 1.389% 1 error / 72 stimuli).*
6	H2 omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 1.389% 1 error / 72 stimuli).*
7	H2 commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.397% (1 error / 252 stimuli).*
8	H1 omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.397% (1 error / 252 stimuli).*
9	T commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.309% (1 error / 324 stimuli).*
10	T omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.309% (1 error / 324 stimuli).*
	*	Omission and commission errors are not normally distributed. This makes a comparison to a norming group difficult, especially when some norming groups (e.g. adults) made no omission/commission errors. Norming groups with no errors (which implies a zero in the norming standard deviation) causes a single error to distort distribution values such as z scores. Because one omission or one commission error is not clinically relevant, the norming standard deviations have been bounded at a minimum of one error.

8.6 Appendix F: Auditory Norms

Table 62: Auditory Norms - Summary

Years of Age	Omission Errors (%): Inattention $Mean \pm SD$	Commission Errors (%): Impulsivity $Mean \pm SD$	Response Time (ms) $Mean \pm SD$	Variability (SD & ms) $Mean \pm SD$	D PRIME: Hit Rate/False Alarm Rate $Mean \pm SD$
Age 6					
Male (N=85)	18.96 + 20.82	10.43 + 14.64	775.63 + 127.05	309.01. + 73.42	2.69 ± 1.48
Female (N=90)	19.05 + 20.51	8.38 + 13.27	806.51 + 117.35	309.98 + 61.16	2.82 ± 1.32
Age 7					
Male (N=92)	12.20 + 18.97	6.58 + 8.13	701.82 + 127.34	266.41 + 70.79	3.35 ± 1.42
Female (N=82)	15.03 + 21.43	5.41 + 7.95	752.50 + 137.70	272.92 + 67.98	3.56 ± 1.69
Age 8					
Male (N=97)	6.50 + 13.15	4.15 + 4.34	663.21 + 109.48	240.06 + 65.38	4.02 ± 1.39
Female (N=108)	6.46 + 13.53	3.10 + 3.54	681.88 + 119.08	225.43 + 64.57	4.28 ± 1.49
Age 9-					
Male (N=104)	4.49 + 11.32	3.07 + 3.89	640.90 + 107.58	215.02 + 66.30	4.41 ± 1.30
Female (N=100)	4.19 + 9.42	2.64 + 2.29	636.17 + 111.07	205.02 + 63.36	4.51 ± 1.33
Age 10					
Male (N=106)	2.35 + 8.38	2.32 + 2.83	588.63 + 93.15	180.28 + 54.41	5.06 ± 1.48
Female (N=107)	1.50 + 3.12	1.51 + 1.44	585.33 + 98.77	171.90 + 59.36	5.42 ± 1.37
Age 11					
Male (N=96)	.88 + 1.69	1.54 + 1.27	562.04 + 92.64	162.40 + 55.80	5.54 ± 1.30
Female (N=104)	1.49 + 3.42	1.44 + 1.39	573.87 + 113.87	164.03 + 61.52	5.45 ± 1.48
Age 12					
Male (N=87)	1.50 + 7.81	1.40 + 1.53	569.63 + 104.86	167.43 + 58.33	5.74 ± 1.57
Female (N=94)	.74 + 1.36	1.08 + 1.04	574.14 + 108.32	161.31 + 60.52	5.78 ± 1.38
Age 13					
Male (N=98)	1.03 + 2.21	1.17 + 1.36	559.24 + 96.89	164.35 + 58.13	5.79 ± 1.50
Female (N=91)	2.17 + 5.99	1.33 + 1.68	548.52 + 93.68	163.11 + 64.67	5.60 ± 1.55
Age 14					
Male (N=100)	1.45 + 6.17	1.20 + 1.69	523.00 + 95.95	159.70 + 62.84	5.95 ± 1.46
Female (N=101)	.69 + 1.18	.85 + .97	521.12 + 93.05	146.99 + 56.91	6.03 ± 1.49
Age 15					
Male (N=98)	.51 + 1.28	.88 + .93	510.76 + 111.05	148.95 + 62.30	6.15 ± 1.32
Female (N=90)	1.47 + 7.16	1.13 + 2.35	517.72 + 106.38	150.68 + 64.76	5.88 ± 1.55
Age 16					
Male (N=94)	.72 + 1.40	.71 + .79	511.30 + 109.41	144.78 + 53.66	6.14 ± 1.44
Female (N=87)	.78 + 1.90	.68 + 1.16	499.97 + 109.84	135.79 + 57.39	6.54 ± 1.59
Age 17					
Male (N=99)	.49 + .98	.67 + 1.29	480.81 + 84.41	132.75 + 49.76	6.47 ± 1.56
Female (N=107)	.84 + 2.58	.97 + 3.56	492.13 + 109.23	126.53 + 57.96	6.58 ± 1.62
Age 18					
Male (N=101)	.43 + 1.78	.52 + .71	477.90 + 88.76	127.39 + 47.52	6.65 ± 1.39
Female (N=101)	.55 + 1.38	.38 + .53	492.42 + 98.42	125.11 + 50.23	6.81 ± 1.44
Age 19					
Male (N=22)	.44 + 1.03	.49 + .90	476.40 + 94.67	127.09 + 47.34	6.89 ± 1.60
Female (N=10)	.34 + .71	.56 + .76	450.59 + 90.54	128.72 + 60.26	7.00 ± 1.62
Age 20 - 29					
Male (N=54)	1.22 ± 3.26	1.571 ± 1.59	490.33 ± 127.47	119.28 ± 62.97	5.88 ± 1.31
Female (N=75)	.56 ± 1.20	1.11 ± 1.40	511.97 ± 120.63	115.59 ± 49.73	6.34 ± 1.38

Table 63: Auditory Norms - Omissions (%)(See end of this section for reference key.)

Years of Age	Quarter				Half		Total
	1	2	3	4	1	2	
Age 6							
Male (N=85)	11.61 ± 14.91	13.43 ± 17.45	19.60 ± 22.66	21.99 ± 25.09	12.52 ± 15.58	20.87 ± 23.59	18.96 ± 20.82
Female (N=90)	11.26 ± 13.40	16.37 ± 17.54	20.54 ± 23.90	20.66 ± 23.56	13.80 ± 14.69	20.59 ± 23.36	19.05 ± 20.51
Age 7							
Male (N=92)	6.15 ± 12.04	8.42 ± 13.84	13.30 ± 21.49	13.90 ± 22.65	7.28 ± 11.95	13.61 ± 21.65	12.20 ± 18.97
Female (N=82)	8.81 ± 14.45	10.37 ± 16.56	16.94 ± 24.82	16.26 ± 25.15	9.59 ± 14.84	16.62 ± 24.43	15.03 ± 21.43
Age 8							
Male (N=97)	2.01^{4} ± 4.39	3.59 ± 7.88	7.13 ± 15.36	8.08 ± 17.12	2.80 ± 5.52	7.59 ± 15.91	6.50 ± 13.15
Female (N=108)	4.12 ± 11.28	4.16 ± 9.01	7.40 ± 16.47	6.89 ± 14.96	4.14 ± 9.57	7.14 ± 15.48	6.46 ± 13.53
Age 9							
Male (N=104)	1.99^{4} ± 5.22	2.17^{4} ± 5.59	5.35 ± 14.36	5.04 ± 13.34	2.08 ± 5.13	5.19 ± 13.67	4.49 ± 11.32
Female (N=100)	1.72^{4} ± 4.18	2.26^{4} ± 4.61	4.87 ± 12.15	4.79 ± 10.88	1.98 ± 3.92	4.84 ± 11.27	4.19 ± 9.42
Age 10							
Male (N=106)	.85 ± 2.25^{4}	1.24^{4} ± 3.41	3.01 ± 10.72	2.46 ± 10.25	1.05 ± 2.54	2.73 ± 10.42	2.35 ± 8.38
Female (N=107)	1.17^{4} ± 5.85	1.07 ± 2.40^{4}	1.72 ± 4.42	1.50 ± 2.60	1.12 ± 3.90	1.61 ± 3.29	1.50 ± 3.12
Age 11							
Male (N=96)	.29 ± 1.18^{4}	.46 ± 1.55^{4}	1.18 ± 2.54	.88 ± 1.76	$.38^{8}$ ± 1.18	1.03^{6} ± 1.99	.88 ± 1.69
Female (N=104)	.73 ± 2.43^{4}	.89 ± 2.18^{4}	1.79 ± 4.89	1.58 ± 3.59	.81 ± 2.05	1.69 ± 4.11	1.49 ± 3.42
Age 12							
Male (N=87)	$.53^{4}$ ± 3.09	1.62^{4} ± 7.78	1.57 ± 8.14	1.66 ± 9.03	1.08 ± 5.42	1.61 ± 8.56	1.50 ± 7.81
Female (N=94)	.36 ± 1.80^{4}	.77 ± 2.17^{4}	$.69^{2}$ ± 1.38	.87 ± 1.62	.56 ± 1.76	.79 ± 1.36^{6}	.74 ± 1.36
Age 13							
Male (N=98)	.65 ± 2.21^{4}	.79 ± 2.71^{4}	.99 ± 2.38	1.26 ± 2.86	.72 ± 2.24	1.12^{6} ± 2.54	1.03 ± 2.21
Female (N=91)	.74 ± 2.16^{4}	1.51^{4} ± 3.80	2.24 ± 6.28	2.70 ± 8.08	1.12 ± 2.85	2.47 ± 7.09	2.17 ± 5.99
Age 14							
Male (N=100)	.34 ± 1.17^{4}	1.04^{4} ± 4.51	1.64 ± 6.61	1.75 ± 8.59	.69 ± 2.77	1.69 ± 7.53	1.45 ± 6.17
Female (N=101)	.50 ± 2.28^{4}	.63 ± 1.61^{4}	$.77^{2}$ ± 1.54	$.66^{2}$ ± 1.37	.57 ± 1.68	.72 ± 1.28^{6}	.69 ± 1.18
Age 15							
Male (N=98)	.31 ± 1.59^{4}	.31 ± 1.38^{4}	$.50^{2}$ ± 1.26	$.63^{2}$ ± 2.06	$.31^{8}$ ± 1.14	$.57^{6}$ ± 1.56	.51 ± 1.28
Female (N=90)	.37 ± 1.68^{4}	$.71^{4}$ ± 2.81	1.49 ± 7.81	1.98 ± 10.50	.54 ± 2.14	1.73 ± .9.11	1.47 ± 7.16
Age 16							
Male (N=94)	.24 ± $.89^{4}$	.83 ± 2.11^{4}	$.58^{2}$ ± 1.15	.96 ± 2.39	.53 ± 1.21	$.77^{6}$ ± 1.64	.72 ± 1.40
Female (N=87)	.35 ± 1.19^{4}	$.89^{4}$ ± 3.75	$.58^{2}$ ± 1.35	1.07 ± 3.27	.62 ± 2.17	$.82^{6}$ ± 2.01	.78 ± 1.90
Age 17							
Male (N=99)	.22 ± 1.03^{4}	.45 ± 1.30^{4}	$.46^{2}$ ± .88	$.61^{2}$ ± 2.14	$.34^{8}$ ± .85	.54 ± 1.21^{6}	.49 ± .98
Female (N=107)	.31 ± 1.17^{4}	.60 ± 1.75^{4}	1.09 ± 3.59	.81 ± 2.91	.46 ± 1.37	$.95^{6}$ ± .3.16	.84 ± 2.58
Age 18							
Male (N=101)	.25 ± $.80^{4}$	.36 ± 2.07^{4}	$.44^{2}$ ± 1.52	$.49^{2}$ ± 2.58	$.30^{8}$ ± 1.22	$.47^{6}$ ± 1.98	.43 ± 1.78
Female (N=101)	.17 ± $.95^{4}$	.30 ± 1.36^{4}	$.49^{2}$ ± 1.17	.80 ± 2.45	$.23^{8}$ ± .96	$.64^{6}$ ± 1.65	.55 ± 1.38
Age 19							
Male (N=22)	.00 ± $.01^{4}$	.13 ± $.59^{4}$	$.76^{2}$ ± 2.20	.33 ± $.64^{2}$	.06 ± $.30^{8}$	.55 ± 1.33^{6}	.44 ± 1.03
Female (N=10)	.00 ± $.01^{4}$	.00 ± $.01^{4}$	$.64^{2}$ ± 1.19	.24 ± $.75^{2}$	.00 ± $.01^{8}$	.44 ± $.91^{6}$	.34 ± .71
Age 20-29							
Male (N=54)	.51 ± 2.02^{4}	.41 ± $.1.13^{4}$	$.76^{2}$ ± 1.88	2.10 ± 6.66	.46 ± 1.40	1.43 ± 1.10^{6}	1.22 ± 3.26
Female (N=75)	1.26 ± 1.13^{4}	$.78^{4}$ ± 3.75	$.49^{2}$ ± 1.06	$.66^{2}$ ± 1.59	.52 ± 2.17	.57 ± 1.21^{6}	.56 ± 1.20

Table 64: Auditory Norms - Commissions (%)(See end of this section for reference key.)

Years of Age	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Half 1	Half 2	Total
Age 6							
Male (N=85)	6.29 ± 16.52	5.98 ± 15.93	24.96 ± 18.98	28.32 ± 21.79	6.12 ± 15.90	26.54 ± 19.13	10.43 ± 14.64
Female (N=90)	4.40 ± 12.39	5.72 ± 15.84	17.13 ± 18.34	24.53 ± 20.71	5.05 ± 13.88	20.77 ± 18.58	8.38 ± 13.27
Age 7							
Male (N=92)	2.88 ± 9.04	2.44 ± 7.59	17.96 ± 16.75	23.79 ± 19.66	2.63 ± 7.40	20.87 ± 17.36	6.58 ± 8.13
Female (N=82)	2.89 ± 8.40	2.12 ± 7.97	13.44 ± 14.53	18.65 ± 17.27	2.50 ± 7.91	15.97 ± 14.56	5.41 ± 7.95
Age 8							
Male (N=97)	1.18 ± 3.41	.81 ± 3.46	13.96 ± 12.61	17.31 ± 16.05	.99[5] ± 3.38	15.63 ± 13.43	4.15 ± 4.34
Female (N=108)	1.08 ± 2.45	.75[1] ± 2.46	9.20 ± 11.36	12.69 ± 13.50	.91[5] ± 1.92	10.94 ± 11.82	3.10 ± 3.54
Age 9							
Male (N=104)	.92 ± 2.10	.62[1] ± 2.09	9.30 ± 12.70	13.34 ± 16.07	.77[5] ± 1.96	11.30 ± 13.68	3.07 ± 3.89
Female (N=100)	.70[1] ± 1.56	.21 ± .42[1]	8.00 ± 8.09	12.99 ± 12.30	.46 ± .82[5]	10.47 ± 9.29	2.64 ± 2.29
Age 10							
Male (N=106)	.54[1] ± 1.41	.33[1] ± .83	8.04 ± 11.34	10.30 ± 14.27	.43 ± .92[5]	9.16 ± 12.43	2.32 ± 2.83
Female (N=107)	.42[1] ± 1.14	.10 ± .29[1]	4.76 ± 6.46	7.16 ± 6.68	.26 ± .59[5]	5.95 ± 5.92	1.51 ± 1.44
Age 11							
Male (N=96)	.45 ± .68[1]	.15 ± .33[1]	4.93 ± 4.95	7.03 ± 7.44	.30 ± .40[5]	5.96 ± 5.14	1.54 ± 1.27
Female (N=104)	.21 ± .46[1]	.15 ± .37[1]	4.35 ± 4.74	7.52 ± 8.55	.18 ± .34[5]	5.93 ± 6.13	1.44 ± 1.39
Age 12							
Male (N=87)	.40 ± .70[1]	.24 ± .74[1]	4.91 ± 6.45	5.64 ± 7.80	.32 ± .66[5]	5.28 ± 6.65	1.40 ± 1.53
Female (N=94)	.29 ± .67[1]	.11 ± .30[1]	3.08 ± 3.54	5.28 ± 5.59	.20 ± .38[5]	4.18 ± 3.96	1.08 ± 1.04
Age 13							
Male (N=98)	.31 ± .70[1]	.11 ± .33[1]	3.67 ± 4.53	5.49 ± 7.40	.21[5] ± .37	4.57 ± 5.45	1.17 ± 1.36
Female (N=91)	.30 ± .55[1]	.12 ± .37[1]	4.57 ± 7.27	6.09 ± 7.92	.21[5] ± .39	5.32 ± 6.97	1.33 ± 1.68
Age 14							
Male (N=100)	.25 ± .59[1]	.28[1] ± .82	4.22 ± 7.29	4.99 ± 8.05	.27 ± .58[5]	4.60 ± 7.34	1.20 ± 1.69
Female (N=101)	.18 ± .40[1]	.13 ± .33[1]	2.83 ± 4.34	3.76 ± 4.83	.15 ± .27[5]	3.30 ± 3.98	.85 ± .97
Age 15							
Male (N=98)	.22 ± .46[1]	.13 ± .34[1]	3.22 ± 4.18	3.54 ± 4.31	.17 ± .29[5]	3.38 ± 3.67	.88 ± .93
Female (N=90)	.14 ± .49[1]	.10 ± .33[1]	3.98 ± 9.18	5.36 ± 11.70	.12 ± .33[5]	4.67 ± 10.23	1.13 ± 2.35
Age 16							
Male (N=94)	.17 ± .40[1]	.13 ± .31[1]	2.65[3] ± 3.81	2.83 ± 3.90	.15 ± .25[5]	2.73 ± 3.36	.71 ± .79
Female (N=87)	.20[1] ± .81	.07 ± .29[1]	2.11[3] ± 3.94	3.08 ± 5.83	.14 ± .44[5]	2.61 ± 4.54	.68 ± 1.16
Age 17							
Male (N=99)	.15 ± .39[1]	.09 ± .25[1]	2.52[3] ± 6.93	2.99 ± 6.85	.12 ± .25[5]	2.76 ± 6.74	.67 ± 1.29
Female (N=107)	.21[1] ± .91	.49[1] ± 4.47	2.86 ± 8.05	3.59 ± 8.38	.35[5] ± 2.63	3.22 ± 8.01	.97 ± 3.56
Age 18							
Male (N=101)	.12 ± .32[1]	.05 ± .20[1]	1.88[3] ± 3.19	2.25[3] ± 3.84	.09 ± .19[5]	2.06 ± 3.16	.52 ± .71
Female (N=101)	.07 ± .30[1]	.03 ± .15[1]	1.16 ± 2.53[3]	1.94[3] ± 2.89	.05 ± .17[5]	1.55 ± 2.29	.38 ± .53
Age 19							
Male (N=22)	.07 ± .24[1]	.07 ± .23[1]	2.08[3] ± 5.15	1.99[3] ± 3.78	.07 ± .16[5]	2.03 ± 4.17	.49 ± .90
Female (N=10)	.16 ± .33[1]	.08 ± .25[1]	2.32[3] ± 3.78	1.94[3] ± 2.94	.12 ± .19[5]	2.12 ± 3.27	.56 ± .76
Age 20-29							
Male (N=54)	.34 ± .61[1]	.18 ± .32[1]	6.26 ± 7.34	6.39 ± 7.35	.23 ± .33[5]	6.63 ± 6.74	1.57 ± 1.59
Female (N=75)	.23 ± 1.14[1]	.78*v* ± 3.75	4.40 ± 3.10	4.33 ± 5.95	.18 ± .59[5]	4.37 ± 5.70	1.11 ± 1.40

Table 65: Auditory Norms - Response Time (ms)

Years of Age	Quarter				Half		Total
	1	2	3	4	1	2	
Age 6							
Male (N=85)	755.55 ± 148.49	805.03 ± 154.90	765.92 ± 150.78	782.39 ± 163.65	779.88 ± 145.27	779.04 ± 136.72	775.63 ± 127.05
Female (N=90)	772.06 ± 131.58	857.25 ± 149.63	810.08 ± 149.67	818.02 ± 151.79	812.84 ± 130.67	809.13 ± 130.53	806.51 ± 117.35
Age 7							
Male (N=92)	634.11 ± 135.10	700.45 ± 160.09	698.72 ± 129.88	712.68 ± 156.54	666.22 ± 140.93	711.05 ± 129.74	701.82 ± 127.34
Female (N=82)	702.74 ± 155.52	751.57 ± 165.76	755.44 ± 157.94	773.46 ± 147.82	726.89 ± 155.16	765.92 ± 148.99	752.50 ± 137.70
Age 8							
Male (N=97)	605.18 ± 110.17	672.24 ± 130.49	655.92 ± 122.84	693.91 ± 132.78	638.12 ± 115.27	674.55 ± 123.40	663.21 ± 109.48
Female (N=108)	641.04 ± 127.83	685.73 ± 121.89	682.38 ± 141.07	698.25 ± 139.17	661.87 ± 112.03	690.00 ± 135.62	681.88 ± 119.08
Age 9							
Male (N=104)	574.69 ± 94.04	627.57 ± 108.36	640.99 ± 117.55	661.60 ± 144.47	601.03 ± 97.43	654.89 ± 118.73	640.90 ± 107.58
Female (N=100)	585.32 ± 92.93	634.21 ± 106.55	632.77 ± 121.62	654.71 ± 131.57	609.73 ± 96.28	643.63 ± 122.55	636.17 ± 111.07
Age 10							
Male (N=106)	531.05 ± 80.41	584.58 ± 99.00	590.99 ± 100.26	610.84 ± 127.00	557.68 ± 86.77	600.37 ± 105.54	588.63 ± 93.15
Female (N=107)	539.26 ± 93.24	579.55 ± 101.03	585.40 ± 106.26	600.64 ± 116.12	559.44 ± 94.77	592.97 ± 107.09	585.33 ± 98.77
Age 11							
Male (N=96)	508.87 ± 86.73	554.75 ± 99.35	559.01 ± 95.77	582.67 ± 109.43	531.81 ± 90.36	570.84 ± 99.01	562.04 ± 92.64
Female (N=104)	532.50 ± 94.77	567.31 ± 111.43	574.22 ± 122.03	587.88 ± 132.19	549.92 ± 99.64	580.91 ± 123.48	573.87 ± 113.87
Age 12							
Male (N=87)	506.63 ± 85.36	557.93 ± 109.87	572.60 ± 115.18	588.66 ± 123.59	531.39 ± 93.05	580.68 ± 115.54	569.63 ± 104.86
Female (N=94)	531.11 ± 85.81	580.81 ± 102.53	575.54 ± 121.37	583.43 ± 128.14	555.87 ± 90.77	579.48 ± 120.99	574.14 ± 108.32
Age 13							
Male (N=98)	519.10 ± 90.88	574.62 ± 122.11	554.73 ± 99.81	570.81 ± 114.32	546.88 ± 103.29	562.74 ± 102.09	559.24 ± 96.89
Female (N=91)	512.87 ± 89.07	555.82 ± 107.46	541.39 ± 102.03	563.93 ± 106.35	534.27 ± 95.47	552.62 ± 100.98	548.52 ± 93.68
Age 14							
Male (N=100)	478.43 ± 86.90	516.93 ± 112.84	517.19 ± 102.98	543.11 ± 111.06	497.50 ± 96.05	530.16 ± 102.35	523.00 ± 95.95
Female (N=101)	489.02 ± 86.32	530.85 ± 109.31	521.91 ± 97.64	526.65 ± 107.54	509.87 ± 95.75	524.30 ± 98.26	521.12 ± 93.05
Age 15							
Male (N=98)	470.84 ± 103.44	502.43 ± 120.13	509.66 ± 110.62	525.84 ± 131.25	486.58 ± 108.36	517.81 ± 117.42	510.76 ± 111.05
Female (N=90)	501.21 ± 106.36	532.54 ± 126.98	517.92 ± 119.14	519.97 ± 113.61	516.90 ± 113.52	519.06 ± 112.34	517.72 ± 106.38
Age 16							
Male (N=94)	487.77 ± 102.33	528.74 ± 125.06	502.89 ± 122.29	521.46 ± 117.90	508.10 ± 109.96	512.26 ± 117.12	511.30 ± 109.41
Female (N=87)	497.81 ± 105.88	536.73 ± 128.70	496.64 ± 116.45	493.66 ± 118.03	517.09 ± 114.25	495.12 ± 113.93	499.97 ± 109.84
Age 17							
Male (N=99)	471.04 ± 81.82	498.56 ± 98.21	475.08 ± 93.49	483.78 ± 96.92	484.76 ± 87.76	479.49 ± 90.44	480.81 ± 84.41
Female (N=107)	484.82 ± 95.11	515.31 ± 109.75	491.23 ± 117.83	488.82 ± 123.28	500.02 ± 99.83	490.03 ± 117.19	492.13 ± 109.23
Age 18							
Male (N=101)	468.38 ± 94.34	489.55 ± 109.41	469.63 ± 91.95	485.48 ± 101.25	478.91 ± 99.53	477.60 ± 91.87	477.90 ± 88.76
Female (N=101)	487.80 ± 90.53	518.55 ± 107.60	488.75 ± 108.55	489.82 ± 107.15	503.19 ± 96.45	489.36 ± 104.94	492.42 ± 98.42
Age 19							
Male (N=22)	465.19 ± 76.92	500.17 ± 103.66	466.88 ± 104.39	482.00 ± 111.98	482.73 ± 85.79	474.55 ± 103.77	476.40 ± 94.67
Female (N=10)	464.87 ± 92.09	464.70 ± 110.54	439.82 ± 92.73	452.87 ± 107.66	464.81 ± 99.41	446.54 ± 90.72	450.59 ± 90.54
Age 20-29							
Male (N=54)	488.28 ± 132.77	509.09 ± 144.16	479.50 ± 128.39	496.96 ± 136.66	498.67 ± 136.22	488.05 ± 130.05	490.33 ± 127.47
Female (N=75)	499.95 ± 108.35	522.39 ± 127.94	504.39 ± 124.75	520.59 ± 130.93	510.88 ± 115.62	512.47 ± 125.56	511.97 ± 120.63

Table 66: Auditory Norms - Variability (ms)

Years of Age	Quarter 1	2	3	4	Half 1	2	Total
Age 6							
Male (N=85)	244.75 ± 80.21	263.95 ± 84.24	307.98 ± 84.47	321.13 ± 89.94	261.24 ± 76.15	321.99 ± 81.79	309.01 ± 73.42
Female (N=90)	247.01 ± 80.30	272.10 ± 78.37	306.12 ± 75.47	316.06 ± 72.03	270.78 ± 70.35	317.79 ± 65.56	309.98 ± 61.16
Age 7							
Male (N=92)	196.89 ± 78.55	212.53 ± 77.79	260.68 ± 80.61	280.16 ± 86.72	211.74 ± 71.85	274.90 ± 74.79	266.41 ± 70.79
Female (N=82)	208.12 ± 81.63	223.67 ± 85.30	265.60 ± 80.28	283.00 ± 86.80	223.50 ± 77.10	281.18 ± 78.06	272.92 ± 67.98
Age 8							
Male (N=97)	160.48 ± 59.21	193.29 ± 77.20	234.58 ± 70.20	259.66 ± 82.67	184.56 ± 63.71	250.94 ± 72.79	240.06 ± 65.38
Female (N=108)	174.79 ± 68.30	187.11 ± 63.51	217.32 ± 70.00	234.37 ± 77.88	188.58 ± 61.04	229.32 ± 70.74	225.43 ± 64.57
Age 9							
Male (N=104)	150.98 ± 64.09	170.77 ± 71.30	205.41 ± 70.95	228.86 ± 79.00	167.75 ± 61.78	221.76 ± 71.32	215.02 ± 66.30
Female (N=100)	151.77 ± 65.35	161.70 ± 64.06	200.30 ± 70.58	213.92 ± 72.30	162.90 ± 59.23	210.56 ± 68.03	205.02 ± 63.36
Age 10							
Male (N=106)	124.76 ± 50.75	137.80 ± 53.89	176.73 ± 61.87	190.18 ± 67.44	137.17 ± 49.37	188.47 ± 61.79	180.28 ± 54.41
Female (N=107)	125.04 ± 58.26	140.25 ± 59.99	165.25 ± 67.24	177.35 ± 64.95	137.71 ± 55.55	175.00 ± 63.55	171.90 ± 59.36
Age 11							
Male (N=96)	109.41 ± 39.59	128.62 ± 50.86	157.25 ± 58.06	171.09 ± 65.18	124.62 ± 42.76	167.50 ± 59.92	162.40 ± 55.80
Female (N=104)	127.97 ± 59.00	128.44 ± 58.70	155.78 ± 69.02	169.62 ± 67.32	134.84 ± 53.01	166.12 ± 66.68	164.03 ± 61.52
Age 12							
Male (N=87)	113.31 ± 44.06	133.99 ± 59.54	160.42 ± 61.90	171.92 ± 67.75	129.70 ± 50.71	169.93 ± 62.44	167.43 ± 58.33
Female (N=94)	111.81 ± 48.53	133.73 ± 57.65	153.24 ± 64.80	164.18 ± 70.52	129.22 ± 50.91	162.58 ± 65.47	161.31 ± 60.52
Age 13							
Male (N=98)	119.37 ± 46.68	135.66 ± 59.40	154.30 ± 61.96	171.03 ± 66.33	134.76 ± 51.91	166.64 ± 62.94	164.35 ± 58.13
Female (N=91)	112.59 ± 57.07	124.66 ± 56.53	156.24 ± 70.75	172.04 ± 71.96	124.01 ± 55.04	167.54 ± 69.06	163.11 ± 64.67
Age 14							
Male (N=100)	109.84 ± 52.85	123.25 ± 55.88	153.19 ± 65.55	166.92 ± 73.63	122.37 ± 52.89	164.19 ± 67.35	159.70 ± 62.84
Female (N=101)	101.26 ± 47.05	119.51 ± 56.47	139.41 ± 56.32	152.73 ± 69.26	115.92 ± 49.68	149.77 ± 61.69	146.99 ± 56.91
Age 15							
Male (N=98)	98.05 ± 44.31	109.61 ± 49.97	144.67 ± 65.62	155.16 ± 70.64	109.04 ± 46.78	153.77 ± 66.80	148.95 ± 62.30
Female (N=90)	99.93 ± 41.13	119.49 ± 66.03	145.18 ± 67.38	152.78 ± 73.32	115.86 ± 52.83	154.26 ± 66.96	150.68 ± 64.76
Age 16							
Male (N=94)	105.83 ± 43.43	116.50 ± 49.55	136.53 ± 54.80	147.11 ± 63.74	118.39 ± 42.98	145.47 ± 57.85	144.78 ± 53.66
Female (N=87)	101.42 ± 52.40	111.62 ± 64.03	127.11 ± 58.97	136.48 ± 68.37	113.17 ± 55.25	135.79 ± 61.17	135.79 ± 57.39
Age 17							
Male (N=99)	97.44 ± 37.82	106.68 ± 51.71	123.79 ± 55.12	135.01 ± 58.64	106.40 ± 42.31	134.18 ± 53.83	132.75 ± 49.76
Female (N=107)	88.54 ± 39.10	99.68 ± 49.63	119.83 ± 63.49	130.00 ± 64.47	99.51 ± 41.91	128.63 ± 63.03	126.53 ± 57.96
Age 18							
Male (N=101)	102.05 ± 46.07	102.98 ± 48.10	114.80 ± 45.24	129.97 ± 62.11	107.37 ± 42.25	126.98 ± 52.53	127.39 ± 47.52
Female (N=101)	85.47 ± 36.59	96.83 ± 41.52	119.59 ± 53.39	127.64 ± 60.03	96.72 ± 36.74	126.53 ± 55.78	125.11 ± 50.23
Age 19							
Male (N=22)	98.08 ± 39.02	106.35 ± 56.34	119.32 ± 52.92	124.22 ± 51.05	109.02 ± 46.47	125.53 ± 51.58	127.09 ± 47.34
Female (N=10)	81.77 ± 32.06	77.45 ± 40.26	119.12 ± 54.21	140.75 ± 77.14	82.71 ± 35.11	136.44 ± 67.78	128.72 ± 60.26
Age 20-29							
Male (N=54)	78.14 ± 35.72	91.34 ± 57.55	110.26 ± 57.58	128.83 ± 73.65	89.79 ± 46.87	122.13 ± 64.31	119.28 ± 62.97
Female (N=75)	80.65 ± 40.29	86.84 ± 48.99	109.98 ± 46.94	121.45 ± 57.97	88.08 ± 44.12	118.66 ± 52.17	115.59 ± 49.73

Table 67: Auditory Norms - D Prime (Perceptual Sensitivity)

Years of Age	Quarter				Half		Total
	1	2	3	4	1	2	
Age 6							
Male (N=85)	4.38 ± 2.24	4.58 ± 2.43	2.08 ± 1.66	1.89 ± 1.76	4.05 ± 2.05	1.90 ± 1.58	2.69 ± 1.48
Female (N=90)	4.87 ± 2.42	4.50 ± 2.21	2.59 ± 1.94	2.21 ± 1.69	4.06 ± 1.88	2.22 ± 1.56	2.82 ± 1.32
Age 7							
Male (N=92)	5.79 ± 2.29	5.50 ± 2.33	2.98 ± 2.04	2.63 ± 2.09	5.08 ± 2.12	2.57 ± 1.67	3.35 ± 1.42
Female (N=82)	5.60 ± 2.39	5.86 ± 2.41	3.34 ± 2.24	2.96 ± 2.12	5.23 ± 2.26	2.90 ± 1.87	3.56 ± 1.69
Age 8							
Male (N=97)	6.58 ± 1.79	6.72 ± 2.07	3.77 ± 1.99	3.48 ± 1.98	5.97 ± 1.89	3.26 ± 1.59	4.02 ± 1.39
Female (N=108)	6.34 ± 2.00	6.74 ± 2.02	4.38 ± 2.23	4.01 ± 2.06	5.98 ± 1.98	3.79 ± 1.78	4.28 ± 1.49
Age 9							
Male (N=104)	6.93 ± 1.76	7.15 ± 1.80	4.38 ± 1.88	4.03 ± 2.27	6.49 ± 1.75	3.76 ± 1.57	4.41 ± 1.30
Female (N=100)	7.03 ± 1.89	7.19 ± 1.62	4.52 ± 1.94	4.05 ± 1.76	6.50 ± 1.72	3.92 ± 1.55	4.51 ± 1.33
Age 10							
Male (N=106)	7.41 ± 1.52	7.47 ± 1.61	4.99 ± 2.10	4.89 ± 2.06	6.94 ± 1.64	4.47 ± 1.74	5.06 ± 1.48
Female (N=107)	7.54 ± 1.37	7.71 ± 1.24	5.80 ± 1.95	5.09 ± 1.81	7.22 ± 1.42	4.93 ± 1.59	5.42 ± 1.37
Age 11							
Male (N=96)	7.58 ± 1.27	7.92 ± 1.08	5.74 ± 1.94	5.37 ± 1.71	7.36 ± 1.34	5.04 ± 1.51	5.54 ± 1.30
Female (N=104)	7.80 ± 1.35	7.69 ± 1.38	5.80 ± 2.02	5.26 ± 1.81	7.41 ± 1.43	5.07 ± 1.72	5.45 ± 1.48
Age 12							
Male (N=87)	7.64 ± 1.30	7.68 ± 1.54	6.04 ± 1.99	5.88 ± 2.11	7.26 ± 1.52	5.52 ± 1.95	5.74 ± 1.57
Female (N=94)	7.89 ± 1.11	7.84 ± 1.34	6.34 ± 1.91	5.69 ± 1.96	7.47 ± 1.35	5.41 ± 1.60	5.78 ± 1.38
Age 13							
Male (N=98)	7.69 ± 1.36	7.94 ± 1.16	6.16 ± 1.88	5.88 ± 2.10	7.40 ± 1.40	5.46 ± 1.77	5.79 ± 1.50
Female (N=91)	7.61 ± 1.45	7.75 ± 1.39	5.91 ± 2.01	5.47 ± 2.09	7.36 ± 1.59	5.14 ± 1.74	5.60 ± 1.55
Age 14							
Male (N=100)	7.80 ± 1.29	7.75 ± 1.41	6.19 ± 2.05	6.14 ± 1.91	7.43 ± 1.48	5.64 ± 1.78	5.95 ± 1.46
Female (N=101)	7.95 ± 1.13	7.84 ± 1.20	6.47 ± 1.89	6.20 ± 1.86	7.54 ± 1.34	5.73 ± 1.76	6.03 ± 1.49
Age 15							
Male (N=98)	7.95 ± 1.10	8.08 ± 1.02	6.51 ± 1.79	6.25 ± 1.80	7.74 ± 1.14	5.81 ± 1.57	6.15 ± 1.32
Female (N=90)	8.11 ± 1.03	7.96 ± 1.18	6.36 ± 2.01	5.81 ± 2.33	7.78 ± 1.26	5.57 ± 1.91	5.88 ± 1.55
Age 16							
Male (N=94)	8.01 ± .95	7.77 ± 1.22	6.51 ± 1.84	6.39 ± 1.94	7.52 ± 1.26	5.96 ± 1.75	6.14 ± 1.44
Female (N=87)	7.99 ± 1.17	8.09 ± 1.08	6.94 ± 1.73	6.58 ± 1.97	7.75 ± 1.30	6.29 ± 1.82	6.54 ± 1.59
Age 17							
Male (N=99)	8.09 ± .96	8.01 ± 1.07	6.80 ± 1.91	6.73 ± 1.87	7.75 ± 1.20	6.22 ± 1.85	6.47 ± 1.56
Female (N=107)	8.05 ± 1.09	7.96 ± 1.21	6.99 ± 1.82	6.72 ± 1.90	7.76 ± 1.30	6.41 ± 1.82	6.58 ± 1.62
Age 18							
Male (N=101)	8.08 ± 1.10	8.25 ± 0.75	7.04 ± 1.72	6.99 ± 1.74	7.94 ± 1.10	6.53 ± 1.70	6.65 ± 1.39
Female (N=101)	8.30 ± 0.67	8.28 ± 0.78	7.35 ± 1.44	6.86 ± 1.87	8.15 ± 0.90	6.58 ± 1.70	6.81 ± 1.44
Age 19							
Male (N=22)	8.36 ± 0.55	8.25 ± 0.71	7.13 ± 1.88	7.14 ± 1.72	8.14 ± 0.74	6.65 ± 1.79	6.89 ± 1.60
Female (N=10)	8.16 ± 0.78	8.34 ± 0.59	7.02 ± 2.17	7.28 ± 1.77	8.05 ± 0.78	6.90 ± 2.00	7.00 ± 1.62
Age 20-29							
Male (N=54)	7.72 ± 1.31	7.97 ± 1.23	5.60 ± 1.72	5.65 ± 1.83	7.46 ± 1.35	5.36 ± 1.51	5.88 ± 1.31
Female (N=75)	8.12 ± 1.11	7.97 ± 1.15	6.23 ± 1.67	6.32 ± 1.77	7.80 ± 1.23	5.93 ± 1.54	6.34 ± 1.38

Table 68: REFERENCE KEY

Ref. #	Type	Description
1	Q1/Q2 commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.794% (1 error / 126 stimuli).*
2	Q3/Q4 omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.794% (1 error / 126 stimuli).*
3	Q3/Q4 commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 2.778% (1 error / 36 stimuli).*
4	Q1/Q2 omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 2.778% (1 error / 36 stimuli).*
5	H1 commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 1.389% 1 error / 72 stimuli).*
6	H2 omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 1.389% 1 error / 72 stimuli).*
7	H2 commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.397% (1 error / 252 stimuli).*
8	H1 omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.397% (1 error / 252 stimuli).*
9	T commissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.309% (1 error / 324 stimuli).*
10	T omissions	Norming group standard deviation values in this norming group were bounded at a minimum value of 0.309% (1 error / 324 stimuli).*
	*	Omission and commission errors are not normally distributed. This makes a comparison to a norming group difficult, especially when some norming groups (e.g. adults) made no omission/commission errors. Norming groups with no errors (which implies a zero in the norming standard deviation) causes a single error to distort distribution values such as z scores. Because one omission or one commission error is not clinically relevant, the norming standard deviations have been bounded at a minimum of one error.

8.7 Appendix G: T.O.V.A. Observer's Behavior Rating Form

Subject's name: _____ ***Test Date*** _____ ***Visual*** ___ ***Auditory*** ___ ***Session #*** _____

Please rate the subject's behavior for each quarter while taking the T.O.V.A., using a scale of 1 (not at all) to 5 (very much).

Behavior	1	2	3	4
	0-5.4 minutes	5.4-10.8 min.	10.8-16.2 min.	16.2-22.4 min.
Distractible: In general	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Visual	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Auditory	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
(Please check here if there were no auditory/visual distractions during test_____)				
Overactive	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Inattentive	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Becomes Frustrated	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Uncooperative or oppositional	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Changes hands	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Tics (vocal or motor)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Staring, falls asleep	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Tires, wears out	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Complaining	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Talking	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Prompting needed	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Not trying hard/doesn't care attitude	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

How many hours did the subject sleep last night?

Medications? (Please list and record dosage and number of hours since last does)

Please record substance us (and hours since last use):

	How much per day in last 2 weeks	How much today
Cigarettes?		
Caffeinated beverages?		
Alcohol?		
Other?		

Figure 25: T.O.V.A. Observer's Behavior Rating Form

8.8 Appendix H: Pearson Product Coefficients, Visual

Table 69: Pearson Product Coefficients - Visual - All Variables

	OM1QT	OM2QT	OM3QT	OM4QT	OM1HF	OM2HF	OMTOT	CO1QT	CO2QT	CO3QT	CO4QT	CO1HF	CO2HF	COTOT	RT1QT	RT2QT	RT3QT
OM1QT	.1																
OM2QT	.6724	.1															
OM3QT	.5863	.6668	.1														
OM4QT	.5934	.6075	.6187	.1													
OM1HF	.9092	.9179	.6889	.6551	.1												
OM2HF	.6566	.7076	.9027	.8947	.7472	.1											
OMOT	.7516	.7952	.8927	.8792	.8466	.9847	.1										
CO1QT	.1355	.1469	.1186	.208	.1505	.1796	.1802	.1									
CO2QT	.1429	.2137	.2002	.2441	.1939	.2421	.2433	.554	.1								
CO3QT	.1063	.1436	.0664	.1736	.1347	.1299	.1391	.358	.4325	.1							
CO4QT	.1687	.2323	.1403	.2511	.2164	.211	.2267	.5265	.4495	.7701	.1						
CO1HF	.1554	.1981	.1735	.2558	.1911	.2359	.2359	.9047	.8258	.5422	.5341	.1					
CO2HF	.149	.2048	.1128	.2301	.1908	.1851	.1987	.5632	.4694	.926	.9527	.5701	.1				
COTOT	.1587	.2111	.1331	.2446	.1993	.2051	.2159	.71	.6064	.9069	.9234	.7334	.9729	.1			
RT1QT	.3188	.3324	.2615	.4102	.3518	.3684	.384	.0828	.0376	.0892	.2158	.0507	.1697	.1433	.1		
RT2QT	.3375	.383	.3013	.453	.3895	.4153	.4316	.1159	.0691	.097	.2369	.0874	.1855	.1654	.9294	.1	
RT3QT	.2211	.2739	.2546	.3752	.266	.3458	.3458	.0398	.0343	-.0806	.0523	.0232	-.0071	-.0094	.8554	.8697	.1
RT4QT	.2125	.2523	.2461	.3877	.2495	.3486	.3415	.0207	.0289	-.0853	-.0034	.0112	-.0419	-.0404	.8144	.839	.9262
RT1HF	.334	.3621	.2848	.4384	.3761	.3974	.4137	.1016	.0527	.0958	.2319	.0697	.1822	.158	.9794	.9839	.8778
RT2HF	.2217	.2679	.2549	.3879	.263	.3532	.3498	.0303	.0313	-.0847	.0236	.0167	-.0259	-.0263	.8506	.87	.9795
RTTOT	.2461	.2892	.268	.4079	.288	.3714	.3707	.049	.0376	-.0428	.0744	.0307	.0239	.0179	.9002	.9163	.9787
V1QT	.3371	.3288	.2484	.3931	.3595	.3518	.3717	.2943	.1576	.2638	.3679	.2442	.3416	.3433	.7396	.6788	.5952
V2QT	.3079	.373	.2988	.4218	.3671	.3982	.4116	.2913	.2301	.2815	.402	.2783	.3706	.3726	.6484	.7509	.5995
V3QT	.2993	.36	.3252	.471	.3539	.4353	.4404	.2373	.2	.2614	.3683	.2208	.3413	.3328	.7511	.7867	.789
V4QT	.2939	.3559	.3053	.5012	.3494	.4417	.4424	.2641	.2232	.2775	.4022	.2568	.3684	.3637	.7296	.7724	.7266
V1HF	.3419	.3878	.3008	.444	.3937	.4106	.4278	.3103	.2159	.2849	.4069	.282	.3749	.3782	.7343	.7816	.6471
V2HF	.3025	.3648	.3187	.4974	.3584	.4466	.4496	.2567	.2185	.2734	.393	.2454	.3613	.3552	.7625	.803	.7796
VTOT	.3306	.3839	.3245	.5054	.3843	.4549	.4624	.2782	.2209	.3044	.4304	.2601	.398	.3894	.7934	.8328	.7598
D1QT	-.4924	-.3884	-.3181	-.406	-.4697	-.3922	-.4262	-.5413	-.3247	-.4614	-.5182	-.4594	-.5148	-.5572	-.336	-.3608	-.2457
D2QT	-.3063	-.5304	-.3267	-.4266	-.449	-.4052	-.4329	-.4522	-.5114	-.4521	-.5087	-.5028	-.5066	-.565	-.3086	-.3481	-.2474
D3QT	-.2785	-.3358	-.3535	-.4031	-.3296	-.4068	-.4043	-.4	-.3116	-.6491	-.6	-.3763	-.6513	-.6193	-.2981	-.3204	-.1692
D4QT	-.3169	-.3806	-.3369	-.5111	-.3729	-.4567	-.4553	-.4133	-.3308	-.5796	-.7114	-.3925	-.6811	-.6468	-.3367	-.3718	-.2098
D1HF	-.4031	-.4738	-.3195	-.4232	-.4684	-.4024	-.4339	-.523	-.4337	-.4787	-.5299	-.5161	-.5302	-.5867	-.3139	-.3563	-.241
D2HF	-.3271	-.3896	-.3938	-.5108	-.3838	-.4919	-.484	-.4204	-.3292	-.6093	-.6582	-.3987	-.6659	-.6385	-.3394	-.3771	-.2165
DTOT	-.3673	-.4506	-.3984	-.5102	-.4381	-.492	-.5023	-.427	-.3489	-.5415	-.6016	-.412	-.6012	-.599	-.3703	-.4132	-.2653

Table 70: Pearson Product Coefficients - Visual - All Variables, continued

	CRMQ4	CRMH1	CRMH2	CRMTOT	CRVQ1	CRVQ2	CRVQ3	CRVQ4	CRVH1	CRVH2	CRVTOT	D1QT	D2QT	D3QT	D4QT	D1HF	D2HF	DTOT
CRMQ4	0.1																	
CRMH1	0.7508	0.1																
CRMH2	0.9509	0.8093	0.1															
CRMTOT	0.9372	0.8845	0.9857	0.1														
CRVQ1	0.5988	0.7369	0.6431	0.6884	0.1													
CRVQ2	0.6158	0.7458	0.6509	0.694	0.7488	0.1												
CRVQ3	0.7146	0.6866	0.7587	0.7619	0.746	0.7683	0.1											
CRVQ4	0.7537	0.6521	0.7317	0.7412	0.7051	0.732	0.8654	0.1										
CRVH1	0.6551	0.7984	0.697	0.7445	0.9125	0.9462	0.8059	0.768	0.1									
CRVH2	0.7661	0.6914	0.7796	0.7804	0.7522	0.78	0.9632	0.9546	0.8176	0.1								
CRVTOT	0.7705	0.7306	0.7927	0.8061	0.8004	0.8275	0.9535	0.9436	0.8702	0.9875	0.1							
D1QT	-0.4339	-0.5103	-0.4719	-0.4949	-0.6428	-0.5904	-0.6015	-0.5473	-0.6485	-0.5994	-0.62	0.1						
D2QT	-0.4481	-0.5493	-0.4948	-0.5204	-0.6349	-0.6502	-0.6386	-0.5842	-0.6815	-0.6383	-0.6573	0.6347	0.1					
D3QT	-0.4537	-0.4589	-0.4845	-0.4868	-0.602	-0.603	-0.7088	-0.6601	-0.6358	-0.7115	-0.7062	0.5844	0.6018	0.1				
D4QT	-0.4684	-0.4804	-0.501	-0.5035	-0.6076	-0.6171	-0.6975	-0.6932	-0.6465	-0.7252	-0.7205	0.567	0.5893	0.7388	0.1			
D1HF	-0.4678	-0.5474	-0.5098	-0.5331	-0.6671	-0.662	-0.6689	-0.6161	-0.703	-0.6682	-0.6873	0.8727	0.8718	0.6413	0.6345	0.1		
D2HF	-0.4837	-0.485	-0.5121	-0.5145	-0.6263	-0.6369	-0.7366	-0.7104	-0.667	-0.7528	-0.7467	0.5845	0.6044	0.8869	0.9223	0.6504	0.1	
DTOT	-0.5115	-0.5218	-0.5432	-0.5498	-0.6607	-0.671	-0.7591	-0.7241	-0.7052	-0.7728	-0.7728	0.668	0.6801	0.8664	0.8926	0.7525	0.9655	0.1

Table 71: Pearson Product Coefficients Visual Condition 1

	OM1QT	OM2QT	OM1HF	OMTOT	CO1QT	CO2QT	CO1HF	COTOT	RT1QT	RT2QT	RT1HF	RTTOT	V1QT	V2QT	V1HF	VTOT
OM1QT	1															
OM2QT	0.6724	1														
OM1HF	0.9092	0.9179	1													
OMTOT	0.7516	0.7952	0.8466	1												
CO1QT	0.1355	0.1469	0.1505	0.1802	1											
CO2QT	0.1429	0.2137	0.1939	0.2433	0.554	1										
CO1HF	0.1554	0.1981	0.1911	0.2359	0.9047	0.8258	1									
COTOT	0.1587	0.2111	0.1993	0.2159	0.71	0.6064	0.7334	1								
RT1QT	0.3188	0.3324	0.3518	0.384	0.0828	0.0376	0.0507	0.1433	1							
RT2QT	0.3375	0.383	0.3895	0.4316	0.1159	0.0691	0.0874	0.1654	0.9294	1						
RT1HF	0.334	0.3621	0.3761	0.4137	0.1016	0.0527	0.0697	0.158	0.9794	0.9839	1					
RTTOT	0.2461	0.2892	0.288	0.3707	0.049	0.0376	0.0307	0.0179	0.9002	0.9163	0.9249	1				
V1QT	0.3371	0.3288	0.3595	0.3717	0.2943	0.1576	0.2442	0.3433	0.7396	0.6788	0.7197	0.6368	1			
V2QT	0.3079	0.373	0.3671	0.4116	0.2913	0.2301	0.2783	0.3726	0.6484	0.7509	0.7142	0.6388	0.6994	1		
V1HF	0.3419	0.3878	0.3937	0.4278	0.3103	0.2159	0.282	0.3782	0.7343	0.7816	0.772	0.6904	0.8935	0.9385	1	
VTOT	0.3306	0.3839	0.3843	0.4624	0.2782	0.2209	0.2601	0.3894	0.7934	0.8328	0.8282	0.8011	0.8088	0.8397	0.8928	1

Table 72: Pearson Product Coefficients Visual Condition 2

	OM3QT	OM4QT	OM2HF	OMTOT	CO3QT	CO4QT	CO2HF	COTOT	RT3QT	RT4QT	RT2HF	RTTOT	V3QT	V4QT	V2HF	VTOT
OM3QT	1															
OM4QT	0.6187	1														
OM2HF	0.9027	0.8947	1													
OMTOT	0.8927	0.8792	0.9847	1												
CO3QT	0.0664	0.1736	0.1299	0.1391	1											
CO4QT	0.1403	0.2511	0.211	0.2267	0.7701	1										
CO2HF	0.1128	0.2301	0.1851	0.1987	0.926	0.9527	1									
COTOT	0.1331	0.2446	0.2051	0.2159	0.9069	0.9234	0.9729	1								
RT3QT	0.2546	0.3752	0.3458	0.3458	-0.0806	0.0523	-0.0071	-0.0094	1							
RT4QT	0.2461	0.3877	0.3486	0.3415	-0.0853	-0.0034	-0.0419	-0.0404	0.9262	1						
RT2HF	0.2549	0.3879	0.3532	0.3498	-0.0847	0.0236	-0.0259	-0.0263	0.9795	0.9823	1					
RTTOT	0.268	0.4079	0.3714	0.3707	-0.0428	0.0744	0.0239	0.0179	0.9787	0.9712	0.9931	1				
V3QT	0.3252	0.471	0.4353	0.4404	0.2614	0.3683	0.3413	0.3328	0.789	0.7285	0.7717	0.7927	1			
V4QT	0.3053	0.5012	0.4417	0.4424	0.2775	0.4022	0.3684	0.3637	0.7266	0.7692	0.7615	0.7802	0.8676	1		
V2HF	0.3187	0.4974	0.4466	0.4496	0.2734	0.393	0.3613	0.3552	0.7796	0.7811	0.7947	0.8136	0.9545	0.9728	1	
VT	0.3245	0.5054	0.4549	0.4624	0.3044	0.4304	0.398	0.3894	0.7598	0.7518	0.7697	0.8011	0.9463	0.9592	0.9874	1

8.9 Appendix I: Pearson Product Coefficients, Auditory

Table 73: Pearson Product Coefficients - Auditory All Variables

	OMPQ1	OMPQ2	OMPQ3	OMPQ4	OMPH1	OMPH2	OMPTOT	COPQ1	COPQ2	COPQ3	COPQ4	COPH1	COPH2	COPTOT	CRMQ1	CRMQ2	CRMQ3
OMPQ1	.1																
OMPQ2	.8082	.1															
OMPQ3	.6756	.7336	.1														
OMPQ4	.6405	.7055	.9358	.1													
OMPH1	.9416	.9593	.7432	.7102	.1												
OMPH2	.669	.731	.9834	.9842	.7385	.1											
OMPTOT	.7325	.7896	.9806	.9769	.8024	.9949	.1										
COPQ1	.4108	.3769	.3736	.3996	.4117	.3948	.4143	.1									
COPQ2	.46	.4135	.3768	.3971	.4562	.3947	.4203	.8664	.1								
COPQ3	.4829	.458	.542	.5592	.4932	.5597	.5685	.4269	.4779	.1							
COPQ4	.4518	.4305	.4952	.489	.4628	.4996	.5104	.3268	.3563	.8299	.1						
COPH1	.4514	.4099	.3884	.4121	.45	.4085	.4319	.9635	.9683	.4697	.3544	.1					
COPH2	.486	.4621	.5391	.5433	.4972	.5498	.56	.3867	.4284	.9476	.9645	.4231	.1				
COPTOT	.5481	.5075	.5302	.5476	.5523	.5487	.57	.8599	.8841	.7778	.7051	.9033	.7701	.1			
CRMQ1	.5544	.5661	.4986	.4847	.5894	.4993	.5289	.2073	.2258	.3582	.39	.2247	.392	.344	.1		
CRMQ2	.4962	.5449	.4803	.4822	.5494	.4889	.5137	.2031	.2198	.339	.3736	.2194	.3736	.3313	.9149	.1	
CRMQ3	.4469	.4748	.5259	.5094	.4855	.5257	.5366	.2008	.2121	.3115	.3439	.214	.3438	.3149	.7822	.8106	.1
CRMQ4	.3718	.4044	.4417	.4377	.4096	.4462	.4549	.1689	.1591	.2869	.314	.1703	.3156	.2704	.7131	.7512	.879
CRMH1	.5322	.5604	.4956	.4891	.5755	.5001	.5275	.2084	.2227	.3533	.3885	.2236	.3889	.3416	.9751	.9808	.8149
CRMH2	.4309	.4656	.5151	.5083	.4727	.5197	.5295	.1986	.2065	.3233	.3506	.2099	.3532	.3167	.7737	.8082	.975
CRMTOT	.4675	.5009	.504	.4968	.5104	.5083	.525	.2106	.2181	.3285	.3577	.2222	.3596	.3279	.85	.8788	.9668
CRVQ1	.5613	.5864	.5493	.5421	.6043	.5545	.5804	.3324	.3027	.4927	.5108	.3284	.5245	.4789	.7472	.6965	.6364
CRVQ2	.5172	.559	.5184	.5286	.5674	.5319	.5548	.3098	.3231	.4983	.5196	.3281	.5327	.4824	.6843	.7718	.6388
CRVQ3	.4977	.5375	.5775	.5661	.5459	.5809	.5945	.2864	.2808	.5437	.5616	.2937	.5781	.4803	.6591	.6823	.7564
CRVQ4	.437	.4746	.4947	.4998	.4811	.5047	.5167	.2184	.2016	.5194	.5651	.2178	.5693	.4239	.6193	.6523	.679
CRVH1	.5767	.6096	.5644	.5678	.6249	.5752	.6017	.3344	.3293	.5184	.541	.3435	.5543	.5035	.7577	.8026	.6892
CRVH2	.4955	.535	.5808	.5823	.5434	.5909	.603	.289	.2783	.5551	.5845	.2938	.5966	.4892	.6592	.6908	.7458
CRVTOT	.52	.5607	.57	.5729	.5699	.5806	.598	.3047	.2993	.5509	.5787	.3128	.5913	.4998	.695	.7323	.7625
D1QT	-.6866	-.6042	-.5707	-.5536	-.6745	-.5713	-.606	-.4739	-.4011	-.5393	-.5457	-.452	-.5667	-.5864	-.5097	-.4914	-.4733
D2QT	-.6038	-.7221	-.6054	-.5936	-.7024	-.6091	-.6434	-.4132	-.459	-.5698	-.5546	-.4523	-.5863	-.5954	-.5378	-.5434	-.4962
D3QT	-.4572	-.4903	-.5788	-.5524	-.4995	-.5744	-.5823	-.2898	-.2867	-.7193	-.6516	-.2986	-.7127	-.5489	-.4516	-.4493	-.471
D4QT	-.4361	-.4708	-.5443	-.574	-.4782	-.5682	-.5736	-.2662	-.262	-.6307	-.742	-.2735	-.7228	-.5363	-.4706	-.472	-.4792
D1HF	-.6214	-.6523	-.5746	-.5601	-.6709	-.5765	-.6098	-.4244	-.4007	-.5698	-.5801	-.427	-.6009	-.5847	-.5358	-.5395	-.5092
D2HF	-.4522	-.4864	-.5679	-.5708	-.4949	-.5784	-.5851	-.2828	-.2759	-.6725	-.7061	-.2892	-.7219	-.5468	-.475	-.4764	-.4928
DTOT	-.5041	-.5388	-.5896	-.5903	-.5497	-.5994	-.6121	-.3416	-.326	-.6463	-.6724	-.3455	-.6901	-.5711	-.5091	-.5147	-.5269

Table 74: Pearson Product Coefficients - Auditory All Variables, continued

	CRMQ4	CRMH1	CRMH2	CRMTOT	CRVQ1	CRVQ2	CRVQ3	CRVQ4	CRVH1	CRVH2	CRVTOT	D1QT	D2QT	D3QT	D4QT	D1HF	D2HF	DTOT
CRMQ4	0.1																	
CRMH1	0.7508	0.1																
CRMH2	0.9509	0.8093	0.1															
CRMTOT	0.9372	0.8845	0.9857	0.1														
CRVQ1	0.5988	0.7369	0.6431	0.6884	0.1													
CRVQ2	0.6158	0.7458	0.6509	0.694	0.7488	0.1												
CRVQ3	0.7146	0.6866	0.7587	0.7619	0.746	0.7683	0.1											
CRVQ4	0.7537	0.6521	0.7317	0.7412	0.7051	0.732	0.8654	0.1										
CRVH1	0.6551	0.7984	0.697	0.7445	0.9125	0.9462	0.8059	0.768	0.1									
CRVH2	0.7661	0.6914	0.7796	0.7804	0.7522	0.78	0.9632	0.9546	0.8176	0.1								
CRVTOT	0.7705	0.7306	0.7927	0.8061	0.8004	0.8275	0.9535	0.9436	0.8702	0.9875	0.1							
D1QT	-0.4339	-0.5103	-0.4719	-0.4949	-0.6428	-0.5904	-0.6015	-0.5473	-0.6485	-0.5994	-0.62	0.1						
D2QT	-0.4481	-0.5493	-0.4948	-0.5204	-0.6349	-0.6502	-0.6386	-0.5842	-0.6815	-0.6383	-0.6573	0.6347	0.1					
D3QT	-0.4537	-0.4589	-0.4845	-0.4868	-0.602	-0.603	-0.7088	-0.6601	-0.6358	-0.7115	-0.7062	0.5844	0.6018	0.1				
D4QT	-0.4684	-0.4804	-0.501	-0.5035	-0.6076	-0.6171	-0.6975	-0.6932	-0.6465	-0.7252	-0.7205	0.567	0.5893	0.7388	0.1			
D1HF	-0.4678	-0.5474	-0.5098	-0.5331	-0.6671	-0.662	-0.6689	-0.6161	-0.703	-0.6682	-0.6873	0.8727	0.8718	0.6413	0.6345	0.1		
D2HF	-0.4837	-0.485	-0.5121	-0.5145	-0.6263	-0.6369	-0.7366	-0.7104	-0.667	-0.7528	-0.7467	0.5845	0.6044	0.8869	0.9223	0.6504	0.1	
DTOT	-0.5115	-0.5218	-0.5432	-0.5498	-0.6607	-0.671	-0.7591	-0.7241	-0.7052	-0.7728	-0.7728	0.668	0.6801	0.8664	0.8926	0.7525	0.9655	0.1

Table 75: Auditory Correlation Coefficients Condition 1

	OMQ1	OMQ2	OMH1	OMT	CQ1	CQ2	CH1	CT	RTQ1	RTQ2	RTH1	RTT	VQ1	VQ2	VH1	VT
OMQ1	1															
OMQ2	0.8082	1														
OMH1	0.9416	0.9593	1													
OMT	0.7325	0.7896	0.8024	1												
CQ1	0.4108	0.3769	0.4117	0.4143	1											
CQ2	0.46	0.4135	0.4562	0.4203	0.8664	1										
CH1	0.4514	0.4099	0.45	0.4319	0.9635	0.9683	1									
CT	0.5481	0.5075	0.5523	0.57	0.8599	0.8841	0.9033	1								
RTQ1	0.5544	0.5661	0.5894	0.5289	0.2073	0.2258	0.2247	0.344	1							
RTQ2	0.4962	0.5449	0.5494	0.5137	0.2031	0.2198	0.2194	0.3313	0.9149	1						
RTH1	0.5322	0.5604	0.5755	0.5275	0.2084	0.2227	0.2236	0.3416	0.9751	0.9808	1					
RTT	0.4675	0.5009	0.5104	0.525	0.2106	0.2181	0.2222	0.3279	0.85	0.8788	0.8845	1				
VQ1	0.5613	0.5864	0.6043	0.5804	0.3324	0.3027	0.3284	0.4789	0.7472	0.6965	0.7369	0.6884	1			
VQ2	0.5172	0.559	0.5674	0.5548	0.3098	0.3231	0.3281	0.4824	0.6843	0.7718	0.7458	0.694	0.7488	1		
VH1	0.5767	0.6096	0.6249	0.6017	0.334	0.3293	0.3435	0.5035	0.7577	0.8026	0.7984	0.7445	0.9125	0.9462	1	
VT	0.52	0.5607	0.5699	0.598	0.3047	0.2993	0.3128	0.4998	0.695	0.7323	0.7306	0.8061	0.8004	0.8275	0.8702	1

Table 76: Auditory Correlation Coefficients Condition 2

	OMQ3	OMQ4	OMH2	OMT	COQ3	COQ4	COH2	COT	RTQ3	RTQ4	RTH2	RTT	VQ3	VQ4	VH2	VT
OMQ3	1															
OMQ4	0.9358	1														
OMH2	0.9834	0.9842	1													
OMT	0.9806	0.9769	0.9949	1												
COQ3	0.542	0.5592	0.5597	0.5685	1											
COQ4	0.4952	0.489	0.4996	0.5104	0.8299	1										
COH2	0.5391	0.5433	0.5498	0.56	0.9476	0.9645	1									
COT	0.5302	0.5476	0.5487	0.57	0.7778	0.7051	0.7701	1								
RTQ3	0.5259	0.5094	0.5257	0.5366	0.3115	0.3439	0.3438	0.3149	1							
RTQ4	0.4417	0.4377	0.4462	0.4549	0.2869	0.314	0.3156	0.2704	0.879	1						
RTH2	0.5151	0.5083	0.5197	0.5295	0.3233	0.3506	0.3532	0.3167	0.975	0.9509	1					
RTT	0.504	0.4968	0.5083	0.525	0.3285	0.3577	0.3596	0.3279	0.9668	0.9372	0.9857	1				
VQ3	0.5775	0.5661	0.5809	0.5945	0.5437	0.5616	0.5781	0.4803	0.7564	0.7146	0.7587	0.7619	1			
VQ4	0.4947	0.4998	0.5047	0.5167	0.5194	0.5651	0.5693	0.4239	0.679	0.7537	0.7317	0.7412	0.8654	1		
VH2	0.5808	0.5823	0.5909	0.603	0.5551	0.5845	0.5966	0.4892	0.7458	0.7661	0.7796	0.7804	0.9632	0.9546	1	
VTOT	0.57	0.5729	0.5806	0.598	0.5509	0.5787	0.5913	0.4998	0.7625	0.7705	0.7927	0.8061	0.9535	0.9436	0.9875	1