PADDS Clinical Research Excerpt

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Chapter 1. Introduction

Overview of the Pediatric Attention Disorders Diagnostic Screener

Pediatric Attention Disorders Diagnostic Screener is an Attention and Executive Functioning Screening System with proven clinical reliability and validity for the screening of Attention and Executive disorders (Scott, 2005; Pedigo, 2003). The ***PADDS*** system is designed to screen for ADHD with children between the ages of 6 to 12 years. This process merges three short and enjoyable computer administered tasks referred to as the Target Tests of Executive Functioning (TTEF) in conjunction with a **Computer Administered and Scored Diagnostic Interview (CADI)** and a **Nomographic Evidence-based Report Analysis** which reveals the positive and negative predictive power across multiple lines of evidence established for or against a given diagnosis. The Target Tests of Executive Functioning computer tasks move beyond routine persistence found with traditional continuous performance tests by tapping greater aspects of executive functioning than CPT's currently in use. Commonly cited areas of executive operations needed in the classroom include among others: **Activating, Focusing, Planning, Organization, Working Memory, Modulating Emotions, and Sustaining Effort**. Prior to completing the TTEF subtests, the examiner provides brief verbal instruction, which is then reinforced by more comprehensive computer instructions. The computer instruction set is designed to ensure the ability to use a computer mouse, to recognize primary colors, basic numbers and to understand the task requirements. These samples must be completed successfully before the program will allow the actual subtest to be run. The TTEF subtests require approximately 25 to 30 minutes to administer and are designed to be more enjoyable and engaging to children than is typically reported with use of traditional CPT's. The **CADI** covers the major areas of comorbidity needed to reliably screen ADHD, and both processes can be completed in total in less than 45 minutes by a clinician or assistant.

All information from both components is maintained in a database for collection and comparison over time. The Nomographically displayed, Evidence-based Analysis combines the incremental validation of information from parent and teacher ratings of DSM-IV ADHD diagnostic criteria, with results from the three Target Tests of Executive Functioning tasks, and if desired, select information provided by the individual clinician. This Evidence-based format compares these results in incremental fashion, against an adjustable base rate, to help establish the positive and negative predictive power for or against a diagnosis.

The **CADI** allows the clinician to efficiently review important areas of development and potential comorbidity to assist with differential diagnosis. The final 3 to 5 page report contains the answers from the CADI that are of clinical significance, consolidated into domain specific sections, and greatly increases the ability to identify co-morbid conditions. This process has proven highly effective and transparent when reviewing evidence for or against a diagnosis. Since the clinician or assistant can effectively administer this system, the clinician's time can be more appropriately allocated to evaluating the results, which are collected along multiple lines of evidence and spending face-to-face time with the patient and family.

This standardized evidence-based approach efficiently provides a preliminary treatment plan that can support a diagnosis when combined with other procedures as deemed necessary by clinical input and judgment. This screening can also support decisions for further evaluation and procedures. The multi-level evidence-based approach incorporated in the ***PADDS*** System is directly in line with the current emphasis of "best practices" called for by prominent researchers, healthcare agencies and professional academies.

Role of the Target Tests of Executive Functioning in Assessment

The Target Tests of Executive Functioning subtests include several differently designed tasks presented via computer aimed at providing objective assessment of a subject's ability to employ various but not all executive processes: (**planning, attending, organizing input, storing and retrieving information, modulating emotions and sustaining effort**).

The Target Tests of Executive Functioning are also designed to be enjoyable and engaging for children while more fully requiring the use of these various Executive Abilities.

These Task demands were selected because they are consistently identified as areas of difficulty for children known to have ADHD. By tapping into these greater aspects of executive functioning, The Target Tests move far beyond the routine persistence tasks of current continuous performance tests.

User Qualifications

The PADDS system is classified as a level B instrument that may be purchased by individuals with certification or licensing from appropriate professional organizations such as AAA, AAP, ACA, AEA, AERA, AMA, AOTA, APA, ASHA, CEC, EAA, INS, NAN, NASP or certification in a closely related field that requires comparable professional codes of conduct and experience with testing and/or measurement.

Examiners should also have experience testing children and familiarity with the Standards for Educational and Psychological Testing (Committee to Develop Standards for Educational and Psychological Testing, 1985).

Although a trained assistant (qualified technician) can administer and input information into the PADDS, the responsibility for interpreting the PADDS results and reports must lie with the appropriately licensed professionals. These individuals should have training in the fundamental principles of assessment, such as establishing rapport with the subject, familiarity with computer-administered tests, and following standard administration procedures as outlined in this manual.

It is also the responsibility of the licensed professional to ensure the PADDS materials are only released to responsible assistants as necessary and to maintain the security and integrity of the test materials by safeguarding the proper use of PADDS at all times.

The PADDS system is intended to work as an adjunct with proper clinical experience and as such is not intended for use as stand alone diagnostic measure.

Chapter 2. Testing Considerations

Time required to Administer PADDS

The Target Tests of Executive Functioning require approximately 25 to 30 minutes to administer
The clinician or assistant can input data from the ***previously completed*** Computer Administered Diagnostic Interview (CADI**)** and SNAP-IV rating scales in 10 – 15 minutes. Both processes can be completed in approximately 45 minutes. This naturally does not include time used to evaluate the reports and results.

Testing Guidelines

The ***PADDS*** system is designed to screen for ADHD in children between the ages of 6 to 12 years. Prior to screening a child with the ***PADDS*** system a given child should have a current referral from home and/or school raising concern in the areas of inattention, poor concentration and/or impulsivity. The ***PADDS*** system is not designed for widespread screening of children in general. This system is designed for use within the context of comprehensive clinical assessment practices and judgment. Since the ***PADDS system*** *is* not a stand-alone assessment instrument, it singularly is not suitable to diagnose any clinical conditions. While the ***PADDS*** system can be administered by a trained clinical assistant its use must be limited to the uses stated in the clinical manual and must be supervised and interpreted by a qualified clinician. Specific environmental considerations and standard administration procedures outlined in this manual must also be maintained. Please review the relevant sections on administration, scoring and interpretation prior to using the ***PADDS*** program.

To ensure a valid administration the following standard guidelines should be adhered to:

Administered in this order on the same day Target Recognition, Target Sequencing, Target Tracking
Administered in the morning hours to avoid diurnal effects if possible
The environment should be clear of undue noise, conversation and distracting toys or equipment
If a child cannot learn the practice items after several attempts the tests should not be given
A behavioral observation score must be recorded, even if 0, for the subtest scores to be saved.
The attendant must sit with the child and provide gentle redirection when needed
The attendant must have the ability to establish and maintain rapport
The attendant must not be a relative or personal friend of the subject
The subtests are completed outside of the presence of the parent or guardian

Chapter 3. Description and Use of the PADDS System Components

Summary of the PADDS Report Features

The PADDS System and Summary Reports represent an innovative advancement in Evidence-based Assessment. This process presents the incremental input of multiple forms of information that research has shown to be most reliable and valid for ADHD assessment. The PADDS system relies on comparison of two well-defined reference groups namely ADHD and Non-ADHD. Each component is calculated in additive or subtractive manner for and against a diagnosis, taking into account the ADHD base rate, (prevalence). The inputs are displayed in a real time format via a computer generated Nomogram presenting an individual and an overall predictive index of likelihood ratios establishing evidence for or against a diagnosis. Results are likewise presented in a normalized, relative Standard, T/Z-Score, and percentile rank format for comparison to the non-clinical reference group.

Parent & Teacher Ratings

The PADDS first step inputs consist of Parent and Teachers ratings of the behavioral criteria for ADHD based on criteria set by the Diagnostic and Statistical Manual of Mental Disorders Fourth Edition-Revised. Specifically, these criteria as rated by short form SNAP-IV **(**Swanson et al., 1992, with permission 02/08**).** The SNAP scales offer categorical and dimensional input across the 18 core diagnostic items from the DSM-IV**.** Each scale has been evaluated to set a threshold for ascribing clinical significance based on the number of items endorsed in conjunction with a threshold for severity. The thresholds were added to the original DSM-IV criteria to reduce the rate of over identification that can occur when only number of items endorsed is used. These behavioral criteria when used in the above-described manner have produced solid sensitivity and specificity in identifying ADHD cases relative to non-clinical reference groups (Zolotor & Mayer, 2004; Green, et al. 1999). These authors report the sensitivity and specificity of various short form ADHD checklists ranging between .70 and .97 percent with the most productive being the SNAP-III R/SNAP-IV which has estimated between 90 to 97 percent sensitive and specific.

Using the Ratings Scales in Conjunction With the PADDS System

The SNAP-IV forms are included for parent and teachers to complete along with the Diagnostic Interview (CADI) or they can be copied or printed from the PADDS Tools menu and then input with the CADI or independent of the CADI. The CADI input is generated via a separate report function and does not have to be used to score and report the behavior ratings along with the cognitive subtests of the PADDS system. If the CADI is not used, it is advised to do some other form of co-morbid condition screening. If the SNAP-IV scales are not used, other ratings such as Vanderbilt or Brief may be input when running the scoring function for the cognitive subtests by placing a check mark in an assigned box which will trigger the automatic calculation and conversion of sensitivity and specificity set at a default of 90%. This results in the assignment of a standard likelihood ratio and allows the result from the parent, teacher or both to be incrementally input along with performance on three cognitive tests of executive functions.

The second component of the PADDS Summary Report consists of the review of the Computer Assisted Diagnostic Interview or CADI which enables the clinician to review multiple potential areas of concern as highlighted by the parent or informant that can be relevant to ruling out comorbid or exacerbating conditions for a given child. This cross validation represents a semi-structured interview and develops a preliminary treatment plan to help support decisions for further assessment and/or referral.

The third component of the PADDS system represents objective assessment of a child's executive functions and working memory. The Target Tests of Executive Functioning have demonstrated superior ability as an adjunct to cross validate behavioral observation and background report. The process is quick and enjoyable and demonstrates superior Reliability, Validity, Sensitivity/Specificity, and Positive and Negative Predictive power over any other measure of its kind currently available (Please refer to the psychometric development and performance section of the PADDS Clinical Manual). These Executive measures were designed to be enjoyable, engaging and ecologically valid by requiring demands that are more consistent with those required in the typical classroom setting. Extensive research has shown that children routinely report them as "fun but hard", typically avoiding the strong negative emotions that are commonly evoked when taking traditional CPTs.

The fourth and final component is the nomographic display of the individual and cumulative inputs. This evidence is evaluated stepwise via the calculation of likelihood Ratios applied incrementally with a Fagan's Nomogram, the results produce an overall predictive index that is compared to the calculated ***base rate*** (ADHD prevalence).

The PADDS is set by default at a conservative base rate of 4%, which is consistent with the reported 95% confidence intervals. Adjusting the base rate in the PADDS is a simple process and is covered fully in the Installation and Use Manual.

Establishing the proper base rate is important because it will have a dramatic effect on the Post-Test, or Posterior Probability, (outcome).

Base rate estimates of ADHD can vary widely depending on the type of settings and methodologies used to calculate them. Epidemiological estimates of ADHD have ranged from 3% to 12% (American Academy of Pediatrics, 2000; American Psychiatric Association, 1994).

Currently reported base rates can range anywhere from 0.03 to 0.74. The higher estimates are from specialized ADHD clinics and the lower estimates are from recent epidemiological studies. Specialized neuropsychology clinics normally have higher base rates as a result of referral sources weeding out many of the more unlikely cases in advance, however, a solid rationale must exist for the use of these extremely high base rates. Whenever possible, the practitioner should calculate the base rate of ADHD based on literature review and the past history of their particular setting, and periodically update this to reflect changes in the population or individual client pool. This approach is important because it allows the clinician to evaluate these incremental inputs while considering the prevalence, or base rate of a condition, without adversely inflating the predictive power, as can happen when we rely on assumptions of sensitivity or specificity alone.

To calculate your clinics actual base rate for ADHD, you must determine the percentage of patients, referred to you for ADHD assessment, who are then properly diagnosed as ADHD.

(# Of Patients identified as ADHD / Total # of Patients referred for ADHD) * 100.

Ex. 34/100 = 0.34, 0.34 X 100 = 34%

(i.e. 100 patients, 34 are positive for ADHD = 34% base rate).

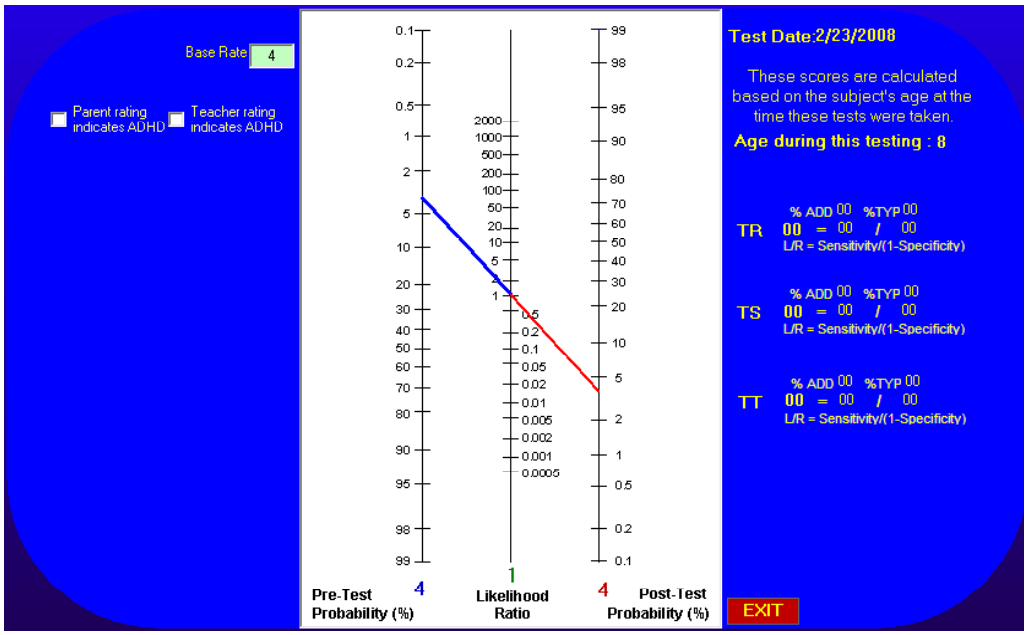
This should to be recalculated periodically to accurately reflect changes in the referral population.

When these components are used in conjunction with clinical judgment they have proven to be highly effective for consideration of diagnosis, in highlighting and documenting a need for further evaluation or actions, and may allow the clinician to evaluate their own diagnostic practices and effectiveness over time.

Chapter 4. Administration and Scoring

Scoring and Interpretation of PADDS Results

In General, interpretation of the PADDS results will be straightforward given that they are compiled, analyzed and presented via the computer program. The basic feature of interpretation is the overall predictive index presented in nomographic format as in the example below.



In the far **upper right** hand corner you will see the **Predictive Index** upper bound range of 99%. This is the maximum upper limit of the predictive index produced by the PADDS program inputs. In the **lower right** hand corner you will see the lower bound range of 0.1%. This is the lower limit of the **Predictive Index (Lower .01…….99 highest)**.

In the **upper left** hand corner you will see the population **Base Rate Box** with the **default of 4%** assigned and that there is a blue and red indicator needle spanning from the pretest side of the nomogram to the posttest side. This inspection will show that the pre-test and post-test probabilities are currently equal at 4 %.

As the parent, teacher and cognitive elements are input one at a time they will produce a given likelihood ratio that will adjust the blue and red indicator set in the middle of the nomogram up or down depending on the performance of a given subject. This is how the program achieves its honesty by giving credit to performances for or against a diagnosis.

Based on the psychometric performance of the PADDS system this set of procedures will typically yield very valuable information to help guide clinical decisions. Please take a minute to review summary listed in Table 4.1 and Table 4.2 respectively, highlighting the strong properties of psychometrics and clinical utility demonstrated by the Target Tests of Executive Functioning.

Analysis of the Target Subtests psychometric and clinical support revealed that individuals with a clinical diagnosis of ADHD scored significantly lower on each of the three tests as compared to individuals who had not been diagnosed with ADHD, all *ts* > 19, $p < .001$. It is also important to note that the 95% confidence intervals that are based on standard errors of measurement (SEM) calculated with reliability estimates of .85 supports the selection of the cut scores used for diagnostic purposes with very little error in classification. Table 4.1 presents the 95% confidence intervals for each individual age grouping. As can be seen little to no overlap is evident on the Target subtests between the Typical and Clinical groups.

Table 4.1 PADDS cut scores, means, standard deviations, standard errors of measurement, and 95% confidence intervals as a function of sample and age groupings.

				Typical						Clinical		
AGE	**PADDS subtest**	**Cut score**	***M***	***SD***	***SEM***	***95% CI***	**Cut score**	***M***	***SD***	***SEM***	***95% CI***
	TR	>94	103.12	34.23	12.81	78 – 128	≤94	65.72	37.31	13.96	38 – 93
6 yrs	**TS**	>22	24.12	10.83	4.05	16 – 32	≤22	16.54	9.46	3.54	10 – 23
	TT	>6	8.65	3.46	1.29	6 – 11	≤6	4.98	3.11	1.16	3 – 7
	TR	>102	111.75	24.92	9.32	93 –130	≤102	75.68	33.92	12.69	51 – 100
7 yrs	**TS**	>26	30.29	5.2	1.95	26 – 34	≤26	16.15	8.83	3.30	10 – 23
	TT	>6	10.13	3.18	1.18	8 – 12	≤6	4.5	2.43	0.91	3 – 6
	TR	>111	118.41	27.36	10.24	98 – 138	≤111	80.91	31.74	11.88	58 – 104
8 yrs	**TS**	>26	31.39	6.62	2.48	27 – 36	≤26	18.21	9.14	3.42	11 – 25
	TT	>8	11.6	3.53	1.32	9 – 14	≤8	5.82	3.66	1.37	3 – 9
	TR	>113	130.25	14.77	5.53	119 – 141	≤113	83.72	30.93	11.57	61 – 106
9 yrs	**TS**	>28	32.23	6.11	2.29	28 – 37	≤28	19.77	8.75	3.27	13 – 26
	TT	>8	11.91	3.97	1.49	9 – 14	≤8	5.78	3.31	1.24	3 – 8
	TR	>125	134.32	12.03	4.50	125 – 143	≤125	107.63	18.95	7.09	94 – 122
10 yrs	**TS**	>31	34	5.2	1.95	30 – 37	≤31	26.79	6.36	2.38	22 – 31
	TT	>11	13.65	3.54	1.32	11 – 16	≤11	9.13	4.50	1.68	6 – 12
	TR	>128	140.49	8.49	3.18	134 – 147	≤128	98.85	34.68	12.98	73 – 124
11 yrs	**TS**	>32	34.87	6.52	2.44	30 – 40	≤32	27.1	7.48	2.80	22 – 33
	TT	>12	14.8	3.47	1.30	12 – 17	≤12	8.95	4.43	1.66	6 – 12
	TR	>128	137.77	9.77	3.66	131 – 145	≤128	130.07	14.42	5.40	119 – 141
12 yrs	**TS**	>34	36.27	2.49	0.93	34 – 38	≤34	29.79	4.08	1.53	27 – 33
	TT	>14	16.05	2.77	1.04	14 – 18	≤14	10.64	4.80	1.80	7 – 14

Note. Within typical sample, age 6 *n* = 25, age 7 *n* = 32, age 8 *n* = 52, age 9 *n* = 64, age 10 *n* = 79, age 11 *n* = 53, age 12 *n* = 25. Within clinical sample, age 6 *n* = 72, age 7 *n* = 80, age 8 *n* = 95, age 9 *n* = 67, age 10 *n* = 44, age 11 *n* = 22, age 12 *n* = 15. SEM = Standard error of measurement.

Using interval specific cut points, the following decision rule was applied to 725 subjects: In order to be considered as a classification hit, two of the three Target Test scores must fall within the predicted direction for subjects to remain classified in their initially known group assignment. (At least two clinical scores for ADHD classification and at least two non-clinical scores for classification as non-clinical).

Table 4.2 presents the clinical utility of the Target subtests by individual age. Taken along with the lack of overlap seen in the 95% confidence intervals presented in Table 4.1, the Target Subtests have demonstrated superior clinical performance in separating typical age peers from their ADHD counterparts.

Table 4.2. Sensitivity, specificity, positive predictive power, and negative predictive power by age grouping.

AGE	SENS	SPEC	PPP	NPP
6 yrs	.89	.84	.94	.72
7 yrs	.90	.88	.95	.78
8 yrs	.87	.87	.92	.79
9 yrs	.91	.92	.92	.91
10 yrs	.86	.91	.84	.92
11 yrs	.86	.92	.83	.94
12 yrs	.80	.84	.75	.88

Important Points to Consider When Interpreting PADDS Results

To ensure a valid administration the following standard guidelines should be adhered to:

Administered in this order on the same day Target Recognition, Target Sequencing, Target Tracking
Administered in the morning hours
The environment should be clear of undue noise, conversation and distracting toys or equipment
If a child cannot learn the practice items after several attempts, the tests should not be given
A behavioral observation score must be recorded, even if 0, for the subtest scores to be saved
The attendant must sit with the child and provide gentle redirection when needed
The attendant must have the ability to establish and maintain rapport
The attendant must not be a relative or personal friend of the subject
The subtests are completed outside of the presence of the parent or guardian

Interpretation of PADDS Results (General Guidelines)

Despite the highly acceptable clinical performance revealed above, raw scores for each Target subtest were analyzed to determine the specific sensitivity and specificity for each raw score at a given age interval. These sensitivities and specificities were then converted to specific Likelihood ratios, which could be applied incrementally via a nomogram to combine information from behavioral ratings along with the cognitive performances from the TTEF. The incremental inputs from behavioral and cognitive results develop a predictive index for and or against a diagnosis. This analysis when considered against the individual practice's base rate constitutes a highly standardized and effective evidence-based ADHD screening procedure.

The following guidelines are offered to assist with considering the objective assessment in conjunction with the CADI along with other information deemed useful to assist in the clinical judgment.

90-99 Percent Probability: PADDS Predictive Index Scores in this range clearly support a diagnosis of ADHD and suggests that strong consideration of the risk for intervening should be made against the risks of not intervening. Typically, scores in this range will have multiple confirming sources of information from well-established measures including demonstrated impairment in academic and or social/emotional areas of functioning. A review of PADDS inputs will show that Parent and/or Teacher Ratings and at least two of the three Target subtests were found in the clinical range (See published Cut Off scores listed below for the Target Tests of Executive Functioning). Consideration the objective assessment must be made in conjunction with Clinical Judgment, and other sources of information (i.e. the CADI or other interview and information or tests deemed useful).

80-90 Percent Probability: PADDS Predictive Index Scores in this range are suggestive of ADHD. Again, multiple inputs will be found supporting a diagnosis. However, actual impairment may not be as evident from the background report and should be considered in conjunction with Clinical Judgment and other information deemed appropriate. (i.e., the CADI or other interview and information or tests deemed useful).

Below 80 Percent Probability: PADDS Predictive Index Scores below this range are not deemed adequate to support a clinical diagnosis of ADHD and suggests that comorbid issues should be looked at closely. However, other information obtained by the clinician along with clinical judgment may in fact show that a diagnosis is warranted.

Interpretation of Target Test scores compared to the non-ADHD group

While the PADDS program automatically calculates the predictive index for the user, at times, it is helpful to review raw score and standard score information. Table 4.1 outlines the 95% confidence interval relative to a given raw score. This confidence interval information along with normalized Relative Z-Scores and cutoff points are presented for review in the cognitive test report.

PADDS Interpretation Guidelines for Unusual or Unexpected Results

Despite the outstanding classification potential demonstrated by the Target Tests of Executive Functioning with known groups (see Table 4.2), these metrics, when applied against an epidemiological base rate of 4% (as with ADHD) will result in significantly lower predictive power than is implied from their ability to separate groups with 100% known assignment (for a graphic depiction see case studies section of manual). This illustrates the importance and necessity of establishing a true base rate. Each potential raw score from the Target Tests of Executive Functioning was analyzed to determine the exact percentile rank for both the ADHD and Typical groups that corresponded to that given raw score. This was done to determine the sensitivity and specificity of every possible score for each of the three Target Tests. These sensitivities and specificities were used to develop likelihood ratios from every potential score for all three subtests. These ratios could then be applied incrementally with other data, as judged clinically appropriate, to a Fagan nomogram. Given that the PADDS program collects data for and against diagnosis, it is possible to get unusual results and while these should not be routine we have listed below several profiles that we have encountered on occasion.

Profile 1

Positive parent and teacher ratings for ADHD produces probability index of 74% and two of the three Target subtests fall within the non-clinical range (see 95% confidence intervals *table 4.1*) reducing the predictive index away from supporting a diagnosis.

Discussion:
This profile suggests that at least under some circumstances the subject can display adequate attention and executive control and therefore points to the risk of over reliance on behavioral ratings or test measures alone. The most common outcomes found with this profile have been:

A. A bright hyperactive subject who was challenged and engaged by the Target Tests. This child often presents as making solid grades but is a frequent disruption to the learning environment. Often complaints show that the child easily irritates peers, teachers, parents and relatives. They may play video games for hours on end and may like risk taking activities. These children typically have a difficult time with slow paced activities, such as the classroom or waiting in line and listening to instructions during sporting activities. These subjects also often show difficulty modifying their activity patterns to better fit with others at church, movies, when dining out, and in most other instances when confronted with tasks and environments that lack frequent, clear and meaningful rewards. As always the final determination of a clinical diagnosis rests with the clinician weighing all the available information. The clinician must determine the extent to which these difficulties impair the social and emotional development of the subject and the likelihood that behavioral and/or medical intervention will help.

B. Consideration that an academic and/or performance problem is creating behaviors similar to ADHD. Below we have listed some of the most frequently cited precautions given when routinely using rating scales.

Subjectivity can be skewed
Demand characteristics may enhance personal leanings
Can be inconsistent even between parents and multiple teachers
Multiple ratings may be considered as redundant information in some cases
Bias may reflect more about the relationship of the child & rater than about the organic functioning of the child.

When the hyperactive profile described above is not evident, we have found many instances of reading disabilities or reading delay especially when the child is being identified for the first time as a rising 3rd or 4th grader.

C. The behavioral rating scales are picking up primarily on an adjustment or emotional disorder.

Clinical judgment, the CADI and other multi-level ratings can help rule in or out such conditions. In some cases they occur co morbidly with ADHD but this is usually seen with combined poor performance on the Target Subtests.

Profile 2.

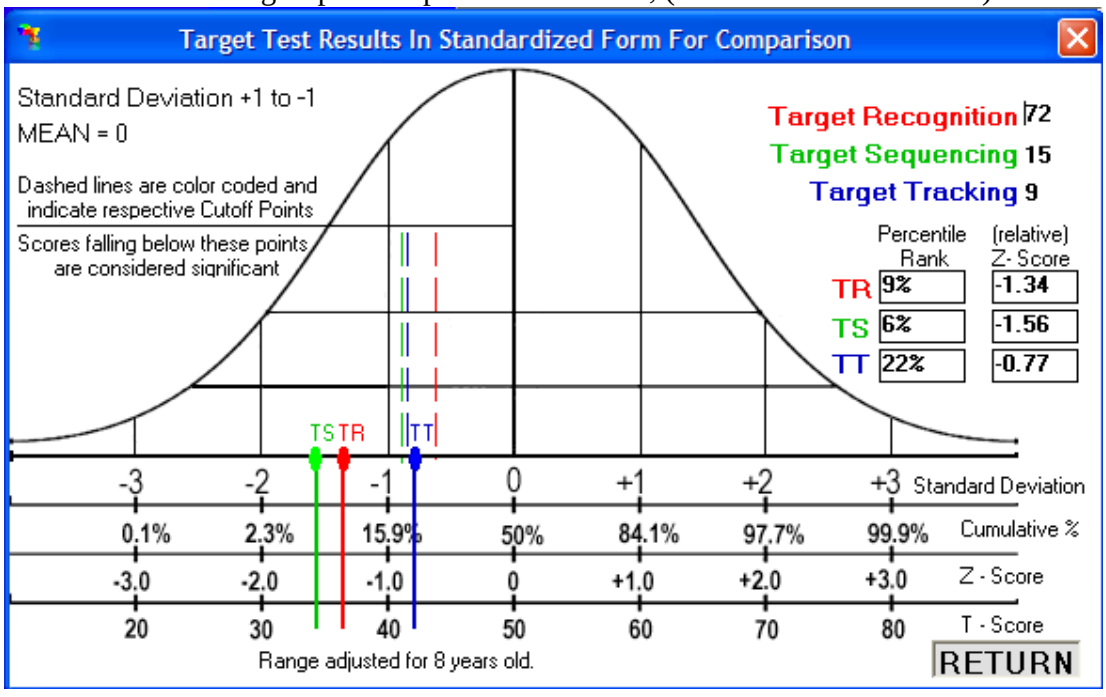
One extreme outlier significantly modifies the predictive model

Discussion: As can be seen in the descriptive statistics present for group classification in Table 4.1, the 95 percent confidence intervals show little to no overlap for the cut scores. However, at times a given score may fall well above or below that found in the confidence bands. The following recommendations are offered to assist in deciding the weight to give such scores.

A Very Low Score: will not modify the predictive model. This would be a score that was not encountered by either reference group as with a score of 2 for the Target Tracking subtest. In general, this type of score is so infrequent that it should not be interpreted.

A Very High Score: When found between two low scores can substantiality alter the predictive model as with a Target Tracking score of 17. A review of the confidence intervals shows that this score falls above the 95th confidence interval for the non-clinical group. Thus, such a score should not be given more weight than the combined input of all other sources of data.

This graph is used to visually compare the individual test performances, (color coded indicators), to the non-ADHD group cutoff points for that test, (color coded dashed lines).



Using age interval specific referenced cut points, the following decision rule was applied with all 725 subjects: In order to be considered as a classification hit, two of the three Target Tests of Executive Functioning performances must fall within the predicted direction for subjects to remain classified in their initially known group assignment (At least two clinical scores for ADHD classification and at least two non-clinical scores for classification as non-clinical).

Chapter 5. Psychometric Properties of the PADDS

Overview of PADDS Reliability and Validity

Reliability

Reliability, broadly defined, is the repeatability of test scores and/or research findings (Kaplan & Saccuzzo, 1997). Several forms of reliability exist and can be estimated using a variety of measures. The choice of reliability estimation technique is often limited in terms of the nature of the data collection and/or the nature of the available data. We report internal consistency reliability as well as test-retest reliability and decision consistency/stability coefficients as estimates of the reliability of the PADDS system. While establishing the reliability of a test is a process that is always ongoing, a generally accepted minimal standard of reliability is .70 (Spector, 1992). When clinical decisions are being made, coefficients of at least .85 are recommended (Rosenthal & Rosnow, 1991).

Internal Consistency. Treating the separate subtests of the PADDS as individual variables in a Cronbach's alpha analysis revealed a highly acceptable degree of **Internal Consistency reliability, α = .86** for the overall PADDS measure within a larger sample of n = 611 cases. The demographic make up of this larger sample had a mean age of 8.66 (SD = 1.71), 60% were male, 70% Caucasian, 25% African American, and 5% Hispanic. This reliability estimate was largely substantiated with alpha values of .86 and .80 in repeated testing of a sample of n = 38 and .80 and .92 in another repeated testing of a sample of n = 27 – samples taken to assess test-retest reliability in two independent samples (reported below). These reliability estimates thereby support the recommended use and comparison of the three subtests for their level of overall agreement in order to generate the maximum diagnostic utility of the test.

Test-Retest – Stability Coefficient. Criterion referenced test-retest reliability was examined by calculating stability coefficients and both the Kappa and Phi coefficients for the degree of diagnostic agreement resulting from two administrations with two separate samples of participants. Statisticians do not agree on whether the Phi or Kappa coefficient is a more appropriate measure of criterion referenced test-retest reliability (Reid & Roberts, 1978), so they are both reported here. The clinical use of the Target Tests combines all three subtest results when determining classification of ADHD or Typical performances. Given this use, assessing the stability of the diagnostic classification at two separate intervals was computed. The first sample included 65% males, mean age 8.36 with SD of 1.76. The participants ethnic make-up included 70% Caucasian, 23% African American, and 7% Hispanic. The 38 participants test and retest performances were collected within 6 months. Results show that 36 of the 38 participants remained appropriately classified resulting in a **stability coefficient of .94**. Phi and Kappa coefficients were also calculated for this sample with results of .70 and .69 respectively all ps<. 001.The second sample included 66% males with a mean age of 8.44 and SD of 1.90. Seventy percent of the participants were Caucasian and 30% were African American. The interval of time for test and retest was one to two years. Overall, 23 of the 27 participants remained appropriately classified across the test-retest procedures producing a **stability coefficient of .85** and indicating a high degree of stability for diagnostic classification over time. Phi and Kappa coefficients were also calculated for this sample of 27 participants with results of .70 and .73 respectively all ps< .001.

It is important to note that the psychometric review of the PADDS Target Test performances produced a main effect for age. This effect shows that the older a child is the better they tended to score on the individual subtests.

This result would be expected given that the Target Tests were designed as measures of executive functions. Since children typically show greater executive control as they age, it would stand to reason that they would improve on the subtests as they get older. Additionally, effects of time, practice, and physical maturation could also serve to increase the difference between test and retest procedures. Thus, differences between stability and Phi and Kappa coefficients would be expected. Overall, results show that individual subtest scores may vary as a function of age, but classification decisions made using age specific cut scores remain highly consistent even across the span of 6 months to 2 years.

Validity

Validity is defined as the degree to which a test measures what it purports to measure. Ultimately, validity is represented by the degree of support for construct validity; that is, does the measure adequately "tap into" the underlying construct it purports to measure? Evidence of construct validity is generated through the presentation of convergent and discriminant validities, primarily, and then more superficially through demonstration of criterion-related validity. Our primary focus at this stage of test development has been the demonstration of concurrent, convergent, and discriminant validities. Future work will continue to focus on establishing additional evidence of criterion-related validity for the measure as more findings emerge.

Concurrent Validity- All participants in the separate validity studies were drawn from the Savannah Child Study Center, Savannah Georgia. The first sample included 121 children age 6 to 12 (M = 8.77; SD = 2.0) who were administered the PADDS and TOVA. Approximately 73% were males and the sample consisted of 61% Caucasian, 33% African American, and 6 % Hispanic. Results from this study are presented in Table 5.1 and show each of the three PADDS subtests are correlated in predicted directions with the TOVA scale except in the case of response time, for which we expected no correlation given that the speed of response measured by the TOVA has no theoretical basis for exhibiting a relationship to any of the three PADDS subtests.

Table 5.1 Correlations between PADDS and TOVA Scale Scores (n = 121)

TOVA Scale	PADDS Scale		
	Target Recognition	Target Sequencing	Target Tracking
Omission	.36***	.43***	.43***
Commission	.34***	.30***	.36***
Response Time	.05	.08	.02
Variability	.33***	.29**	.30***
Multiple Response	-.39***	-.36***	-.27**

The second sample included 38 children age 6 to 12 (*M* = 8.37; *SD* = 1.76) who were administered the PADDS and CPT-II. Approximately 72 % were males and the sample included primarily 54% Caucasian, 41% African American, and 5% Hispanic. Results from this study are displayed in Table 5.2 and show the predicted relationships between the PADDS and the CPT-II. As anticipated, the PADDS subtests were negatively correlated with a number of the CPT-II subtests. These low to moderate negative correlations occurred because the PADDS and CPT-II are scored in opposite direction fro severity indicating that lower scores on the PADDS are associated with more performance errors on the CPT-II, and thus a higher score. The relatively low to moderate values of the observed correlations indicate that the CPT-II and the PADDS are measuring both similar as well as different components of attention and executive function and that they therefore could justifiably be used in conjunction with each other as a means to better capture a holistic view of the attention/concentration construct.

Table 5.2 Correlations between PADDS and CPT-II Scale Scores (*n* = 38)

	PADDS scale		
CPT-II scale	Target Recognition	Target Sequencing	Target Tracking
Omission	-.38**	-.34*	-.46**
Commission	-.13	-.20	-.14
Mean Hit RT	-.40**	-.29*	-.50**
Mean Hit RT (SE)	-.52***	-.33*	-.46**
D	-.21	-.39**	.00
B	-.39**	-.37*	-.47**

The third sample included 59 children age 6 to 12 (*M* = 8.48; *SD* = 1.86) who were administered the PADDS and Brief Scale. Approximately 75% were males and the sample included primarily 56% Caucasian, 34% African American and 10% Hispanic. Results as shown in Table 5.3 reveal that the PADDS and the BRIEF are largely unrelated measures. Perhaps these results are best interpreted in light of the rather distinct types of measures the PADDS and BRIEF are – the PADDS being a measure of executive function *performance* whereas the BRIEF is a *rating* of an individual's executive function abilities. These are quite different measures of a construct that, in order to observe a strong correlation, would require highly accurate ratings from individuals who may not have the necessary insight into ones' executive functioning abilities due to the tremendous possibility for bias in the ratings (especially on the part of parent who does not wish to have his/her child unfairly labeled). The quite low correlations between the PADDS and the BRIEF provide yet further evidence for the necessity of multiple sources of evidence for diagnosis of ADHD, as advocated by the evidence-based approach utilized in the PADDS system, rather than (over) reliance on any single diagnostic tool and its own particular limitations.

Table 5.3 Correlations between PADDS and BRIEF Scale Scores (n = 58)

	PADDS Scale		
BRIEF Scale	Target Recognition	Target Sequencing	Target Tracking
INHIBP	-.23*	-.19	-.18
WMP	.12	-.01	.07
EMCP	-.23*	-.09	-.13
GP	-.10	-.10	-.08
INHIBT	-.12	-.08	-.10
WMT	-.02	.02	-.04
EMCT	-.30*	-.17	-.24*
GT	-.17	-.10	-.13

Note. INHIBP = BRIEF Inhibit Parent Form; WMP = BRIEF Working Memory Parent Form; EMCP = BRIEF Emotional Control Parent Form; GP = BRIEF Global Executive Composite Parent Form; INHIBT = BRIEF Inhibit Teacher Form; WMT = BRIEF Working Memory Teacher Form; EMCT = BRIEF Emotional Control Teacher Form; GT = BRIEF Global Executive Composite Teacher Form.

Convergent validity – Convergent validity describes the extent to which two measures of the same construct correlate. In terms of overall diagnostic classification, there was low moderate diagnostic (classification) agreement between the PADDS and the Test of Variables of Attention (TOVA; Greenberg, 1991) group's measure of ADHD, r (121) = .38, $p < .001$.

In a separate sample of 38 children diagnosed with ADHD that improved on medication, percent agreement for classification of the PADDS Target Tests of Executive Functioning, the Brown Parent or Teacher ratings (Brown, 1996) and the Connors' Continuous Performance Test II (Conners, 1997) was completed to determine percentage of diagnostic utility and percentage of agreement among the measures. For the purpose of this analysis, at least two of the three Target Tests of Executive Functioning had to be found to be at or below established cut scores for classification of ADHD. Brown ADD scales were reported in T score format and for the purposes of this analysis either the parent or the teacher rating meeting the accepted standard of 1.5 standard deviations (or T score = 65) were considered indicative of classification of ADHD. Regarding the Connors' Continuous Performance Test II, also reported in T-score format, overall confidence index of 65 or greater was considered indicative of clinical classification. This sample included 67% males, 75 % Caucasian and 25% African American (mean age =8.70, SD= 1.9. Table 5.4 presents a comparison of the diagnostic utility of the PADDS Target Tests of Executive Functioning, the Brown ADD scales, and the Connors' Continuous Performance Test II. As can be seen, the Target subtests produced the highest hit rate of the three measures at 94% followed by the Conners' CPT at 68% and the Brown ADD Scales at 66%.

The improved hit rate produced by the Target Tests of Executive Functioning was in keeping with the overall data analysis of the larger data set (n = 725) and likely due to the fact that there are three independent measures used in conjunction with one another. These measures used in conjunction and incrementally have demonstrated outstanding ability to accurately classify ADHD subjects from their non-clinical counterparts

Table 5.4 **A comparison of diagnostic utility of PADDS Target Tests of Executive Functioning, Brown ADD Scales, and the Connors' Continuous Performance Test II**

	PADDS Target Tests	Brown ADD Scales	CPT II
Hit rate / N	36/38	25/38	26/38
Percentage	94%	66%	68%

Table 5.5 **A comparison of agreement of diagnostic classification of PADDS Target Tests of Executive Functioning, Brown ADD Scales, and the Connors' Continuous Performance Test II**

	PADDS/Brown	PADDS/ CPT II
Hit rate / N	25/38	24/38
Percentage Agree	66%	63%

Discriminant validity – Discriminant validity describes the extent to which a test is not correlated with constructs it purportedly is unrelated to. Discriminant Validity was assessed with 137 participants (mean age = 8.05, *SD* = 1.50) of whom 64% were male, 67% were Caucasian, 30% were African American and 3% were Hispanic. In our research, as expected, we found that the overall diagnostic classification using the PADDS system was unrelated to: Full Scale IQ, Verbal IQ, Performance IQ as measured by the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999). Also unrelated were visual or verbal memory, along with indices of attention and concentration, (as measured by the Children's Memory Scale (Cohen, 1997). and the Wide Range Assessment of Memory and Learning II, (Sheslow & Adams, 2003); all *p*s > .05. It should be noted that neither of the memory tests indices for Attention and Concentration correlated significantly with diagnostic classification.

Construct validity- *Executive functions* are defined as controls that allow one to perform complex behaviors that require among other things: planning, attending, organizing input, storing and retrieving information, modulating emotions and sustaining effort. Given that the Target Tests were designed to more fully tap these executive areas, in a separate sample of 35 participants 67% males, 75 % Caucasian and 25% African American (mean age =8.50, SD= 1.7. was rated on the Brown ADD Scales (both teacher and parent versions) and tested with the PADDS Target Tests of Executive Functioning to determine the degree to which these subtests correlate. The Brown ADD Scales are a set of commercially available behavior ratings based on the work of Dr. Thomas. E. Brown and are viewed as sensitive to the core domains of executive operations (Brown, 1996). Table 5.6 presents the results of these analyses. As expected, two of three Target Tests of Executive Functioning correlated with the Brown Teacher rating for diagnosis of primarily inattentive and for combined type.

Parent and Teacher ratings did not significantly correlate with one another. Likewise, Parent ratings did not significantly correlate with any of the Target subtests. The lack of correlation may reflect a degree of bias on the part of parent respondents who may have erred on the side of conservative estimate as they completed the Parent scale. This is the most plausible explanation for these findings given that the children in the sample *were previously* diagnosed with ADHD and had shown significant improvement on medication.

Table 5.6 **Intercorrelation of percentile ranks of PADDS Target Tests of Executive Functioning and Brown ADD Scales (Teacher and Parent-versions)**

	TR%ile	**TS%ile**	**TT%ile**	**BP-Inatt %ile**	**BP-Comb %ile**	**BT-Inatt %ile**	**BT-comb %ile**
TR%ile							
TS%ile	.68**						
TT%ile	.43**	.63**					
BP-Inatt %ile	-.18	.00	.10				
BP-Comb %ile	-.18	.01	.12	.97**			
BT-Inatt %ile	-.35*	-.39*	-.25	.21	.19		
BT-comb %ile	-.36*	-.41*	-.26	.26	.22	.86**	

Note. n = 35.
TR%ile = PADDS – Target Recognition percentile
TS%ile = Target Sequencing percentile
TT%ile = Target Tracking percentile
BP-Inatt%ile = Brown Parent Rating of Inattentive Type
BP-Comb%ile = Brown Parent Rating of Combined Type
BT-Inatt%ile = Brown Teacher Rating of Inattentive Type
BT-comb%ile = Brown Teacher Rating of Combined Type

Chapter 6. Receiver Operator Characteristics of the PADDS

ROC Analysis: The ROC curve is a visual representation of the sensitivity (percentage of true positive that are correctly identified) of a test versus its specificity (percentage of cases without ADHD correctly identified) at each potential cut point for diagnosis. In other words, the ROC provides a comparison of all possible cut-points for diagnostic utility and therefore assists the test developer in selecting and verifying the most appropriate cut point to use to maximize both sensitivity and specificity in determining Positive and Negative Predictive Power (PPP & NPP). From this information, the researcher can then produce likelihood ratios to further improve the diagnostic utility of the test. Table 6.1 shows a graphical representation of the ROC analysis of 725 subjects for the three Target Tests of Executive Functioning.

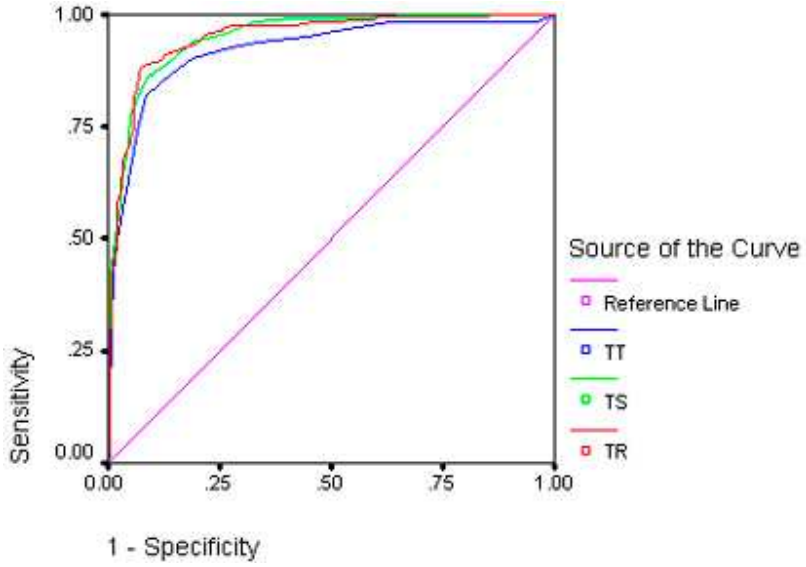


Table 6.1 ROC for the three Target Tests of Executive Functioning.

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error (a)**	**Asymptotic Sig. (b)**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
TR	.950	.009	.000	.932	.969
TS	.951	.009	.000	.934	.969
TT	.921	.013	.000	.896	.946
The test result variable(s): Target Recognition, Target Sequencing, Target Tracking has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.					
a Under the nonparametric assumption					
b Null hypothesis: true area = 0.5					

Using age interval specific referenced cut points, the following decision rule was applied with all 725 subjects: In order to be considered as a classification hit, two of the three Target Tests of Executive Functioning performances must fall within the predicted direction for subjects to remain classified in their initially known group assignment (At least two clinical scores for ADHD classification and at least two non-clinical scores for classification as non-clinical).

Determination of Sensitivity, Specificity, Positive and Negative Predictive Power

Applying the age specific cut scores and decision rule with 725 subjects demonstrated **Sensitivity of .88** and **Specificity of .89** and **Positive Predictive Power of .91 and Negative Predictive Power of .86** indicating exceptional clinical diagnostic utility for screening ADHD and for excluding the over identification of non-ADHD subjects (NPV .86).

Table 6.2 **PADDS Overall Psychometric Performance**

n =725		ADHD	TYP	Totals	PPV =0.91
	Test Positive	347	35	382	NPV =0.86
	Test Negative	48	295	343	Sensitivity =0.88
	Totals	395	330	725	Specificity =0.89

Table 6.3 PADDS cut scores, means, standard deviations, standard errors of measurement, and 95% confidence intervals as a function of sample and age groupings.

				Typical						Clinical		
AGE	**PADDS subtest**	**Cut score**	***M***	***SD***	***SEM***	***95% CI***		**Cut score**	***M***	***SD***	***SEM***	***95% CI***
	TR	>94	103.12	34.23	12.81	78 – 128		≤94	65.72	37.31	13.96	38 – 93
6 yrs	**TS**	>22	24.12	10.83	4.05	16 – 32		≤22	16.54	9.46	3.54	10 – 23
	TT	>6	8.65	3.46	1.29	6 – 11		≤6	4.98	3.11	1.16	3 – 7
	TR	>102	111.75	24.92	9.32	93 –130		≤102	75.68	33.92	12.69	51 – 100
7 yrs	**TS**	>26	30.29	5.2	1.95	26 – 34		≤26	16.15	8.83	3.30	10 – 23
	TT	>6	10.13	3.18	1.18	8 – 12		≤6	4.5	2.43	0.91	3 – 6
	TR	>111	118.41	27.36	10.24	98 – 138		≤111	80.91	31.74	11.88	58 – 104
8 yrs	**TS**	>26	31.39	6.62	2.48	27 – 36		≤26	18.21	9.14	3.42	11 – 25
	TT	>8	11.6	3.53	1.32	9 – 14		≤8	5.82	3.66	1.37	3 – 9
	TR	>113	130.25	14.77	5.53	119 – 141		≤113	83.72	30.93	11.57	61 – 106
9 yrs	**TS**	>28	32.23	6.11	2.29	28 – 37		≤28	19.77	8.75	3.27	13 – 26
	TT	>8	11.91	3.97	1.49	9 – 14		≤8	5.78	3.31	1.24	3 – 8
	TR	>125	134.32	12.03	4.50	125 – 143		≤125	107.63	18.95	7.09	94 – 122
10 yrs	**TS**	>31	34	5.2	1.95	30 – 37		≤31	26.79	6.36	2.38	22 – 31
	TT	>11	13.65	3.54	1.32	11 – 16		≤11	9.13	4.50	1.68	6 – 12
	TR	>128	140.49	8.49	3.18	134 – 147		≤128	98.85	34.68	12.98	73 – 124
11 yrs	**TS**	>32	34.87	6.52	2.44	30 – 40		≤32	27.1	7.48	2.80	22 – 33
	TT	>12	14.8	3.47	1.30	12 – 17		≤12	8.95	4.43	1.66	6 – 12
	TR	>128	137.77	9.77	3.66	131 – 145		≤128	130.07	14.42	5.40	119 – 141
12 yrs	**TS**	>34	36.27	2.49	0.93	34 – 38		≤34	29.79	4.08	1.53	27 – 33
	TT	>14	16.05	2.77	1.04	14 – 18		≤14	10.64	4.80	1.80	7 – 14

Note. Within typical sample, age 6 *n* = 25, age 7 *n* = 32, age 8 *n* = 52, age 9 *n* = 64, age 10 *n* = 79, age 11 *n* = 53, age 12 *n* = 25. Within clinical sample, age 6 *n* = 72, age 7 *n* = 80, age 8 *n* = 95, age 9 *n* = 67, age 10 *n* = 44, age 11 *n* = 22, age 12 *n* = 15. SEM = Standard error of measurement.

Table 6.4. Sensitivity, specificity, positive predictive power, and negative predictive power by age grouping.

AGE	SENS	SPEC	PPP	NPP
6 yrs	.89	.84	.94	.72
7 yrs	.90	.88	.95	.78
8 yrs	.87	.87	.92	.79
9 yrs	.91	.92	.92	.91
10 yrs	.86	.91	.84	.92
11 yrs	.86	.92	.83	.94
12 yrs	.80	.84	.75	.88

Development of Likelihood Ratios and Evidence-based Application in PADDS

Despite the outstanding classification potential demonstrated by the Target Tests of Executive Functioning with known groups, these metrics, when applied against an epidemiological base rate of 4% (as with ADHD) will result in significantly lower predictive power than is implied from their ability to separate groups with 100% known assignment. This illustrates the importance and necessity of establishing a true base rate. Each potential raw score from the Target Tests of Executive Functioning was analyzed to determine the exact percentile rank for both the ADHD and Typical groups that corresponded to that given raw score. This was done to determine the sensitivity and specificity of every possible score for each of the three Target Tests. These sensitivities and specificities were used to develop likelihood ratios from every potential score for all three subtests. These ratios could then be applied incrementally with other data, as judged clinically appropriate, to a Fagan nomogram. These incremental inputs develop a predictive index for or against diagnosis in a given case. This transparent process forces the clinician to evaluate the relative weight of all procedures and to consider the combined evidence accumulated for or against a diagnosis in conjunction with clinical judgment. This is the heart of an evidence-based approach and will constitute a highly standardized approach to ADHD assessment that could help clinicians reduce both over and under identification of ADHD by fine tuning their diagnostic approach over time.

Background Info for Using the Likelihood Ratios

Few, if any, diagnostic tests are accurate enough to "rule in" or "rule out" conditions effectively in all cases.
The best approach is to look at test results as altering the probability of an existent condition (ADHD). To do this requires the estimation of a pre-test probability, (base rate), that will then be adjusted up or down by each of the additional measures or tests results.

This process is referred to as the application of Bayesian logic, which uses an adjustment factor called the **likelihood ratio (LR),** to convert a pre-test probability into a post-test probability.
The upward adjustment of the probability after a positive result is called the LR (+) and is a number > 1, while the downward adjustment after a negative result is the LR (-) and is a fraction < 1.

The LRs are used to assess how good a diagnostic test is and to help in selecting an appropriate diagnostic test or sequence of tests. They have advantages over sensitivity and specificity alone because they are less likely to change with the prevalence of the disorder, they can be calculated for several levels of the test result, most importantly, they can be used to **combine** the results of **multiple diagnostic tests** which then can be used to calculate a post-test probability for a target disorder. The key feature of the likelihood ratio is that it incorporates both the sensitivity and specificity of a given measure, or multiple measures, into a more useful form for making a clinical decision. Making an evidence-based diagnosis, (or considering subsequent decisions for management or referral) depends on comparing this post-test probability with thresholds for further action based on factors such as severity of impairment and the risks of possible side effects, versus the risk of further delays or no treatment at all.

The factors used by the PADDS scoring paradigm were developed using this 2X2 Matrix:
(Sometimes referred to as a "Gold Standard")

- Group **a** : # of subjects ***with*** ADHD, and a ***positive*** Test Score.
- Group **b** : # of subjects ***without*** ADHD, and a ***positive*** Test Score.
- Group **c** : # of subjects ***with*** ADHD, and a ***negative*** Test Score.
- Group **d** : # of subjects ***without*** ADHD, and a ***negative*** Test Score

Table 6.5 Gold Standard 2X2 Matrix

		Condition Present	Condition Absent	Totals
Target Test Score Result	(Result +)	a	b	a+b
	(Result -)	c	d	c+d
		a+c	b+d	a+b+c+d

Using the 2X2 matrix in Table 6.5 we calculate sensitivity and specificity using these formulas

Sensitivity is the proportion of patients ***with*** ADHD who have a ***positive*** test.

Sensitivity = a / (a + c)

Specificity is the proportion of patients ***without*** ADHD who have a ***negative*** test.

Specificity = d / (b + d)

Calculate the Ratios:

Likelihood ratio (LR+) = sensitivity/(1-specificity) = (a/(a+c))/(b/(b+d))

Likelihood ratio (LR-) = (1-sensitivity)/specificity = (c/(a+c))/(d/(b+d))

The reference information provided above was adapted from the following Web resources for EBA: (http://www.childrensmercy.org/stats/category/DiagnosticTesting.asp), & (Centre for Evidence-based Medicine (nd). *Likelihood Ratios.* Oxford-Centre for Evidence-based Medicine, http://www.cebm.net/likelihood_ratios.asp

Chapter 7. Pediatric Attention Disorders Diagnostic Screener (*PADDS*)

Advantage of the *PADDS* System

The PADDS system was developed by a pediatric psychologist with ADHD experience spanning 15 years and personal completion or supervision of over 6000 individual ADHD evaluations. This system was developed by a clinician for use by clinicians. Thus several practical issues were of primary importance:

1. The Target Tests of Executive Functioning tasks are enjoyable and engaging. Most of the children polled during the normative process reported them as "fun but hard." Clinician's frequently observe a wide range of escape behaviors elicited by children in response to completing commonly used CPTs. These off-task behaviors, while of observational importance, can be produced in a wide range of children for various reasons unrelated to ADHD. Thus, these negative reactions can be a critical source of error. Additionally, since computer measures are often used as screening tools and presented early on in the evaluation process, unduly frustrating children can lead to compromised rapport, invalid test results and reduced effort for subsequent tasks.

2. Both ADHD and matched Control groups were normed allowing for Evidence-based Analysis against the population base rate as well as standard score comparison made to the typical or non-ADHD reference group. Beyond improving diagnostic accuracy, the Evidence-based Process used by the ***PADDS*** system allows the clinician to evaluate their own approach to assessment and to refine procedures in response to their ongoing practice.

3. The Target Tests of Executive Functioning tasks were designed from current research (Biderman et al., 2004; Brown, 2002, 2000,1999; Barkley, 1997,1998; Denckla, 1996) indicating the need to assess greater aspects of children's executive functioning and working memory. By tapping these skills the Target Tests of Executive Functioning subtests were able to demonstrate (with 725 children age 6 to 12 split evenly between highly defined ADHD and Typical reference groups) highly acceptable rates of classification: Sensitivity .88, Specificity .89, Positive Predictive Power of .91 and Negative Predictive Power of .86.

4. The Target Tests of Executive functioning can be completed in approximately 30 minutes and the entire system can be effectively administered and scored/reported in approximately 45 minutes. This process combines several highly effective innovative techniques (CADI, Target Tests of Executive Functioning, Evidence-based analysis and Report, all combined with the clinician's expertise) that can save time and money while standardizing the ADHD process and reducing the potential for both under and over identification of ADHD.

DEVELOPMENT OF THE *PADDS*

The PADDS was developed in response to clinical observation in three key areas:

1. Researchers and authorities on ADHD pointed out the weak Negative Predictive Power (i.e., good performance actually rules out attention disorders) of CPTs and numerous neuropsychological measures traditionally used to evaluate ADHD in light of the base rate (conservative estimate of 4%), (Barkely, & Grodzinksi, 1994; Ellwood, 1993; Matier-Sharma, et al., 1995). For example, a given test with 90% sensitivity and specificity applied to an evidence-based analysis calculating probability for or against a diagnosis at a base rate of 4% will produce a result with a predictive index or post-test probability of merely 25% (Dumont, Willis & Stevens, 2001; Centre for Evidence-based Medicine (nd).) If a second measure with 90 % sensitivity and specificity were added, the post-test probability would increase to 74%. This is hardly enough to warrant a clinical diagnosis. Thus, the variable nature of ADHD and varying base rates will require that multiple levels of information be collected from well-developed sources with strong psychometric evidence if a reliable diagnosis is to be made.

2. ADHD is the most commonly diagnosed childhood psychiatric disorder affecting school-age children with estimates ranging from 3 to 12 percent (American Academy of Pediatrics, 2000; American Psychiatric Association, 1994). Concern has been expressed for the significant number of children this prevalence suggests coupled with reportedly wide variations in clinical practice and research approaches. These concerns point to the need to develop pragmatic assessment tools and approaches for use in the major systems of service entry. Specifically of importance are assessment approaches that can be used within primary care settings, schools, and clinics as well as within the private sector.

3. Other comorbid conditions often occur with ADHD. These conditions may include, but are not limited to, Mood Disorders, Anxiety Disorders, Disruptive Behavior Disorders, and Learning Disorders. Bipolar Disorder is also becoming increasingly recognized by some professionals within adolescent populations. These facts highlight the importance of considering other conditions that may mimic or exacerbate the presence of ADHD. The following list of prevalence ranges for ADHD and Comorbid conditions was adapted from the following source: Pliszka, S. R., Carlson, C. L., & Swanson, J. M. (1999). ADHD with Comorbid Disorders: Clinical assessment and management. New York, N.Y.: The Guilford Press.

***Table 7.1 Prevalence* of Comorbidities**

Primary Diagnosis / Secondary Diagnosis	Range of Prevalence
ADHD/ODD-CD	15% to 61%
ODD-CD/ADHD	35% to 87%
ADHD/Depression	0% to 38%
Depression/ADHD	0% to 57%
ADHD/Anxiety	23% to 30%
Anxiety/ADHD	9% to 35%
ADHD/LD (Reading, Spelling, & Math)	7% to 60%
ADHD/OCD	6% to 33%

Other related conditions needing assessment/ consideration include:
Neurological Impairment PDD/Autistic Spectrum Disorders Developmental disabilities

The Development and Validation of Diagnostic Tools Grounded in the Basic Sciences

During the 1998 NIH Consensus Development Conference, it was determined that development and validation of diagnostic tools grounded in the basic sciences was warranted. Consensus statements indicated a need to develop more objective assessment tools, rating scales and/or diagnostic interviews that map onto basic underlying processes as well as a need to supplement behavioral assessment tools with improved cognitive and/or neuropsychological measures. Many of the currently utilized assessment measures and treatments for ADHD are incompatible with the time constraints of a primary care setting. Clinicians have voiced concerns regarding adequate preparation and training along with the ambiguous billing/coding procedures currently approved. There is also a dearth of practical decision-making tools for medication monitoring, differential diagnosis, and determining type of referral service most appropriate to differing levels of severity. Consequently, there is a great need for the development of practical, reliable, and valid procedures to be used in primary care settings to identify and manage ADHD symptoms, as well as to distinguish appropriate referral needs (NIH conference, 1998).

Recent developments within the field of ADHD have increasingly pointed to the need to evaluate the various *executive operations* and *working memory* of children suspected of Attention Disorders. (Biderman, et al., 2004; Brown, 2002, 2000,1999b; Barkley, 1997, 1998; Denckla, 1996.) Generally, *executive functions* are defined as controls that allow one to perform complex behaviors that require among other things: planning, attending, organizing input, storing and retrieving information, modulating emotions and sustaining effort.

While the identification of significantly hyperactive children can be simple, the evaluation of children who only display difficulty in learning or in completing activities that are more complex is where the greatest need for improvement lies. Difficulties in these **Executive Processes** (**planning, attending, organizing input, storing and retrieving information, modulating emotions and sustaining effort**) exemplify the complaints of teachers and parents.

Situations that require an orchestration of these abilities are often most problematic for ADHD students. Parents will often report confusion at their child's ability to play video games, watch television or engage in favorite activities. However, on closer inspection, these activities often do not produce the same demands as found within the classroom. These favorite activities are often over learned, fast paced, and allow the child to move freely in and out of the activity. Changing the structure of these activities (implementing learning demands) can quickly produce frustration in ADHD children.

Conceptual and Technical Issues Relevant to the Development of the Target Tests of Executive Functioning (TTEF)

The development of the Target Tests of Executive Functioning (TTEF) was stimulated from several areas of interest. Recently, multiple researchers have called for the inclusion of the evaluation of executive operations to improve upon standards aimed at valid ADHD assessment (Biderman et al., 2004; Brown, 2002, 2000,1999b; Barkley, 1997, 1998; Denckla, 1996). However, this inclusion has been more difficult to do utilizing pencil and paper tasks than it is to use them for the assessment of domain specific areas of function (Language, Reading & Writing skills). The complexity of the neuroanatomical substrates and constructs of attention and executive control suggests that no single measure will address all facets of attention and executive control (Denckla, 1994; Riccio, Reynolds, & Lowe, 2001).

Thus, the Target Tests of Executive Functioning subtests include several differently designed tasks presented via computer aimed at providing objective assessment of a subject's ability to employ various but not all executive processes: (**planning, attending, organizing input, storing and retrieving information, modulating emotions and sustaining effort**). These Task demands were selected because they have been consistently identified as areas of difficulty for children known to have ADHD. Furthermore, these areas were likewise presented in the two models of attention and executive control that were given special consideration during the development of the specific Target Subtests.

The first model considered in the development of the Target Tests of Executive Functioning is the integrative theory of the prefrontal cortex function as outlined by Earl Miller and Jonathan Cohen (Miller &Cohen, 2001). In this integrative theory, the authors argue that cognitive control is the primary function of the Pre-Frontal Cortex (PFC). They assert that control is implemented by increasing the gain or recruitment of sensory or motor neurons that are engaged by task- or goal-relevant elements of the external environment. Specifically, they suggest that the PFC serves to exert primary control in cognition. Thus, the PFC sets the stage for more complex mental and behavioral operations by selecting what must be attended while recruiting wider neural involvement. Miller and Cohen consider that the effective control of selective bias or selected stimuli is guiding the flow of neural activity along pathways that establish the proper mappings between inputs, internal states, and outputs needed to perform a given task. To illustrate their case Miller and Cohen use earlier theory of visual attention which conceptualizes perception of a visual scene in terms of competition among multiple representations - such as colors, individuals, or objects that act to 'bias' this competition in favor of certain selected features or representations.

For example, if a parent loses a small child in a public setting he or she will select specific (biased) features of the child's physical appearance and clothing to track within a crowd.
This bias will produce a gain or recruitment in neurons responsive to these selected features increasing the likelihood that this information will become assessable to a wider range of neural activity. According to Miller and Cohen, this selective attention mechanism is in fact just a special case of cognitive control whereby the PFC exerts control over inputs, outputs, memory and emotions. The implication of this view is that cognitive control can be applied to any situation where selected stimuli or information can be used to aid task completion and thus becomes the crucial glue required when employing an array of processing tasks such as exerting inhibitory control, in utilizing selective attention or decision making and in the employment of memory skills.

Of equal importance to the conceptual basis of the Target Tests of Executive Functioning subtests development is the consideration of the unifying theory of behavioral inhibition forwarded by renowned ADHD researcher Dr. Russell Barkley (Barkley, 1997). The major premise gleaned from this theory highlights the importance of the PFC while suggesting that the major deficit encountered by ADHD subjects is not necessarily poor attention or memory skills but rather inefficient ability to employ inhibitory control. It is this ability to exert inhibitory control that allows the expression of complex activity. In this model the ability to direct thought or action requires inhibiting unrelated or insignificant material. This material can take the form of internal thoughts, emotions, or the intrusion of unrelated factors in the external environment. To the extent these forces can be controlled/inhibited, then more complex behavior becomes possible. Thus, ADHD is considered as a primary problem of starting and maintaining inhibitory control. The inefficient use of the executive system is seen as a by-product of a given subject's inability to exert or maintain inhibitory control. The model of behavioral inhibition forwarded by Dr. Barkley has been reprinted here in diagram 1 with permission (Barkley R.A., 1997).

A review of this schematic shows the overarching importance of inhibitory control which allows the expression of the executive system and evenutally leads to behavioral products.

It is Barkley's model of behavioral inhibition which emphazies the abilities to inhibit prepotent responses to stop a response and to mitigate intereference combined with Miller and Cohen's view of cognitive control as hinging on selective bias and neural recruitment that has served as the basis for the selection of stimuli and task demands employed by the Target Tests of Executive Functioning subtests. The unifying theme used from both models is the ability to select/detect important information while inhibiting non-relevant or competing material in the service of the employment of the executive processes. Each of the three Target Subtests were designed to force these controls while placing demands on various executive functions. It was hypothesized that such demands would tax both the inhibitory or cognitive controls for ADHD subjects thus producing inefficient use of the executive functions as tapped by the Target Tests of Executive Functioning subtests. Each subtest is later reviewed with relevant discussion regarding the inhibitory and executive controls required.

Final consideration was placed on practical issues regarding the need to develop tasks that were primarily not language based, that lended themselves to cross-cultural uses and that remained as simple or parsimonious as possible. In selecting stimuli and task features, the following list of typical classroom demands were also considered.

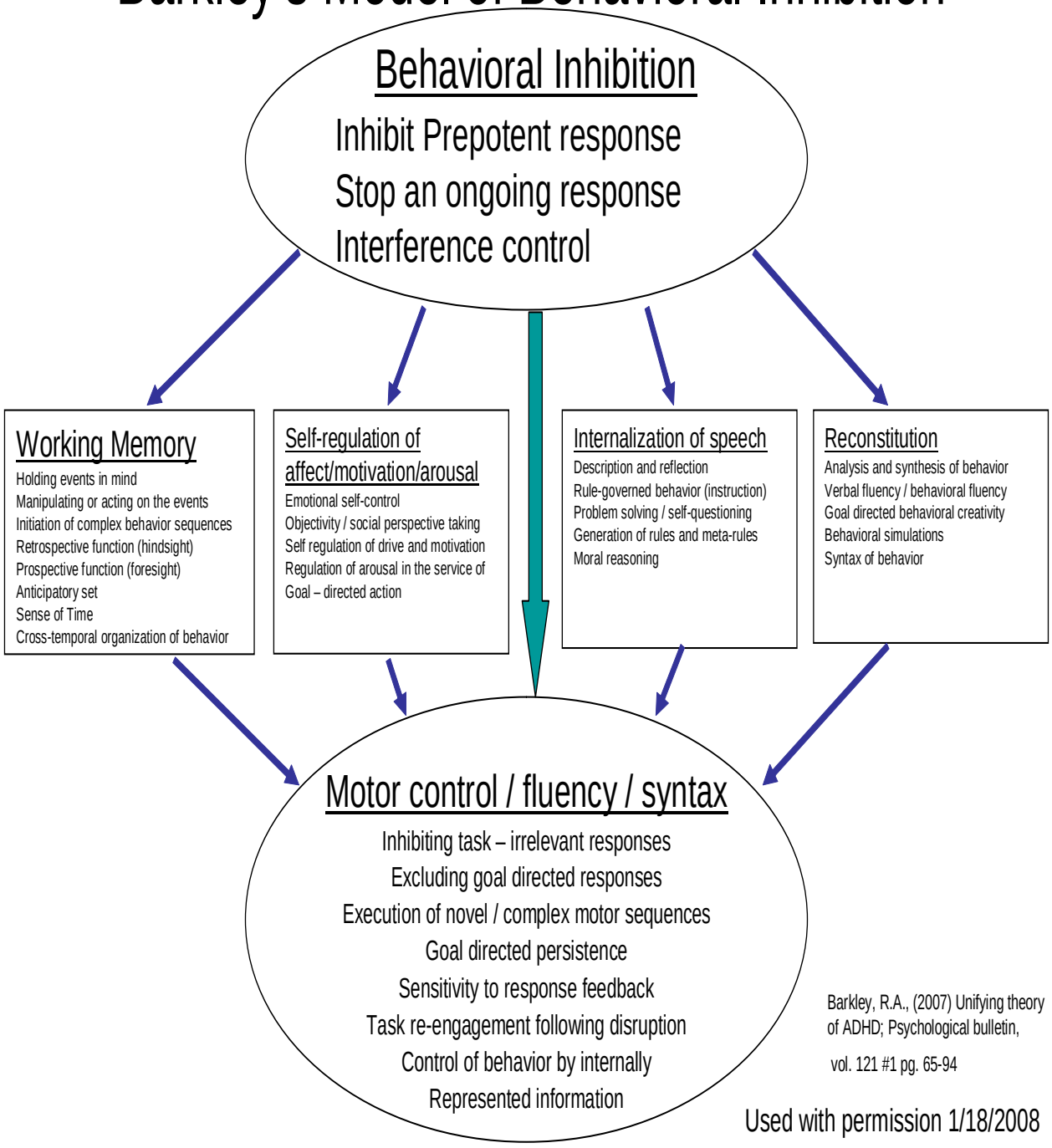
Basic Demands of the Classroom

Attending to instruction
Assimilating information
Accommodating information
Organizing, sequencing, manipulating information
Monitoring emotional activity
Formulating a plan of action
Implementing the plan

Other Factors

Time pressure
Distractions
Preparedness

Barkley's Model of Behavioral Inhibition



Barkley, R.A., (2007) Unifying theory of ADHD; Psychological bulletin, vol. 121 #1 pg. 65-94

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Demands Basic To All Three Target Subtests

Subject is preloaded to search and detect relevant information

Subject must inhibit irrelevant stimuli

Subject must use a metacognitive strategy forcing the use of internal diaglogue

Subject must wait a short lag time before employing task demands

Subject must inhibit while formulating a plan of action

Subject must formulate, reconstitute and execute plans in the face of changing or novel stimuli

Subject must be sensitive and responsive to feedback

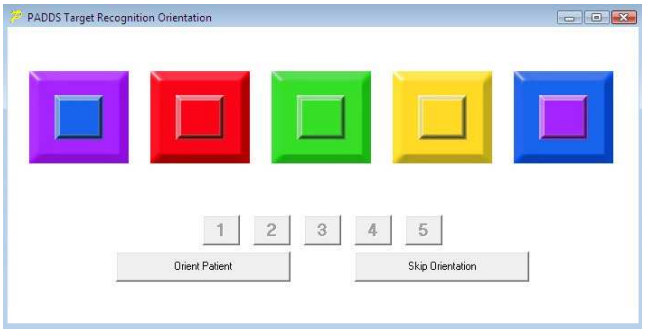
Subject must be able to do the above to discover that there are recurrent patterns presented in the task demands

Subject must employ motivational and emotional control in the service of ongoing activity.

Subject must evaluate outcome against plans, intentions and feedback to direct future efforts accurately.

Task Specific Demands:

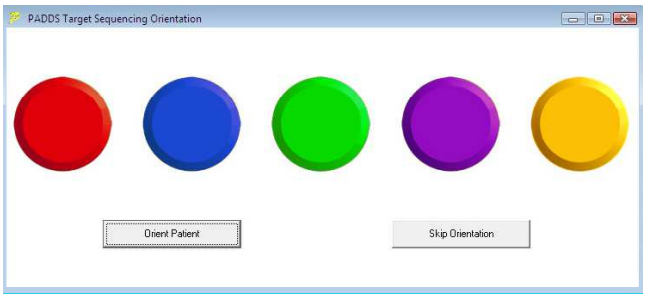
Target Recognition- Target Recognition presents five large colored squares with smaller squares inside them. Below the squares are five small boxes labeled 1 thru 5. The colored squares simultaneously blink on and off the screen at 1 ½ second intervals for a total of 153 presentations. The child is taught a strategy to read from left to right and to count the number of large squares with small squares inside them of the same color and then to click on the corresponding number in the small box below labeled 1 thru 5.



Specific requirements for task completion include among others:

Attention to detail, avoiding distraction, maintenance of effort or persistance, holding information in mind through the use of metacognition, feedback, and emotional regulation while developing a response to changes in novel stimuli.

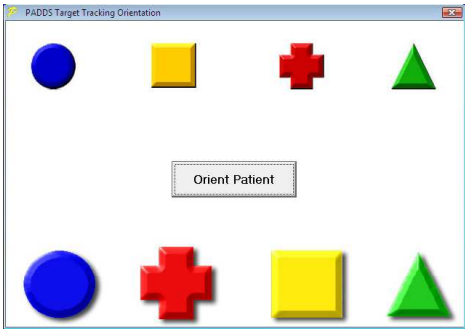
Target Sequencing- Across 39 trials five large colored circles are presented. A small square moves through them starting in the middle or at either of the end circles. The child is taught to attend only to circles when the square matches it in color and to say the name of the color to him or her self while at the same time disregarding the circles that have squares with different color. Once the squares have moved through all five circles the child clicks on each of the circles that had matching colors in the order that they stated to him/herself. First match first, second match second and last match last.



Specific requirements for task completion include among others:

Attention to detail, avoiding distraction, maintenance of effort or persistance, holding information in mind through the use of metacognition, feedback, and emotional regulation during the initiation and follow through of a response to complex sequences while remaining sensitive to changes in novel stimuli.

Target Tracking- Through 20 trials this subtest presents four colored shapes at the top and bottom of the screen. The computer creates one move at a time two and three step moves that the child must repeat/recreate in the same order seen. First move first, second move second and last move last.



Specific requirements for task completion include among others:

Attention to detail, maintaining divided attention, holding information in mind, maintenance of effort or persistance and emotional regulation while completing complex two and three step instructions.