DOI: 10.5455/BCP.20111004014003

Behavioral Rating Inventory and Laboratory Tests Measure Different Aspects of Executive Functioning in Boys: A Validity Study

Emel Erdogan Bakar[1], Yasemen Isik Taner[2], Azime Sebnem Soysal[3], Sirel Karakas[4], Atilla Turgay[5]

ÖZET:

Davranış derecelendirme envanteri ve laboratuvar testleri erkek çocuklarda yönetici fonksiyonların farklı yönlerini ölçmektedir: Bir geçerlik çalışması

Amaç: Bu çalışmanın amacı yönetici işlevleri (Yİ) ölçme açısından günlük yaşamdaki davranışları değerlendiren ekolojik bir test ile laboratuvar testleri ile arasındaki örtüşmeyi incelemek, ekolojik testin Dikkat Eksikliği Hiperaktivite Bozukluğunun (DEHB) tanısında kullanılabilirliğini incelemektir.

Yöntem: Örneklem ilaç almamış ve kliniğe ilk kez başvurmuş olan, sadece DEHB tanısı olan ve alt tiplere göre ayrışmış bulunan (dikkat dağınıklığının önde geldiği grupta 22 çocuk, hiperaktivite/dürtüselliğin önde geldiği grupta 17; birleşik grupta 22 çocuk). Sağlıklı kontrol grubu yaş açısından eşleştirilmiş 19 erkek çocuktan oluşmuştur. Yİ'nin günlük yaşamda derecelendirilmesi için Davranış Derecelendirme Envanterinin (Behavioral Rating Inventory of Executive Functions: BRIEF) öğretmen ve ebeveyn formları kullanılmıştır (BRIEF-Ö ve BRIEF-E). Laboratuvar testleri Stroop Testi, Wisconsin Kart Eşleme Testi ve Raven Standart Progresif Matrisler Testinden oluşmuştur.

Bulgular: DEHB grubunda, BRIEF'in faktör yapısı davranışsal düzenleme göstergesi ve üstbiliş göstergesinden oluşmuştur (açıklanan varyanslar BRIEF-Ö için %70.07 ve BRIEF-Ö için %72.29). Yönetici işlevleri ölçen ekolojik ve laboratuvar testleri aynı faktör altında yer almamıştır. Çok Değişkenli varyans analizi BRİEF puanları açısından grup etkisinin anlamlı olduğunu ancak altgruplar arasında anlamlı fark olmadığını ortaya koymuştur. BRIEF puanları ile yapılan lojistik regresyon analizinde duyarlık %90.20, özgüllük %63.20 olarak bulunmuştur.

Tartışma: Çalışma Yİ'ye özel bilişsel özellikleri ve bunların davranışsal göstergelerini belirleyebilmek için ilgili özelliklerin bir arada taranmasını sağlayan ekolojik ve laboratuvar testlerinin kullanılması, bilgilerin hem öğretmen hem de ebeveynden ayrı ayrı alınması gerektiği ortaya konmuştur. BRIEF'in ve laboratuvar testlerinin ölçtüğü Yİ'nin aynı özellikler kümesinden oluşmadığına gösteren sonuçlar BRIEF'in Türk kültürü üzerindeki geçerliğine de ışık tutmaktadır.

Anahtar sözcükler: BRIEF, dikkat eksikliği hiperaktivite bozukluğu, yönetici işlevler, laboratuar testler, ekolojik testler

Klinik Psikofarmakoloji Bülteni 2011;21(4):302-16

ABSTRACT:

Behavioral rating inventory and laboratory tests measure different aspects of executive functioning in boys: a validity study

Objective: The aim of this study is to investigate the correspondence between an ecological test of everyday behavior and laboratory tests of executive functions (EF) and to analyze whether the prior can be used in the diagnosis of Attention Deficit Hyperactivity Disorder (ADHD).

Method: Sample consisted of 61 unmedicated first referral males who were diagnosed only with ADHD and were classified into subtypes (predominantly inattentive subtype: n= 22; predominantly hyperactive/impulsive subtype: n= 17; combined subtype: n= 22). Healthy control group consisted of age-matched healthy males (n= 19). Rating of everyday behavior of EF was performed using both the teacher and parent forms (BRIEF-T and P, respectively) of Behavioral Rating Inventory of Executive Functions (BRIEF). Laboratory tests consisted of the Stroop Test, Wisconsin Card Sorting Test and Raven Standard Progressive Matrices.

Results: In the ADHD group, factor structure of BRIEF consisted of behavioral regulation index and metacognition index (explained variances: 70.07% in BRIEF-T and 72.29% in BRIEF-P). In no case did the laboratory and ecological measures of EF took place under the factors that the BRIEF scores loaded. Multivariate analyses of variance showed a significant effect of group but not of subgroup on BRIEF scores. Logistic regression analyses showed a sensitivity of 90.20% and specificity of 63.20% of BRIEF scores.

Discussion: A multi-trait and multi-method approach, covering both the laboratory tests and ecological rating scales and both the teacher and parent informants should be used in order to capture the specific cognitive processes of EF and their behavioral manifestations. The findings showing the dissimilarity between the EF that BRIEF and the laboratory tests measure and shed light on the validity of BRIEF on the Turkish culture.

Key words: BRIEF, attention deficit hyperactivity disorder, executive function, laboratory tests, ecological tests

Bulletin of Clinical Psychopharmacology 2011;21(4):302-16

[1]Ufuk University, Department of Psychology, Ankara-Turkey
[2]Gazi University, Department of Child Psychiatry, Ankara, Turkey
[3]Gazi University, Department of Pediatric, Ankara-Turkey
[4]Hacettepe University, KOSGEB Technology Development Center, Ankara-Turkey
[5]University of Toronto, Department of Family and Community Medicine, Toronto-Canada

Yazışma Adresi / Address reprint requests to: Emel Erdoğan Bakar, Ufuk University, Department of Psychology, Ankara-Turkey

Elektronik posta adresi / E-mail address: eerdoganbakar@gmail.com

Gönderme tarihi / Date of submission: 24 Mart 2011 / March 24, 2011

Kabul tarihi / Date of acceptance: 04 Ekim 2011 / October 04, 2011

Bağıntı beyanı:
E.E.B., Y.I.T., A.S.S., S.K., A.T.: Yazarlar bu makale ile ilgili olarak herhangi bir çıkar çatışması bildirmemişlerdir.

Declaration of interest:
E.E.B., Y.I.T., A.S.S., S.K., A.T.: The authors reported noconflict of interest related to this article.

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a syndrome of childhood onset that is defined in the Diagnostic and Statistical Manual of Mental Disorders (1) and International Classification of Diseases (2). ADHD is characterized by symptoms of attention deficit (AD) and/or hyperactivity/impulsivity (HI). ADHD also includes functional impairment in social, academic, and/or occupational settings.

All patients with ADHD suffer from significant executive function (EF) impairment (3,4). Children with ADHD who displayed EF impairment in a laboratory setting also displayed poor task performance in a real-life setting when compared with control subjects without executive dysfunction (EdF) (5,6). Children with EdF were found to be at a greater risk for poor academic outcomes (e.g., learning disabilities or grade repetitions) (7). Not only boys but also girls with ADHD were found to have many EF impairments compared to normal controls; 5-year follow-up showed a persistence of many of the previous EF impairments (8). These findings culminated in neuropsychological theories, which suggest that symptoms of ADHD arise from a primary deficit in executive functions (EF) (3,9,10).

There are conflicting findings in the literature with regard to EdF in ADHD. A meta-analysis of 83 studies on children and adolescents with and without ADHD (11) found that only a relatively small percentage of ADHD cases suffered from EF impairment. Of those who did show such impairments, the strongest and most consistent effects were obtained on measures of response inhibition, vigilance, working memory and planning. In another study, boys were found to display deficits in interference control, inhibition of an ongoing response, planning, and letter fluency (12); however, none of these deficits remained after controlling for age and IQ.

The conflicting interpretations on EF with regard to ADHD may be due to a host of factors, one of which may be the nature of the psychometric tool used in measuring EF. A psychometric device that is often used in applied settings is the Behavior Rating Inventory of Executive Function (BRIEF) (13,14). Gioia et al. (2008) claim that EF consists of a collection of processes that are ultimately essential for setting goals and solving problems (15). Accordingly, the BRIEF was designed as a test of complex, every-day or real-world problem-solving skills, and adaptive behavior (16-20).

Rating EF based on integrated aspects of complex everyday problem solving skills may have high ecological validity (18,21). However, this approach usually results in low experimental control and process specificity, and thus a low internal validity (18). A second group of measurement devices is the "laboratory" or "performance-based" tests. The laboratory tests for EF do not evaluate complex, everyday behavior; therefore, they have low ecological validity (16). However, since they measure limited but relatively well-defined aspects of a specific type of behavior, they have high internal validity.

EF is conceptualized as an umbrella term, consisting of a collection of interrelated cognitive functions classified into five domains (22): inhibition, planning, set-shifting (flexibility), working memory, verbal fluency. The Hybrid Neuropsychological Model of Executive Functions (3) reduces representations of EF to inhibition (inhibition of a prepotent response, inhibition of an ongoing response, and interference control) (23-25). The extent to which the ecological tests that rate everyday behavior capture the processes that are defined in the conceptual framework of EF is an issue to be considered (3,22-26).

On the other hand, the Stroop Test (STP) (27) is a widely used laboratory device that measures one type of inhibition in EF, that of interference control (3,26). Interference control is measured in the test via the ability to inhibit the response tendency for a habitual/automatic act and to make, in place, an alternative task-relevant response (28-30). A second type of inhibition in the realm of EF is the ability to inhibit an ongoing response (3,26), is widely measured using the Wisconsin Card Sorting Test (WCST) (31-33). The specific type of inhibition that the test measures is the capacity for flexibility, specifically the capacity to shift to another response alternative when the test-taker is informed that the emitted response is no longer correct (34,35). As such, the WCST also measures working memory, another essential element of EF (36,37). The Raven Standard Progressive Matrices (RSPM) (38,39) measures analytical reasoning and problem solving and as such, is considered a culture-fair test of general ability (40). However, since test performance depends on the detection of increasingly complex classification principles both within and between subtests, it is also a test of working memory (41-44). (For reviews, see 40,45,46).

The present study investigated the correspondence between the ecological measure of EF (BRIEF) and measures from three laboratory tests (STP, WCST, RSPM) that are used for assessing specific domains of EF, namely inhibition and working memory. The aim of the study was to show the extent to which the BRIEF scores overlap with those on interference control (STP), inhibition of an ongoing response (WCST), and working memory (WCST and RSPM). A second aim of the study was to investigate whether scores on the BRIEF can be used to predict membership in clinical and control groups and membership in the subtypes of ADHD. These approaches serve to demonstrate the validity of the BRIEF in the Turkish culture; hence, the present study is a validation study of this clinical scale.

METHODS

Participants

The study was conducted on a total of 80 male children. Participants were in the 77-137 months of age range (Table 1) and were attending grades 1-5 of primary school. All were at the typical age ranges for given grade levels; i.e., 6 years of age for Grade 1, 7 years of age for Grade 2, 8 years of age for Grade 3, 9 years of age for Grade 4, 10 years of age for Grade 5. Children who were younger or older than the typical age for a given grade level were not included in the sample.

Table 1: The Number of Participants and Ages in Subtypes of ADHD and the Comparison Group.

		Age (months)	
Groups	N	Range	Mean and Standard Error
ADHD-AD	22	77-137	104.18±4.32
ADHD-HD	17	82-131	104.59±3.31
ADHD-C	22	80-132	103.77±2.95
Control Group	19	80-136	103.63±3.87
TOTAL	80	77-137	

Cases were clinically referred or were recruited from schools via parent support groups. Nineteen children were in the healthy control (for brevity, hereafter named as the control group) and 61 were in the ADHD group. The diagnostic procedures were conducted by a child psychiatrist in the Department of Psychiatry according to the criteria that are described in the Diagnostic and Statistical Manual of Mental Disorders (1). The children diagnosed with ADHD were classified into subtypes of ADHD according to the diagnostic criteria listed in the DSM-IV and in the Schedule for Affective Disorders and Schizophrenia for School-Aged Children-Present and Lifetime Version (K-SADS-PL) (47). In addition, the latter tool was used to rate symptom intensity. In both tools, the informants were both of the parents. In the ADHD group, 22 were in the subtype with predominantly attention deficit (ADHD-AD), 17 were in the subtype with predominantly hyperactivity and/or impulsivity (ADHD-HI) and 22 were in the combined subtype where there was both AD and HI (ADHD-C).

The cases in the ADHD group were not on any medication and were first time referrals. Exclusion criteria for both the clinical and the control group were a history of psychiatric and/or neurological dysfunction other than ADHD and in the clinical group, use of any drugs that might alter cognitive functioning, uncorrected visual and/or auditory impairments, and Full Scale WISC-R IQ below 90 or above 129. Due to the effect of depression on cognitive processing (48), cases with a depression score over 19 (cutoff for Turkish norms by Öy, 1991) (49) in the Kovacs Depression Inventory for Children (50,51) were not included in the sample. Similarly, cases with an anxiety score over 45 (cutoff for Turkish norms by Özusta, 1995) (52) in the Spielberger State-Trait Anxiety Questionnaire (53) were also not included in the sample.

The nature of the study was fully explained to the parents. Volunteering parents signed the Informed Consent Form according to the institutional regulatory criteria. Oral consent from the children was another requirement for participation. The study was approved by the Ethical Committees of two universities (Hacettepe University and Gazi University, Ankara) and abided by the Declaration of Helsinki and the document of the Ministry of Health on principles of clinical research.

Assessment Devices

The dependent variables of the study were derived from the BRIEF and three laboratory tests: the STP, the WCST, and the RSPM

Behavior Rating Inventory of Executive Function (BRIEF). The BRIEF is a parent and teacher report and is

designed to measure the multidimensional nature of EF based on everyday behavior (13,14).

The Teacher Form (BRIEF-T, briefly T Form) and the Parent Form (BRIEF-P, briefly P Form) are each composed of 86 items. The items are grouped under 8 scales that claim to assess different domains of EF. The scales in turn contribute to two supra-ordinate indices: The Behavior Regulation Index (BRI) and the Metacognition Index (MI).

The BRI index is a composite of the following three Scales: Emotional Control (the ability to modulate emotional responses appropriately), Shift (the ability to move freely from one situation, activity, or aspect of problem to another as the situation demands, the ability to solve problems in a flexible way), Inhibit (the ability to control impulses and to stop own behavior at the proper time). The MI index is a composite of the of the following five Scales: Plan/Organize (the ability to anticipate future events, set goals, develop appropriate steps ahead of time, carry out tasks in a systematic manner, understand and communicate main ideas), Working Memory (the ability to simultaneously hold and process information in short-term memory), Initiate (the ability to begin a task or activity and to generate ideas independently), Organization of Materials (ability to maintain relevant parts of the environment in a systematic manner) and Monitor (ability to check work, assess performance, and keep track of own and others' efforts). A composite of BRI and MI renders the Global Executive Composite (GEC).

In filling out the BRIEF forms, the parent or the teacher indicates whether the child exhibits problems pertaining to the behavior pattern that a given item describes. Behavior, which is described as "Never", "Sometimes" or "Often" are scored as "1"," 2," or "3", respectively. Hence, high scores on BRIEF indicates poor executive functioning (Gioia et al., 2000a and b).

StroopTest(STP). This widely used neuropsychological test (30) is a laboratory measure of interference control (3,26,28,54,29,30). STP has different versions (40,45). The version that the present study used consisted of a combination of the original Stroop Test (27)(STP-1 to STP-3, STP-5) and the Victoria version (45) (STP-4). The combined version of STP consisted of the following sequence of subtests: Reading color names printed in black (STP-1), reading color names printed in incongruent colors (STP-2), naming colors of circles (STP-3), naming colors of neutral words (STP-4), naming colors of incongruent words (e.g. the word "red" printed in blue) (STP-5). The combined version of Stroop had previously been studied extensively on Turkish samples (for a review see 55-59). The scores consisted of the time to complete each of the subtests.

Wisconsin Card Sorting Test (WCST). This laboratory test measures the ability to inhibit an ongoing response, a second type of inhibition (3,26). In WCST, the test-taker is asked to find the correct matching category on the basis of feedback that is provided on response accuracy, to maintain the response set so long as it is valid but to inhibit this response and to flexibly shift to another matching category when the response is no longer correct (31-33).

WCST contains 4 stimulus cards and 120 response cards. There are one to four figures (plus, circle, star or triangle) on each card and these can be in one of four colors (red, green, blue, or yellow). The task is to match each response card with one of the stimulus cards according to the criterion (color, shape, or number of items) which the participant thinks is currently valid. Immediate feedback is provided by the testers on response accuracy. The matching rule changes after 10 accurate responses (i.e. the same response then becomes inaccurate), and the participant has to find the new rule and make the corresponding response. WCST renders 13 scores (Table 2, for further information see 32) that are derived/calculated from accurate or inaccurate responses (32,33). WCST had been studied extensively with respect to its psychometric properties on Turkish samples (for a review see 55,60,61).

Raven Standard Progressive Matrices (RSPM). This laboratory test measures analytical reasoning and problem solving and is considered a culture-fair test of general intelligence (38,39). The test consists of five subtests (Sets

Table 2: The scores of the Wisconsin Card Sorting Test.

WCST 1	Total number of responses
WCST 2	Total number of incorrect responses
WCST 3	Total number of incorrect responses
WCST 4	Number of categories completed
WCST 5	Total number of perseverative response
WCST 6	Total number of perseverative errors
WCST 7	Total number of nonperseverative errors
WCST 8	Percentage of perseverative errors
WCST 9	Number of responses to complete the first category
WCST 10	Number of conceptual level responses
WCST 11	Percentage of conceptual level responses
WCST 12	Failure to maintain set
WCST 13	Failure to maintain set

Table 3: Mean and Standart Error Score of BRIEF in ADHD and the Comparison Group

	ADHD-AD (N=22)	ADHD-HD (N=17)	ADHD-C (N=22)	ADHD (N=61)	COMPARISON (N=19)
A: TEACHER FORM					
BRI Scale Scores					
Inhibit	20.00±1.29	22.29±1.02	23.91±1.02	22.05±0.68	15.42±1.32
Shift	18.23±0.88	19.82±1.06	19.00±0.63	18.95±0.49	16.05±1.19
Emotional Control	16.73±0.92	18.76±1.00	18.55±0.85	17.95±0.54	14.26±1.05
MI Scale Scores					
Initiate	14.73±0.71	15.12±0.79	15.73±0.62	15.20±0.40	11.16±0.89
Working Memory	21.95±0.72	21.82±0.88	23.32±0.90	22.41±0.48	15.68±1.32
Plan /Organize	22.32±0.88	22.29±1.17	23.36±0.75	22.69±0.52	16.63±1.34
Organization of Materials	13.50±0.87	12.88±0.98	16.36±0.63	14.36±0.51	10.53±0.87
Monitor	21.86±0.95	22.76±1.19	24.50±0.77	23.07±0.56	16.68±1.30
Composite scores					
BRI Index	54.95±2.58	60.88±2.67	61.45±1.96	58.95±1.42	45.74±3.31
MI Index	94.36±3.40	94.88±4.22	103.27±2.86	97.72±2.03	70.68±5.41
GEC	149.32±5.39	155.76±6.27	164.73±4.11	156.67±3.07	116.42±8.55
B: PARENT FORM					
BRI Scale Scores					
Inhibit	18.50±1.17	21.06±1.20	22.23±1.06	20.56±0.68	14.16±1.08
Shift	16.04 ±0.54	15.41±0.75	16.41±0.45	16.00±0.33	14.21±0.56
Emotional Control	20.45± 0.84	22.06±1.11	22.14±0.88	21.51±0.54	17.63±1.11
MI Scale Scores					
Initiate	15.91±0.62	15.76±0.94	16.77±0.75	16.18±0.43	13.26±0.77
Working Memory	21.86±0.77	21.12±1.21	22.95±1.06	22.05±0.58	16.89±1.01
Plan/Organize	26.36±1.14	26.65±1.46	28.45±1.05	27.20±0.69	21.32±1.16
Organization of Materials	12.73±0.67	13.06±0.64	14.14±0.68	13.33±0.39	11.42±0.81
Monitor	17.73±0.75	18.65±0.67	19.36±0.72	18.57±0.42	14.37±0.78
Composite scores					
BRI Index	55.00±2.12	58.53±2.48	60.77±2.01	58.07±1.28	46.00±2.35
MI Index	94.59±3.27	95.24±4.41	101.68±3.66	97.33±2.16	76.89±3.93
GEC	149.59±4.55	153.76±6.25	162.45±5.10	155.39±3.05	122.89±5.95

A-E). The task is to complete the missing part of a complex visual design by one of the visual alternatives that is provided on the same page of the booklet. There are six alternative responses in subtests A and B, and 8 alternatives in subtests C-E. Item difficulty increases within each subtest from items 1 to 12 and between each subtest from A to E. The test had been studied extensively with respect to its psychometric properties on Turkish samples (for a review see 55,62,63,64,65).

Procedures

The STP, WCST and RSPM were administered to the children as a part of an extensive neuropsychological assessment program. Licensed psychologists who were blind to the diagnosis individually administered the tests. Parents filled in the BRIEF-P as their child was going through neuropsychological assessment. Parents gave the BRIEF-T to the schoolteachers (classroom teacher or, in children with more than one teacher, the teacher that spent the most time with the child) and brought them back after they were completed.

Statistical Analysis

Statistical analyses were performed using SPSS / PC 17.0. The effect of ADHD on the BRIEF scores was studied using multivariate analysis of covariance (MANCOVA), with age serving as the covariate. The factor structure of the BRIEF scores was studied using Principal Component Analysis (PCA) with varimax rotation. PCA was also used for studying the overlap of the BRIEF scores and the scores from the three laboratory tests of executive functions (Stroop Test-TBAG Form,

WCST, RSPM). Predictability of group membership from the BRIEF scores was studied with logistic regression analysis using the backward technique.

RESULTS

Table 3 presents the arithmetic mean and standard error of scale and composite scores of the T Form and the P Form. Multivariate analysis of covariance (MANCOVA) was used to study the effect of the group variable (3 subtypes of ADHD) on the 8 scale scores of the BRIEF. Age served as the covariate. The table presents data on each of the subtypes of ADHD, the total clinical samples, and the control group. In both forms of the BRIEF, the control group obtained the lowest scores. The highest scores were generally obtained by the ADHD-C subtype, indicating that the highest level of EdF was found in this combined subgroup. Within the subgroups of ADHD, the lowest scores were generally obtained by the ADHD-AD group, indicating a better performance on the BRIEF when compared to the other two subgroups of ADHD.

The Factor Structure of the BRIEF and the Laboratory Tests

The factor structure of the BRIEF scale scores (3 BRI and 5 MI scores) was studied using principal Component Analysis (PCA) with varimax rotation. Analyses were separately performed for the ADHD and control groups and for the T and P forms. In order to increase the robustness of PCA, the clinical sample was not differentiated into subtypes. The cut-off for including a variable (scores) when interpreting a factor was .45, indicating an overlap of 20% between a variable and its factor.

A 2-factor structure was obtained for the BRIEF, regardless of the group (ADHD and control group) and form (BRIEF-T and BRIEF-P) (Table 4A-D). In the ADHD group (Table 4A and B) 3 BRI scores loaded on one of the factors and the 5 MI scores loaded on the other. This finding was obtained in both the T and P forms with comparable explained variances. The 2-factor structure with a clear differentiation between the BRI and MI scores was not obtained in the control group (Table 4C and D). Overall, explained variances were higher in the control group than the ADHD group. Explained variances in the T form were higher in the control group; however, those in the ADHD group were comparable for the T and P forms.

The overlap of the BRIEF scores and the scores from

Table 4: Principal Component Analyses of BRIEF Scores. A: Results from the ADHD Group using scores on BRIEF-T. B. B: Results from the ADHD Group using scores on BRIEF-P. C: Results from the Comparison Group using scores on BRIEF-T. D: Results from the Comparison Group using scores on BRIEF-P. (Factor loadings in bold indicate the higher factor loading for a given variable.

A	**Factor 1**	**Factor 2**
İnitiate	0.86	0.00
Working Memory	0.81	0.00
Plan /Organize	0.81	0.30
Organization of Materials	0.70	0.00
Monitor	0.66	0.58
Inhibit	0.00	0.79
Shift	0.00	0.70
Emotional Control	0.00	0.90
Eigenvalues	3.12	2.48
Explained variance (%)	39.03	31.04
Cumulative Variance (%)	39.03	70.07
B		
İnitiate	0.87	0.00
Working Memory	0.89	0.00
Plan /Organize	0.90	0.00
Organization of Materials	0.58	0.55
Monitor	0.76	0.00
Inhibit	0.00	0.79
Shift	0.58	0.58
Emotional Control	0.00	0.89
Eigenvalues	3.58	2.02
Explained variance (%)	44.77	27.52
Cumulative Variance (%)	44.77	72.29
C		
Inhibit	0.90	0.00
Emotional Control	0.78	0.51
İnitiate	0.82	0.00
Working Memory	0.83	0.45
Plan /Organize	0.88	0.00
Organization of Materials	0.81	0.00
Monitor	0.91	0.00
Shift	0.00	0.92
Eigenvalues	5.18	2.01
Explained variance (%)	64.81	25.14
Cumulative Variance (%)	64.81	89.95
D		
Inhibit	0.77	0.00
Shift	0.80	0.00
Emotional Control	0.82	0.00
İnitiate	0.71	0.55
Monitor	0.84	0.00
Working Memory	0.00	0.87
Plan /Organize	0.58	0.77
Organization of Materials	0.00	0.87
Eigenvalues	3.59	2.75
Explained variance (%)	44.82	34.37
Cumulative Variance (%)	44.82	79.19

Table 5 A-B: Principal Component Analyses of scores on the ADHD Group from BRIEF and the Laboratory Tests on. A: BRIEF-T and SPT Scores. B: BRIEF-P and SPT Scores. (Factor loadings in bold indicate the higher factor loading scores for a given variable.

A	Factor 1	Factor 2	Factor 3	Factor 4
Initiate	**0.86**	0.00	0.00	0.00
Working Memory	**0.82**	0.00	0.00	0.00
Plan /Organize	**0.81**	0.00	0.00	0.00
Organization of Materials	**0.72**	-0.00	0.00	0.00
Monitor	**0.68**	0.00	0.54	0.00
ST1-Duration	0.00	**0.92**	0.00	0.00
ST2-Duration	0.00	**0.92**	0.00	0.00
Inhibit	0.00	0.00	**0.77**	0.00
Shift	0.00	0.00	**0.69**	0.00
Emotional Control	0.00	0.00	**0.90**	0.00
ST3-Duration	0.00	0.62	0.00	**0.67**
ST4-Duration	0.00	0.00	0.00	**0.87**
ST5-Duration	0.00	0.00	0.00	**0.88**
Eigenvalues	3.30	2.53	2.35	2.23
Explained variance (%)	25.37	19.44	18.07	17.12
Cumulative Variance (%)	25.37	44.81	62.88	79.99
B				
Initiate	**0.87**	0.00	0.00	0.00
Working Memory	**0.88**	0.00	0.00	0.00
Plan /Organize	**0.91**	0.00	0.00	0.00
Organization of Materials	**0.64**	0.00	0.00	0.00
Monitor	**0.80**	0.00	0.00	0.00
ST1-Duration	0.00	**0.94**	0.00	0.00
ST2-Duration	0.00	**0.95**	0.00	0.00
ST3-Duration	0.00	**0.70**	0.58	0.00
ST4-Duration	0.00	0.00	**0.86**	0.00
ST5-Duration	0.00	0.00	**0.90**	0.00
Inhibit	0.00	0.00	0.00	**0.77**
Shift	0.49	0.00	0.00	**0.52**
Emotional Control	0.00	0.00	0.00	**0.89**
Eigenvalues	3.81	2.49	2.13	1.98
Explained variance (%)	29.30	19.15	16.39	15.26
Cumulative Variance (%)	29.30	48.45	64.83	80.09

the three laboratory tests of executive functions were studied by using PCA with varimax rotation (cut-off: 20%). Since the BRIEF claims to measure EdF, analyses were performed for only the ADHD group. Overall, in no case did the laboratory measures of EF take place under the factors where the BRIEF scores loaded. The 2-factor solution of the BRIEF was obtained in all the analyses and in both forms of the BRIEF. The explained variances in the T and P forms were comparable.

When the BRIEF scores were analyzed with scores of the Stroop Test, a 4-factor solution was obtained explaining 79.99% and 80.09% of the variance for T Form and P Form, respectively (Tables 5A and B). In both forms, the MI scores loaded on the first factor. The BRI scores loaded on the third (T Form) or the fourth factors (P Form). In the T Form, STP subtests pertaining to reading loaded on Factor 2 and those on color naming loaded on Factor 4. This structure was somewhat maintained in the BRIEF-P. The factor structure of STP was in accordance with the factor structure that was obtained on Turkish samples specifically when PCA was performed using the T Form (56,58,59,66). Contrary to expectations, the STP5 score, which measures interference control, did not load on the same factor as BRI scores in either the T or the P Form.

When PCA was performed using the BRIEF and WCST scores, a 5-factor solution was obtained explaining 79.35% and 79.20% of the variance for the T Form and P Form, respectively (Tables 5C and D). There was again a clear differentiation of the BRI and MI scores in the T Form. In the P Form, Shift (BRI score) loaded on Factor 2 along with the other MI scores. WCST scores were distributed over the three remaining factors in accordance with the factor structure of the WCST obtained on Turkish samples (60,61). Of the 13 WCST scores, WCST 9 loaded

Table 5 C: Principal Component Analyses of scores on the ADHD Group from BRIEF and the Laboratory Tests on. C: BRIEF-T and WCST Scores. (Factor loadings in bold indicate the higher factor loading scores for a given variable.

C	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Değişken					
WCST1	**0.84**	0.00	0.00	0.00	0.00
WCST2	**0.95**	0.00	0.00	0.00	0.00
WCST4	**-0.81**	0.00	0.00	0.00	0.00
WCST5	**0.91**	0.00	0.00	0.00	0.00
WCST6	**0.89**	0.00	0.00	0.00	0.00
WCST8	**0.83**	0.00	0.00	0.00	0.00
WCST9	**0.47**	0.00	0.00	0.39	0.46
WCST11	**-0.94**	0.00	0.00	0.00	0.00
İnitiate	0.00	**0.83**	0.00	0.00	0.00
Working Memory	0.00	**0.79**	0.00	0.00	0.00
Plan /Organize	0.00	**0.81**	0.00	0.00	0.00
Organization of Materials	0.00	**0.72**	0.00	0.00	0.00
Monitor	0.00	**0.74**	0.00	0.47	0.00
WCST3	0.00	0.00	**0.85**	0.00	0.00
WCST10	-0.60	0.00	**0.75**	0.00	0.00
WCST12	0.00	0.00	**0.83**	0.00	0.00
Inhibit	0.00	0.47	0.00	**0.66**	0.00
Shift	0.00	0.00	0.00	**0.68**	0.00
Emotional Control	0.00	0.00	0.00	**0.83**	0.00
WCST7	0.46	0.00	0.00	0.00	**-0.71**
WCST13	0.00	0.00	0.00	0.00	**0.75**
Eigenvalues	6.40	3.66	2.46	2.33	1.81
Explained variance (%)	30.48	17.44	11.72	11.09	8.61
Cumulative Variance (%)	30.48	47.93	59.65	70.74	79.35

Table 5 D: Principal Component Analyses of scores on the ADHD Group from BRIEF and the Laboratory Tests on. D: BRIEF-P and WCST Scores. (Factor loadings in bold indicate the higher factor loading scores for a given variable.

D	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
WCST1	**0.81**	0.00	0.00	-0.00	0.00
WCST2	**0.94**	0.00	0.00	0.00	0.00
WCST4	**-0.81**	0.00	0.00	0.00	0.00
WCST5	**0.92**	0.00	0.00	0.00	0.00
WCST6	**0.91**	0.00	0.00	0.00	0.00
WCST8	**0.85**	0.00	0.00	0.00	0.00
WCST9	**0.45**	0.00	0.00	0.00	0.00
WCST11	**-0.93**	0.00	0.00	0.00	0.00
Shift	0.00	**0.72**	0.00	0.00	0.00
İnitiate	0.00	**0.92**	0.00	0.00	0.00
Working Memory	0.00	**0.89**	0.00	0.00	0.00
Plan /Organize	0.00	**0.87**	0.00	0.00	0.00
Organization of Materials	0.00	**0.66**	0.00	0.00	0.44
Monitor	0.00	**0.80**	0.00	0.00	0.00
WCST3	0.00	0.00	**0.82**	0.00	0.00
WCST10	-0.61	0.00	**0.73**	0.00	0.00
WCST12	0.00	0.00	**0.83**	0.00	0.00
WCST7	0.41	0.00	0.00	**-0.77**	0.00
WCST1 3	0.00	0.00	0.00	**0.77**	0.00
Inhibit	0.00	0.00	0.00	0.00	**0.77**
Emotional Control	0.00	0.00	0.49	0.00	**0.60**
Eigenvalues	6.32	4.33	2.55	1.85	1.58
Explained variance (%)	30.09	20.61	12.61	8.83	7.51
Cumulative Variance (%)	30.09	50.69	62.85	71.69	79.20

Table 5 E-F: Principal Component Analyses of scores on the ADHD Group from BRIEF and the Laboratory Tests on. E: BRIEF-T and RSPM Scores. F: BRIEF-P and RSPM Scores. (Factor loadings in bold indicate the higher factor loading scores for a given variable.

E	Factor 1	Factor 2	Factor 3	Factor 4
İnitiate	**0.88**	0.00	0.00	0.00
Working Memory	**0.83**	0.00	0.00	0.00
Plan /Organize	**0.84**	0.00	0.00	0.00
Organization of Materials	**0.67**	0.00	0.00	0.00
Monitor	**0.66**	0.58	0.00	0.00
Inhibit	0.00	**0.82**	0.00	0.00
Shift	0.00	**0.61**	-0.46	0.00
Emotioanl Control	0.00	**0.89**	0.00	0.00
RSPM-Total Score	0.00	0.00	**0.90**	0.00
RSPM-Time	0.00	0.00	0.00	**0.99**
Eigenvalues	3.24	2.34	1.17	1.01
Explained variance (%)	32.37	23.42	11.75	10.09
Cumulative Variance (%)	32.37	55.79	67.54	77.63
F				
İnitiate	**0.88**	0.00	0.00	0.00
Working Memory	**0.90**	0.00	0.00	0.00
Plan /Organize	**0.90**	0.00	0.00	0.00
Organization ofMaterials	**0.59**	0.00	0.00	0.00
Monitor	**0.77**	0.00	0.00	0.00
Inhibit	0.00	**0.77**	0.00	0.00
Shift	0.49	**0.56**	0.00	0.00
Emotional Control	0.00	**0.90**	0.00	0.00
RSPM-Total Score	0.00	0.00	**0.97**	0.00
RSPM-Time	0.00	0.00	0.00	**0.97**
Eigenvalues	3.67	2.10	1.08	1.06
Explained variance (%)	36.72	21.01	10.84	10.65
Cumulative Variance (%)	36.72	57.73	68.53	79.18

with the three BRI scores in the T Form. In the P form, Emotional Control (BRI) loaded with WCST 3, 10 and 12.

When PCA was performed using the BRIEF and the RSPM scores, a 4-factor solution was obtained explaining 77.63% and 79.18 % of the variance in the BRIEF-T and the BRIEF-P respectively (Tables 5E and F). In both the T and P forms, the first factor included the MI scores and the second factor included the BRI scores. There was a clear differentiation of the BRI and MI scores. The two RSPM scores loaded on the remaining two factors in accordance with the factor structure of the RSPM obtained on Turkish samples (67). In the T Form, the RSPM total score loaded with negative values on the same factor with Shift (BRI).

The Value of the BRIEF in Subgroup Differentiation

Multivariate analysis of covariance (MANCOVA) was used to study the effect of the group variable (3 subtypes of ADHD and the control group) on the 8 scale and 3 supraordinate scores of the BRIEF. Age served as the covariate. Significant group effects were obtained on all of the BRIEF scores. The effect was found to be significant in all of the scores in the BRIEF-T (Wilks' Lambda: F (24, 197)=2.059, p=004) and in the BRIEF-P (Wilks' Lambda: F(27, 196)=1.756, p=.016). Post hoc analysis showed that for all of the scores, significant effects derived from the differences between the control group and subgroups of ADHD. Scores were not significantly different between subgroups of ADHD (Table 6).

To study whether group membership can be predicted from the BRIEF scores, logistic regression analysis (backward method) was employed. In regards to the BRIEF-T (Table 6A), the model that predicted group membership to the clinical sample and the control group was found to be statistically significant (p=.001, df=5, χ^2=27.493) and the -2 log likelihood was found to be 60.216. The prediction of membership to the ADHD group (sensitivity) was 96.70% and to the control group (specificity) was 57.90%. The overall correctness of estimation was 87.50%. The significant effect was obtained for the Working Memory score (MI).

Table 6 A: Classification Table For Logistic Regression Analysis Showing The Statistical Predictability Of Group from scoreds on BRIEF-T.

		Predicted		
		Group		Correctness of Estimation (%)
Observed		ADHD	Comparison	
Group	ADHD	59	2	96.70
	Comparison	8	11	57.90
Total (%)				87.50

		Predicted		
		Group		Correctness of Estimation (%)
Observed		ADHD-AD	ADHD-C	
Group	ADHD-AD	15	7	68.20
	ADHD-C	6	16	72.70
Total (%)%				70.05

		Predicted		
		Group		Correctness of Estimation (%)
Observed		ADHD-Hİ	ADHD-C	
Group	ADHD-Hİ	8	9	47.10
	ADHD-C	2	20	90.90
Total (%)%				71.80

		Predicted		
		Group		Correctness of Estimation (%)
Observed		ADHD-AD	ADHD-Hİ	
Group	ADHD-AD	14	8	63.60
	ADHD-Hİ	7	10	58.80
Total (%)%				61.50

Table 6 B: Classification Table For Logistic Regression Analysis Showing The Statistical Predictability Of Group from scoreds on BRIEF-P

		Predicted		
		Group		Correctness of Estimation (%)
Observed		ADHD	Comparison	
Group	ADHD	55	6	90.20
	Comparison	7	12	63.20
Total (%)				83.80

		Predicted		
		Group		Correctness of Estimation (%)
Observed		ADHD-AD	ADHD-C	
Group	ADHD-AD	15	7	68.20
	ADHD-C	8	14	63.60
Total (%)%				65.90

		Predicted		
		Group		Correctness of Estimation (%)
Observed		ADHD-Hİ	ADHD-C	
Group	ADHD-Hİ	8	9	47.10
	ADHD-C	3	19	72.70
Total (%)%				61.50

		Predicted		
		Group		Correctness of Estimation (%)
Observed		ADHD-AD	ADHD-Hİ	
Group	ADHD-AD	18	4	81.80
	ADHD-Hİ	8	9	52.90
Total (%)%				69.20

With regard to the BRIEF-P (Table 6B), the model that predicted group membership to the clinical sample and the control group was found to be statistically significant (p=.001, df=6, χ^2=26.204) and the -2 log likelihood was found to be 61.505. Prediction of membership to the ADHD group was 90.20% and to the control group, 63.20%. The overall true estimate was 83.80%. The significant effect was obtained for the Inhibit score (BRI).

When logistic regression analysis was conducted on pairs of ADHD subtypes, the predictive value of the BRIEF scores was lower (correctness of estimation on the T Form in Table 6A: 70.05%, 71.80%, 61.50%; correctness of estimation on the P Form in Table 6B: 65.90%, 61.50%, 69.20%), indicating a lower power for subtype classification. In the BRIEF-T, the only significant variable was found at the model for ADHD-C and ADHD-HI classification (p=.028, df=4, χ^2=10.848) and the -2 log likelihood was found to be 42.575 (explained variance: 71.8%). The significant variable was Organization of Materials score (MI). In the BRIEF-P, the only significant variable was found at the model for ADHD-C and ADHD-AD classification (p=.041 df=2, χ^2=6.400) and the -2 log likelihood was found to be 54.597(explained variance: 65.9%). The significant variable was Inhibit score (BRI).

DISCUSSION

The present study was conducted on a sample of ADHD boys and an age-matched healthy control group of the same sex. The children in the ADHD group were referred for first-time evaluation, had not yet been on any medication, and did not have comorbid neurological or psychiatric disorders. An intelligence quotient between 90 and 130 on the Wechsler Intelligent Test-Revised was an inclusion criterion for both groups.

In line with its planned structure (13,14), the BRIEF scores in the present study were organized under two factors. This structure was also demonstrated in the other studies that used exploratory factor analysis on the 8 BRIEF scales (13,14,18). The findings of the present study thus show the construct validity of the BRIEF-T and the BRIEF-P. They also point out that the BRIEF scores of the present study and those in the specified literature represent similar cognitive constructs. These findings further demonstrate the applicability of the BRIEF to cultures other than those for which the scale was originally devised. In the present study, one of the factors included the BRI scores and the other factor included the MI scores specifically in the ADHD group. This finding very much agrees with theoretical basis of the BRIEF (13,14), which is to measure the degree of ADHD-related behavioral disorders that represent different aspects of EdF.

EF is a multidimensional concept; however, inhibition is a core element (3,23-26). One type of inhibition, interference control, is widely measured in the literature by using the Stroop Test; the second type of inhibition, that of the ability to inhibit an ongoing response, is measured by using the WCST (34-37). Working memory, another element in EF (3,22), is measured by using the WCST (36,37) and the RSPM (41-44). The present study investigated the extent to which the BRIEF measures EF by using three laboratory tests that are widely used for measuring two fundamental aspects of EF (3,26,40,45).

Executive Functions Denote Different Sets of Phenomena in the BRIEF and Laboratory Tests

The relationship between the BRIEF and laboratory measures of EF was analyzed in the present study using orthogonal and correlational statistical techniques. In both the Parent and the Teacher Forms, the robust structure of the BRIEF, with a distribution of MI scores to one factor and the distribution of the BRI scores to the other, was maintained in PCA when ADHD data were used. This structure was preserved when laboratory test scores were also used in PCA. These findings support the 2-factor structure of both the T Form and the P form when used in the ADHD sample (18). However, regardless of whether the teacher or the parent performed the rating, scores on laboratory tests of EF were not located under the factors where the BRIEF scores loaded. The scores of the laboratory tests of EF loaded on separate factors that were in line with the cognitive processes that they measure (55-58,60,66,68,69). These findings suggest that the BRI scales, and specifically Inhibit, do not represent interference control which the STP measures (28-30,56) or inhibition of an ongoing response, which the WCST measures (34,35,60). The MI scores, specifically the Working Memory score, do not measure working memory that is represented in the WCST scores (specifically WCST3 10, 12) and the RSPM scores (36,37,42,43,44,60,69,70).

The lack of correlation between laboratory tests of EF and rating of everyday behavior at home and school was also reported in other studies. Vriezen and Pigott (71) could not find any correlation between the BRIEF scores (Parent Form) and laboratory scores of EF on children with traumatic brain injury. The EF test in this study included the WCST and two other tests that measure planning (Trail Making Test) and fluency (Verbal Fluency Test). In addition, Mahone et al (19) could not find a correlation between the BRIEF and performance on neuropsychological tests. The lack of any evidence for an overlap between the three laboratory tests and the BRIEF show that everyday behaviors that are claimed to be manifestations of EF do not represent the constructs that the laboratory tests of the present study measure.

Toplak et al. (72) reported associations between performance-based (laboratory) tests and the BRIEF scores; but each measure was not uniquely associated with its respective score on the rating scales. Correlation was reported in the literature between scores of the Dysexecutive Questionnaire (DEX) and scores from a spectrum of EF tests on a sample of adults (73). It may be that, in adults, the BRIEF is more sensitive and specific to the type of EF that the laboratory tests measure. It may also be that the components of EF that the DEX scores represent bear a higher similarity to those that are measured in the laboratory tests of EF.

The Diagnostic Utility of the BRIEF

Whether the BRIEF can be helpful in ADHD diagnosis was analyzed also using orthogonal and correlational statistical techniques. MANCOVA (an orthogonal technique) showed significant differences between only the ADHD group and control group. The differences were obtained in all 22 of the BRIEF scores (16 scale scores, 6 composite score)In line with this finding, logistic regression analysis (a correlational technique) showed a high correctness of estimation when classifying cases into the ADHD and control group (87.50% for the BRIEF-T and 83.80% for the BRIEF-P). Overall, these findings show, as others in the literature (19,72,74-76), that the BRIEF can be used as an auxiliary tool in the diagnosis of ADHD.

In regards to the subtype classification, orthogonal statistical techniques could not find significant differences between subgroups of ADHD with the BRIEF scores. Correlational techniques showed a medium level of correctness of estimation in the BRIEF-P, a somewhat higher level of correctness in the BRIEF-T. According to Gioia et al. (14), the Inhibit scale has the greatest overlap with the hyperactive-impulsive subtype and the Working Memory Scale, with the inattention subtype. The present study, where the effect of the contaminating subject and environmental variables were controlled, showed that this differentiation depended on the form that is used. Albeit with a medium level of estimation correctness, the Inhibit scale differentiated the subtype with attention deficit from the combined group, but this was obtained in the BRIEF-P. On the other hand, an MI score (Organization of Materials) differentiated the subtype with hyperactivity/impulsivity from the combined group in the BRIEF-T. These findings are in line with those of McCandles and O'Laughlin (2007) showing that BRI scores are significant in the BRIEF-P and MI scores are significant in the BRIEF-T (75).

Accordingly, these findings show that different combinations of the BRIEF scores represent subtypes of ADHD, indicating the complex cognitive configuration represented in each subtype. This is in contrast to the findings on autistic spectrum disorders (17). In autism, the scores contributing to the metacognitive index (mainly working memory and initiate scores) were specifically correlated with the adaptive functioning impairment in high functioning children with autistic spectrum disorders.

Overall, the explained variances were higher in the control group than the ADHD group. The explained variances in the T form were higher in the control group. However, those in the ADHD group were comparable for the T and P forms.

Taking into account the explained variances, the T and P forms measure BRI and MI to comparable degrees in the ADHD. However, teacher ratings had a higher power for differentiating the ADHD group from the control group and in differentiating subtypes of ADHD. This interpretation is in line with the finding, which showed that teachers are less biased when they use well-operationalized scales for rating cases with ADHD and Oppositional Defiant Disorder (77).

Conclusions and Proposals

The present study allows the following conclusions:

- The present study supported the 2-factor model of the BRIEF and thus demonstrated that the rating scale

measures a behavioral regulation consisting of the capacity to inhibit and shift responses and for emotional control and a metacognition index consisting of the capacity for working memory, to initiate responses and cognitions, to plan and organize, to organize materials, and to monitor.

- According to the theoretical foundations of the BRIEF, BRI and MI represent aspects of executive functions. In the present study, the BRIEF scores did not generally correlate with those of the laboratory (performance-based) tests, which measure specific and narrow-band aspects of EF. We can tentatively state that the scores on the BRIEF and from the neuropsychological tests do not represent the same aspects of EF.
- Overall, parents are better reporters on children's behavioral deficits (as represented in the BRI scores), whereas teachers provide better information about behaviors associated with cognitive deficits (as represented in MI scores). These findings emphasize the importance of obtaining information from both parents and teachers when EdF is assessed in patients with ADHD.
- A multi-trait and multi-technological method approach, covering both the performance-based, ecologically valid BRIEF, and the internally valid laboratory measures of EF may be more appropriate to capture the specific cognitive processes and the behavioral manifestations of the umbrella construct, EF. The multi-technological approach should include as informants, both the teachers and the parents.

The limitations of the present study were firstly, the sample size, which was small, due to the many exclusion criteria that were necessary for experimental clarity. Secondly, the BRIEF was evaluated in the present study at the scale not at the item level. Thirdly, the present study used only three of the most relevant neuropsychological tests of EF to validate the BRIEF. Future studies should analytically investigate the utility of the BRIEF at the item level by using larger sample sizes. Finally, future validation studies on the BRIEF should use those neuropsychological tests that measure other aspects of EF, such as planning, sequencing, and word fluency.

References:

1. American Psychiatric Association. Attention deficit and disruptive behavior disorder. In American Psychiatric Association: Diagnostic and statistical manual of mental disorders, American Psychiatric Association (editors). Washington DC: American Psychiatric Association; 2000.p.134-5.
2. World Health Organization ICD-10. Hyperkinetic disorder. In World Health Organization ICD-10: The ICD-10 Classification of Mental and Behavioural Disorders: Clinical Descriptions and Diagnostic Guidelines, World Health Organization (editors). Geneva: World Health Organization; 1992.p.155-7.
3. Barkley RA. Behavioural inhibition, sustained attention, and executive functions: Constructing a unifying theory of AD/HD. Psychol Bull 1997a; 121(1): 65-94.
4. Brown TE. Executive functions and attention deficit hyperactivity disorder: Implications of two conflicting views. Int J Disability Develop Educ 2006; 53(1): 35-46.
5. Lawrence V, Houghton S, Douglas G, Durkin K, Whiting K, Tannock R. Executive function and ADHD: a comparison of children's performance during neuropsychological testing and real-world activities. J Atten Disord 2004; 7(3): 137-49.
6. Lawrence V, Houghton S, Tannock R, Douglas G, Durkin K, Whiting K. ADHD outside the laboratory: boys' executive function performance on tasks in videogame play and on a visit to the zoo. J Abnorm Child Psychol 2002; 30(5): 447-62.
7. Biederman J, Monuteaux MC, Doyle AE, Seidman LJ, Wilens TE, Ferrero F, et al. Impact on executive function deficits and attention-deficit/hyperactivity disorder (ADHD) on academic outcomes in children. J Consult Clin Psychol. 2004;72(5):757-66
8. Biederman J, Petty CR, Doyle AE, Spencer T, Henderson CS, Marion B, et al. Stability of executive function deficits in girls with ADHD: a prospective longitudinal followup study into adolescence. Dev Neuropsychol 2008; 33(1): 44-61.
9. Benson F. The role of frontal dysfunction in attention deficit hyperactivity disorder. J Child Neurol 1991; 6 (Suppl.1): 9-12.
10. Stuss DT, Benson, DF. The Frontal lobes and the control of cognition and memory. In Perecman E (editor). The Frontal Lobes Revisited. New York: Raven Press; 1987.p.141-158.
11. Willcutt EG, Pennington BF, Olson RK, Chhabildas N, Hulslander J. Neuropsychological analyses of comorbidity between reading disability and attention deficit hyperactivity disorder: in search of the common deficit. Dev. Neuropsychol. 2005; 27(1): 35-78.
12. Scheres A, Oosterlaan J, Geurts H, Morein-Zamir S, Meiran N, Schut H. Executive functioning in boys with ADHD: primarily an inhibition deficit? Arch Clin Neuropsychol 2004; 19(4): 569-94.
13. Gioia GA, Isquith PK, Guy SC, Kenworthy L. Behavior Rating Inventory of Executive Function Professional Manual. Lutz FL: Psychological Assessment Resources Inc.; 2000a.
14. Gioia GA, Isquith PK, Guy SC, Kenworthy L. Behavior Rating Inventory of Executive Function. Child Neuropsychol. 2000b; 6(3): 235-8.
15. Gioia GA, Isquith PK, Kenealy LE. Assessment of behavioral aspects of executive function. In Executive Functions And The Frontal Lobes: A lifespan perspective, V. AndersonV, Jacobs R, Anderson PJ (editors). New York: Psychology Press; 2008. p. 179-218.

16. Burgess PW. Theory and methodology in executive function research. In Rabbitt P (editors). Methodology of Frontal and Executive Function, East Sussex, U.K.: Psychology Press; 1997.p. 81-116.

17. Gilotty L, Kenworthy L, Sirian L, Black DO, Wagner AE. Adaptive skills and executive function in autism spectrum disorders. Child Neuropsychol 2002; 8(4): 241-8.

18. Gioia GA, Isquith PK, Retzlaff PD, Espy KA. Confirmatory factor analysis of the Behavior Rating Inventory of Executive Function (BRIEF) in a clinical sample. Child Neuropsychol 2002; 8(4): 249-57.

19. Mahone EM, Cirino PT, Cutting LE, Cerrone PM, Hagelthorn KM, Hiemenz JR, et al. Validity of the behavior rating inventory of executive function in children with ADHD and/or Tourette syndrome. Arch Clin Neuropsychol 2002; 17(7): 643-62.

20. Slick DJ Lautzenhiser A, Sherman EM, Eyrl K. Frequency of scale elevations and factor structure of the Behavior Rating Inventory of Executive Function (BRIEF) in children and adolescents with intractable epilepsy. Child Neuropsychol 2006; 12(3): 181-9.

21. Gioia GA, Isquith PK. Ecological assessment of executive function in traumatic brain injury. Dev Neuropsychol 2004; 25 (1-2): 135-58.

22. Pennington BF, Ozonoff S. Executive functions and developmental psychopathology. J Child Psychol Psychiatry 1996; 37(1): 51-87.

23. Karatekin C, Asarnow RF. Working memory in childhood onset schizophrenia and attention deficit hyperactivity disorder. Psychiatry Res 1998; 80(2): 165-76.

24. Pennington BF. Dimensions of executive function in normal and abnormal development. In Development Of The Prefrontal Cortex: Evolution, Neurobiology, and Behavior, Krasnegor NA, Lyon GR, Goldman-Rakic PS (editors). Baltimore, MD: Brooks Publ.;1997.p. 265-81.

25. Pennington BF. The working memory functions of the prefrontal cortices: Implication for development and individual differences in cognition. In Future Oriented Processes and Development, Haith M, Benson J, Roberts R, (editors). Chicago: Univ. Chicago Press; 1994.p.243-89.

26. Barkley RA. Attention-deficit/hyperactivity disorder, self-regulation, and time: toward a more comprehensive theory. J Dev Behav Pediatr 1997b; 18(4): 215-85.

27. Stroop RJ. Studies of interference in serial verbal reactions. J Exp Psychol 1935; 18(6): 643-61.

28. Jensen AR, Rohwer WD, Jr. The Stroop Color-Word Test: A review. Acta Psychologica 1966; 25(1): 36-93.

29. MacLeod CM. Half a century of research on the Stroop Effect: An integrative review. Psychol Bull 1991; 109(2): 162-203.

30. MacLeod CM. The Stroop task: The "Gold Standard" of attentional measures. J Exp Psychol 1992; 121(1): 12-4.

31. Berg EA. A simple objective technique for measuring flexibility in thinking. J Gen Psychol 1948; 39: 15-22.

32. Heaton RK, Chelune GJ, Talley JL, Kay GG, Curtis G. Wisconsin Card Sorting Test Manual-Revised and Expanded. Lutz FL: Psychological Assessment Resources Inc.; 1993.

33. Heaton RK. Wisconsin Card Sorting Test Manual. Odessa, Florida: Psychological Assessment Resources; 1981.

34. King MC, Snow, WG. Problem-solving task performance in brain-damaged subjects. J Clin Psychol 1981; 37(2): 400-4.

35. Pendleton MG, Heaton RKA. Comparison of the Wisconsin Card Sorting Test and The Category Test. J Clin Psychol 1982; 38(2): 392-96.

36. Berman KF, Ostrem JL, Randolph C, Gold J, Goldberg T, Coppola R, et al. Physiological activation of a cortical network during performance of the Wisconsin Card Sorting Test: A positron emission tomography study. Neuropsychologia 1995; 33(8): 1027-46

37. Gold JM, Carpenter C, Randolph C, Goldberg TE, Weinberger DR. Auditory working memory and Wisconsin Card Sorting Test performance in schizophrenia. Arch Gen Psychiatry 1997; 54 (2): 159-65.

38. Raven JC Guide to the Standard Progressive Matrices. New York: The Psychological Corporation; 1956.

39. Raven JC, Court JH, Raven J. Manual for Raven's Standard Progressive Matrices. Oxford: Oxford Psychologists Press; 1992.

40. Lezak MD. Principles of neuropsychological assesment. In Behavioral neurology and neuropsychology. Feinberg TE, Farah MJ (editors). New York: McGraw-Hill; 1997.

41. Carpenter P, Just MA, Shell P. What one intelligence test measures: A theoretical account of the processing in the Raven Progressive Matrices Test. Psychol Rev 1990; 97(3): 404-31.

42. Conway ARA, Cowan N, Bunting MF, Therriault SRB, Minkoff SRB. A latent variabe analysis of working memory capacity, short-term memory, processing speed, and general fluid intelligence. Intelligence 2002; 30(2): 163-83.

43. Fry AF, Hale S. Relationships among processing speed, working memory, and fluid intelligence in children. Biol Psychol 2000; 54(1-3):1-34.

44. O'Leary MU, Rush KM, Guastello SJ. Estimating age-stratified WAIS-R IQ from scores on the Raven Standart Progressive Matrices. J Clin Psychol 1991; 47(2): 277-84.

45. Spreen O, Strauss E. A Compendium Of Neuropsychological Tests: Administration, Norms And Commentary. New York: Oxford University Press; 1991.

46. Mitrushina M, Boone KB, Razani J, D'Elia, LF. Handbook of Normative Data for Neuropsychological Assessment. NewYork: Oxford University Press; 2005.

47. Kaufman J, Kaufman J, Birmaher B, Brent D, Rao U, Flynn C, et al. Schedule for affective disorders and schizophrenia fo schoolage children-present and lifetime version (K-SADS-PL): İnitial reliability and validity data. J Am Acad Child Adolesc Psychiatry 1997; 36(7): 980-8.

48. Matthews A. Cognitive processes in anxiety and depression. J Royal Soc Med 1986; 79(2): 158-61.

49. Öy B. Child Depression Inventory: Reliability and Validity Study. Turk Psikiyatri Derg 1991; 2(2): 132-6 (Turkish).

50. Kovacs M. Rating Scales to assess depression in school aged children. Acta Paedopsychiatr 1981; 46(5-6): 305- 13.

51. Kovacs M. The Children's Depression Inventory (CDI). Psychopharmacol Bull 1985; 21(4): 995-98.

52. Özusta Ş. The Turkish Standardization reliability and validity of State Trait Anxiety Inventory for Children. Türk Psikoloji Dergisi 1995; 10(1): 32-44 (Turkish).

53. Spielberger CD, Gorsuch RL, Cushene RE. Manual for the State-Trait Anxiety Inventory. California: Consulting Psychologists Press; 1970.

54. Luria A. Higher Cortical Functions in Man. New York: Basic Books; 1966.

55. Karakaş S. A Neuropsychological Test Battery Standardized To The Turkish Culture: BILNOT Battery. 2nd ed. Ankara: Eryılmaz Ofset; 2006 (Turkish).

56. Karakaş S, Erdoğan E, Sak L, Soysal AŞ, Ulusoy T, Yüceyurt Ulusoy İ, et al. The standardization of the Stroop Test to the Turkish culture: reliability and validity. Klinik Psikiyatri Dergisi 1999a; 2(2): 75-88 (Turkish).

57. Karakaş S, Bekçi B, Doğutepe E, Erzengin ÖU. The electrophysiology of Stroop Test performance: Event-related potentilas and brain maps. Klinik Psikiyatri Dergisi 2005; 8(4): 155-71 (Turkish).

58. Karakaş S, Bekçi B, Doğutepe E. Stroop Test performance: perceptual conflict or response competition. 13th World Congress of Psychophysiology. The Olympics of the Brain. Int J Psychophysiol 2006; 61(3): 371.

59. Karakaş S, Doğutepe E, Sosyal AŞ, Erdoğan Bakar E. Path analysis of Stroop Test performance: attention and/or interference? 13th World Congress of Psychophysiology. The Olympics of the Brain. Int J Psychophysiol 2006; 61(3): 347.

60. Karakaş S, Irak M, Kurt M, Erzengin ÖU. Wisconsin Card Sorting Test and StroopTest TBAG Version: Comparative analysis. J Psych Psychol and Psychopharmacol 1999b; 7(3): 179-92.

61. Yalçın K, Karakaş S. The age level where Wisconsin Card Sorting Test scores represent the cognitive processes found for adults. 13th World Congress of Psychophysiology. The Olympics of the Brain. Int J Psychophysiol 2006; 61(3): 344.

62. Kurt M, Karakaş S. The effect of an original attention-related training program on visuospatial neglect. 12th World Congress of Psychophysiology (IOP) Int J Psychophysiol 2004; 54 (1-2): 152-3.

63. Şahin N, Düzen E. A validation study on teacher nominations of gifted children. In Competence and Responsibility (Vol. 2), Heller KA, Heny EA (editors). Göttingen: Hogrefe and Huber; 1994.

64. Şahin N, Düzen E. Ability profiles of the teacher-nominated gifted children. Competence and responsibility. The Third European Conference of the European Council for the High Ability (Vol. 1), Ernst AH, Heller AK (editors). Göttingen: Hogrefe and Huber; 1992.

65. Şahin N, Düzen E. Turkish Standardization of the Raven's SPM (ages 6-15). 23rd International Congress of Applied Psychology, July 1994, Madrid, Spain.

66. Kılıç BG, Koçkar IA, Irak M, Şener Ş, Karakaş K. The standardization study of Stroop test TBAG version on children between 6 and 11 years of age. Çocuk ve Ergen Ruh Sağlığı Dergisi 2002; 9(2): 86-99 (Turkish).

67. Kurt M, Karakaş S. The factor structure of three neuropsychological tests sensitive to right hemispheric functioning. Psikiyatri Psikoloji Psikofarmakoloji Dergisi 2000; 8(4): 251-65 (Turkish).

68. Barcelo F, Sanz M, Molina V, Rubia FJ. The Wisconsin Card Sorting Test and the assessment of frontal function: A validation study with event. Neuropsychologia 1997; 24(3): 288-397.

69. Karzmark P. Factor analysis of special Wisconsin Card Sorting measures in a comprehensive neuropsychological assessment. J Clin Exp Neuropsychol 1992; 14 (3): 339-53.

70. Perrine K. Differential aspects of conceptual processing in the Category Test and the Wisconsin Card Sorting Test. J Clin Exp Neuropsychol 1993; 15(4): 461-73.

71. Vriezen ER, Pigott SE. The relationship between parental report on the BRIEF and performance-based measures of executive function in children with moderate to severe traumatic brain injury. Child Neuropsychol 2002; 8(4): 296-303

72. Toplak ME, Bucciarelli SM, Jain U, Tannock R. Executive functions: performance-based measures and the Behavior Rating Inventory of Executive Function (BRIEF) in adolescents with Attention/Deficit hyperactivity Disorder. Child Neuropsychol 2009; 15(1): 53-72.

73. Burgess P, Alderman N, Evans J, Emslie H, Wilson BA. The ecological validity of tests of executive function. J Int Neuropsychol Soc 1998; 4(6): 547-58.

74. Alloway TC, Gathercole SE, Holmes J, Place M, Elliott JG, Hilton K. The diagnostic utility of Behavioral Checklists in identifying children with ADHD and children with working memory deficits. Child Psychiatry Hum Dev 2009; 40(3): 353-66.

75. McCandles S, O'Laughlin L. The clinical utility of the Behavior rating Inventory of Executive Function (BRIEF) in the diagnosis of ADHD. J Atten Disord 2007; 10(4): 381-89.

76. Jarratt KP, Riccio CA, Siekierski BM. Assessment of attention deficit hyperactivity disorder (ADHD) using the BASC and BRIEF. Appl Neuropsychol 2005; 12(2):83-93.

77. Stevens J, Quittner AL, Abikoff H. Factors influencing elementary school teachers ratings' of ADHD and ODD behaviors. J Clin Child Psychol 1998; 27(2): 406-14.