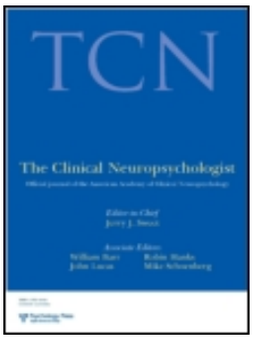

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Rey-Osterrieth Complex Figure Performance in Adults with Attention Deficit Hyperactivity Disorder: A Validation Study of the Boston Qualitative Scoring System*

Hope E. Schreiber[1], Debbie J. Javorsky[2,4], Judith E. Robinson[3], and Robert A. Stern[4]
[1]Department of Psychiatry, New England Medical Center, Tufts University School of Medicine, [2]Department of Psychology, University of Rhode Island, [3]Department of Psychiatry, New England Medical Center, Tufts University School of Medicine, and [4]Departments of Psychiatry & Human Behavior and Clinical Neuroscience, Brown University School of Medicine

ABSTRACT

Rey-Osterrieth Complex Figure (ROCF) productions from 18 adults with Attention Deficit Hyperactivity Disorder (ADHD) were compared to 18 matched controls using the Boston Qualitative Scoring System (BQSS). ADHD adults showed impairment in measures of configural accuracy, planning, and neatness. A logistic regression model resulted in 75% sensitivity and 81% specificity in discriminating ADHD from control subjects. In contrast, there was no significant difference on the traditional ROCF 36-point score, and the sensitivity and specificity for the 36-point score were lower (68% and 71%, respectively). These findings suggest persisting executive dysfunction in adults with ADHD that can be detected in ROCF productions. Thus, the BQSS may be a useful tool contributing to the neuropsychological evaluation of adults with ADHD.

Attention Deficit Hyperactivity Disorder (ADHD) is a highly prevalent disorder, with onset early in childhood. It is estimated to affect 3–11% of school-age children (Goldman, Genel, Bezman, & Slanetz, 1998; Zametkin & Ernst, 1999), and symptoms frequently continue into adolescence and adulthood (Bhandary, 1997; Biederman, 1991; Denckla, 1991; Gittelman, Mannuzza, Shenker, & Bonagura, 1985; Weiss & Hechtman, 1993), impacting as many as 50–66% of adults with ADHD (Weiss & Hechtman, 1993). These symptoms, which can impair the quality of an individual's life, include distractibility, disorganization, impulsivity, emotional lability, irresponsibility, antisocial behavior, difficulty with goal attainment, and substance abuse (Achenbach, Howell, McConaughty, & Stranger, 1995; Barkley, 1990; Denckla, 1993; Weiss & Hechtman; 1993; Whalen & Henker, 1992). Although the pathogenesis of ADHD and its impact on neuropsychological functioning have been widely studied in children, specific descriptions of the nature and severity of deficits in adults with ADHD have been sparsely reported, despite increasing evidence of its prevalence and disabling impact on social, academic, and occupational functioning throughout the lifespan.

Insight into the neurological basis of ADHD was first provided by structural and functional neuroimaging studies conducted with children, which implicated involvement of several areas of the brain, including the frontal, parietal, and subcortical regions. Studies utilizing regional cerebral blood flow (Giedd et al., 1994; Hynd et al., 1991; Lou, Henriksen, & Bruhn, 1984; Lou, Henriksen, Bruhn, Borner, & Nielsen, 1989; Semrud-Clikeman et al., 1994) and brain electri-

* Address correspondence to: Dr. Hope Schreiber, Department of Psychiatry, NEMC # 1007, 750 Washington Street, Boston, MA 02111, USA. Tel: (617) 636-5774. E-mail: hschreib@opal.tufts.edu.
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cal activity mapping (Satterfield, 1986) demonstrated decreased activity in frontal lobe areas during performance of cognitive tasks by children with ADHD. Other studies showed increased regional cerebral blood flow in frontal areas in children with ADHD following administration of Ritalin (Lou et al., 1984, 1989). Using MRI-based morphometry, Filipek and colleagues (1997) found anomalies in the left caudate, right prefrontal/frontal, and posterior parietal hemispheric regions, and Castellanos and associates (1996) found decreased volume in the prefrontal cortex, caudate nucleus, and globus pallidus, predominantly on the right side. Lower cerebral metabolic glucose rates, as measured by PET during an auditory continuous performance task, have also been reported in parietal and subcortical regions of children with ADHD (Ernst et al., 1994).

There have been substantially fewer neuroimaging studies on adults with ADHD than on children. However, existing research suggests that structural and metabolic abnormalities in adults with a diagnosis of childhood ADHD are similar to those of children with ADHD. For example, using a PET procedure in a study of never-medicated adults with childhood ADHD, Zametkin and colleagues (1990) found reduced glucose metabolism primarily in the premotor and superior prefrontal cortex. In a later study, Zametkin and associates (1993) found significantly reduced normalized glucose metabolism in 6 of 60 brain regions, with symptom severity significantly correlated with reduced metabolism in the left anterior frontal lobe. Reduced global cerebral glucose metabolism has been associated with increased age in ADHD females (Ernst, Zametkin, Phillips, & Cohen, 1998).

Neuropsychological testing may be a useful tool in the diagnostic process in adults with ADHD, though little research is currently available on its utility. The few studies which have been conducted with adults with ADHD have provided evidence of impairments in memory (Denckla, 1991; Downey, Stelson, Pomerleau, & Giordani, 1997; Seidman & Biederman, 1998), attention/vigilance (Downey et al., 1997; Seidman & Biederman, 1998), executive functioning (Denckla, 1993; Lezak, 1995; Lovejoy et al., 1999), and visuospatial skills (Denckla, 1993). Recent studies have shown that specific neuropsychological tests, including the Paced Auditory Serial Addition Test, California Verbal Learning Test, and Continuous Performance Test, may be useful in differentiating between adults with ADHD and adults with no childhood history of this disorder (Epstein, Conners, Sitarenios, & Erhardt, 1998; Jenkins et al., 1998). Similarly, Lovejoy et al. (1999) showed that other tests, including Trails A and B, Controlled Oral Word Association (FAS), the Stroop and WAIS-R Freedom from Distractibility factor, successfully differentiated ADHD adults from adults without this disorder. It has been suggested by Lovejoy and colleagues that executive dysfunction, in particular, is an important factor in many of the disabilities seen in adults with ADHD, a stance shared by other workers (Barkley, 1997a; Denckla, 1993). Such dysfunction would be consistent with the neuroimaging studies implicating frontal system abnormalities.

The executive dysfunction hypothesis is supported by studies of children with ADHD. The primary symptoms of ADHD in children are hyperactivity, impulsivity, distractibility, and poor working memory (Barkley, 1997a; Castellanos, 1997; Gualtieri & Hicks, 1985; Mattes, 1989; Pontius, 1973; Rosenthal & Allen, 1978; Stamm & Kreder, 1979; Zametkin & Rapoport, 1987). Moreover, studies have consistently found that youths with ADHD perform significantly worse than those without ADHD on tests believed to measure executive functioning (Aronowitz et al., 1994; Moffitt & Henry, 1989; Seidman, Biederman, Faraone, Weber, & Ouellette, 1997), even when compared to non-ADHD children who were delinquent and/or conduct disordered.

Although studies suggest that structural, functional, and cognitive issues present in childhood ADHD may persist into adulthood, the diagnosis of ADHD in adults continues to be described as a ''clinical diagnosis.'' In the diagnostic process, focus often has been placed on retrospective review of childhood symptoms (Ward, Wender, & Reimherr, 1993), and Barkley (1997b) has described the utility of self-report measures. Clinical diagnosis based on DSM-IV

(American Psychiatric Association, 1994) uses criteria which apply equally to children and adults. While these are valuable tools in differential diagnosis of ADHD, little is known about the impact of developmental change occurring across the lifespan on symptom expression.

Further empirical evaluation of the utility of neuropsychological tests in differentiating adults with ADHD from controls would help more clearly and quantitatively to describe specific cognitive deficits present in adults with ADHD and begin to delineate the potential usefulness of specific tests in contributing to the diagnostic process when working with adults with ADHD. The Rey-Osterrieth Complex Figure (ROCF) is a particularly useful neuropsychological instrument which permits observation of a wide variety of cognitive functions. It provides a clinical and research opportunity not only to measure visuoconstructive ability, but also to observe the ability to evaluate and organize an approach to a complex problem and effectively plan and carry out a strategy to complete the task. Seidman and colleagues (1995) identify difficulty with organization as a hallmark of ADHD regardless of the presence of comorbid disorders. They used the Developmental Scoring System (DSS) for the ROCF (Bernstein & Waber, 1996) to differentiate children with ADHD from control children. The children with ADHD obtained significantly lower Copy Organization scores than the control children. These findings were similar to previous research using the same scoring system (Barr, Douglas, & Sananes, 1990; Grodzinsky & Diamond, 1992).

The DSS was designed to assess developmental process variables on the ROCF relevant to child populations (Bernstein & Waber, 1996). Because of this theoretical basis, and because of the lack of adult normative data, it may not be appropriate for use with adults. The Boston Qualitative Scoring System (BQSS; Stern et al., 1994, 1999), on the other hand, is a recently developed comprehensive scoring system for the ROCF specifically devised for and standardized with adults, though it has also been used in studies of children with ADHD (Cahn et al., 1996; Conners et al., in press). The BQSS was developed to produce a quantifiable set of scores that could assess a number of qualitative dimensions of the ROCF, including the presence, accuracy, and placement of specific elements of the figure, as well as the fragmentation, planning, perseveration, confabulation, size distortions, neatness, rotation, and asymmetry of the entire figure. The BQSS also provides summary scores for overall presence and accuracy of the production, immediate and delayed retention, and organization (Stern et al., 1999). Selected BQSS scores have been shown to differentiate children with ADHD from age-matched controls on their reproductions of the ROCF (Cahn et al., 1996). Children with ADHD performed more poorly than control children on measures tapping attention to detail, expansion, accuracy, and neatness. Individual BQSS measures yielded an overall sensitivity of 64% and specificity of 97% for the diagnosis of ADHD, indicating that the BQSS has some utility in detecting underlying qualitative differences between children with ADHD and normal control children. In another study using the BQSS, Conners and colleagues (in press) found evidence that children's ADHD may, in part, be subtyped through ROCF performance.

Several reliability and validity studies have been conducted in adult samples with the BQSS and are summarized in the BQSS professional manual (Stern et al., 1999). Interrater reliability has been shown to be good to excellent, and both convergent and predictive validity evidence has been established. In a recent study (Somerville, Tremont, & Stern, 1999), four BQSS scores developed to be sensitive to executive functioning (Fragmentation, Planning, Perseveration, and Organization) were significantly related to performance on traditional neuropsychological tests presumed to measure various aspects of executive functioning, supporting the convergent validity of executive aspects of the BQSS. All four BQSS variables were significantly and highly correlated with Wisconsin Card Sorting Test (WCST) Perseverative Responses and Categories Completed. The BQSS scores were also each significantly correlated with at least two other variables (Trail Making Test B, Controlled Oral Word Association, and WAIS-R Similarities).

Given that scoring with the BQSS can be more time-consuming than the traditional 36-point system (Corwin & Bylsma, 1993; Lezak, 1995), the question of whether or not the BQSS qualitative scores are better able to discriminate amongst different diagnostic groups than the 36-point scoring system was addressed by Stern and associates (1999). Using several patient populations (e.g., Alzheimer's Dementia vs. Ischemic Vascular Dementia; Javorsky & Stern, 1999) they found the overall classification rate of the 36-point scoring system to be substantially lower than that of the BQSS. Additionally, a Quick Scoring Guide (QSG) is available in which BQSS scores are rated without specific reference to the elaborate, more comprehensive criteria and exemplars. It is intended for use by highly trained clinicians who are in need of a rapid method for scoring ROCF productions, but who still want to glean as much qualitative information as possible from the test. The BQSS professional manual presents a study in which the validity of the QSG was investigated by comparing QSG ratings and the comprehensive BQSS scores, as well as the interrater agreement between two clinicians using the QSG. The use of the QSG required less than 4 min per ROCF production (similar to the time necessary to score with the traditional 36-point method), and results demonstrated that the two raters exhibited predominantly good to excellent interrater agreement. Furthermore, Spearman rank-order correlations between QSG ratings and the more comprehensive scores ranged from .51 to 1.00, with the majority of the correlations falling above .70. This indicates very good convergent validity for the QSG, suggesting that clinicians with limited experience with the BQSS can quickly learn to use the QSG and produce accurate and reliable qualitative ratings of ROCF performance in a much shorter time than it would take using the more comprehensive scoring approach of the BQSS.

The BQSS is presently the most comprehensive scoring method for the widely-used ROCF. Using the BQSS to qualitatively evaluate ROCF productions of adults with ADHD may help provide a better understanding of persisting deficits in this population, as there is evidence that it may be sensitive to cognitive dysfunction relevant to individuals with this syndrome, such as executive impairment. To date, there have been no published studies comparing ROCF productions of adults with ADHD to controls using a qualitative scoring system. This study was designed to investigate the utility of the BQSS in differentiating between adults with ADHD and matched controls, specifically on variables thought to be sensitive to executive dysfunction.

METHOD

Participants

ADHD participants

Adults with ADHD were selected retrospectively from a group of adults evaluated in the outpatient psychiatry clinic of a large urban teaching hospital. Twelve of these individuals were referred from university or college learning disability support services; physicians within the hospital, and clinicians in the community referred the remaining six. Referral questions often involved the reason for life-long academic difficulty, or poor organizational and follow-through skills in the workplace, and ADHD was suspected. Approximately 50 charts from individuals who were referred for these reasons were reviewed to obtain the selected participants. Individuals were selected if they fulfilled the following criteria:

(1) Persons were diagnosed with ADHD in independent evaluations by both a clinical neuropsychologist (H.E.S.) *and* a board-certified psychiatrist (J.E.R). Neither clinician had any knowledge of the BQSS scoring approach or of the BQSS scores at the time of diagnosis. Referrals may have been for testing neuropsychological evaluation first or for psychiatric evaluation first, but all subjects completed both examinations. The neuropsychologist conducted a comprehensive clinical interview, with a focus on DSM-IV criteria for ADHD. The majority of those referred had been given Barkley's ADHD-IV Self-Report of Current Behavior (Barkley, 1997c), or an earlier version of this self-report form (R. Barkley, personal communication, June, 1997), to aid review of DSM-IV criteria. For all participants, a third party, such as a parent or spouse, was contacted to confirm early history of symptoms associated with ADHD. The formal evaluation included tests of intelligence, achievement, and specific neuropsychological do-

mains, including attention, executive functioning, language, visuospatial ability, and learning and memory. Although both qualitative and quantitative consideration of test performance was noted, statistically significant disruption in more than one test of attention and executive functioning, as well as disruption in tests of complex learning, was sought to make the ADHD diagnosis, in conjunction with meeting behavioral and historical criteria. The psychiatric evaluation included a comprehensive psychiatric interview, as well as a review of DSM-IV criteria for ADHD, aided by Barkley self-report forms, as above. As before, a third party was contacted to confirm the early history of symptoms associated with ADHD.
(2) Participants did not have active comorbid psychiatric disorders by DSM-IV criteria as determined in psychiatric interview.
(3) Participants did not have learning disorders by DSM-IV criteria as determined by the neuropsychological evaluation.

The resulting group of 18 adults with ADHD included 9 males and 9 females. This gender distribution is consistent with other reports of individuals who are referred for evaluation (Biederman et al., 1994). Their ages ranged from 18 to 52, with a mean age of 30.3 (*SD* = 10.4). Mean years of education of the ADHD sample was 16.1 (*SD* = 2.6). The mean WAIS-R Full Scale IQ score was 109.8 (*SD* = 8.6), with a range of 95–124. The sample included 7 college or entering-college students, 2 medical students, 2 advanced degree students, 2 professionals preparing for national examinations, and 5 employed individuals. While this was a relatively high functioning group, their referral questions were typical for those seeking ADHD evaluations as adults (Denckla, 1993). Although only one individual had been diagnosed with ADHD earlier in life, most others had strongly suspected the diagnosis. All but one individual met DSM-IV behavioral criteria for ADHD by self-report, or met Barkley's 1.5 *SD* cut-off for this disorder. The remaining individual had a strong childhood history of such criteria by both self- and parental-report. Sixteen of the participants had the Predominantly Inattentive Type, while the 2 remaining individuals met criteria for the Combined Type. Neuropsychological evaluations took place before any medication trial. All subjects were strong positive responders to methylphenidate.

At the time of evaluation, the 36-point system (Lezak, 1995) was used to score the ROCF. While the figures were viewed critically in consideration of ADHD, they were not used as the final diagnostic criteria. As stated earlier, the neuropsychologist was blind to BQSS scores and unfamiliar with the scoring system at the time of diagnosis. ROCF productions were re-scored using the BQSS and the 36-point scoring method for this study.

Normal control participants

Normal control (NC) participants were selected from a large sample of adults who received the ROCF as part of other studies included in the standardization sample for the BQSS (Stern et. al., 1999). Each control participant was as closely matched as possible on gender, age, and education to an individual in the ADHD group. This resulted in 18 individuals, 9 males and 9 females. Their ages ranged from 18–51, with a mean age of 29.5 (*SD* = 11.5). Mean years of education was 15.1 (*SD* = 1.7). The WAIS-R Full Scale IQ score was not available for the NC participants. There were no significant differences between the ADHD and NC groups on gender or age. The ADHD subjects were more educated than the NC subjects ($p < .05$). However, this difference was viewed as creating a more conservative comparison of BQSS scores between the two groups. It should be noted, however, that in the BQSS standardization sample (Stern et al., 1999) there was no significant relationship between education level and BQSS performance, a finding also seen in other scoring systems (e.g., Meyers & Meyers, 1995). No person in the NC group had a history of neurological disorder, major medical illness, psychiatric illness, developmental disorder, learning disability, ADHD, or significant visual or auditory impairments. The control participants were tested in various settings, including a university, a local community center, and a clinic.

Instrumentation

Administration

All participants were individually administered the ROCF using a standardized procedure including copy, immediate recall, and 20–30 min delayed recall. Control participants were examined as part of the assessment protocol of the various normative studies. The ADHD participants were examined as part of the larger clinical neuropsychological evaluation. The ROCF was administered using the procedures described in the BQSS manual (Stern et al., 1999). Specifically, all participants were instructed to copy the ROCF as carefully as possible onto an 8 1/2 in. x 11 in. sheet of white paper presented with a ''landscape'' orientation. Subjects were told that at specific intervals they would be given a different colored pen to continue their drawing. Pens were switched in a manner de-

signed to record the order in which the elements were drawn, in order to depict fragmentation of the production as well as specific planning strategies. Subjects were not allowed to rotate the stimulus or the blank sheet of paper, and were told to indicate to the examiner when they were finished with the drawing.

Scoring

BQSS. Productions were scored using the BQSS by trained research assistants who were blind to group membership. A recent study of the interrater reliability of these scorers is detailed in the BQSS manual (Stern et al., 1999). In this study, the two research assistants were initially trained in the administration and scoring of the ROCF using the BQSS. They then independently scored the copy, immediate, and delayed recall productions of 62 individuals representing several research populations. For the copy condition, 11 scores demonstrated excellent reliability, 4 had good reliability, and 1 (i.e., detail placement) had fair reliability. The asymmetry score evidenced excellent reliability in that there was 100% agreement between the two raters. The six summary scores had good to excellent reliability.

The 17 BQSS scores derived to assess a number of qualitative dimensions of each ROCF production are more fully discussed elsewhere (Cahn et al., 1996; Stern et al., 1994, 1999). In brief, the ROCF is divided into Configural Elements (i.e., items that are fundamental to the structure of the figure), Clusters (i.e., items that appear to form a coherent gestalt within the main figure), and Details (i.e., single line segments). Scores are derived using an extensive set of criteria, templates, and exemplar productions. Specifically, each configural Element is scored for Presence, Accuracy, and Fragmentation. Each Cluster is scored for Presence, Accuracy, and Placement. Additionally, one Cluster is also scored for Fragmentation. Details are scored for Presence and Placement only. The Planning, Perseveration, Confabulation, and Neatness ratings take into account the entire production as a whole and are scored by using anchor points and exemplar figures. Reduction, Vertical Expansion, Horizontal Expansion, and Rotation are assessed using transparency templates. In addition, each production is assessed for the presence of Asymmetry (none, left or right). All ratings (except Asymmetry) are scored on a zero-to 4-point scale (0 = severely impaired performance; 4 = above average performance). Several summary scores (e.g., Copy Presence and Accuracy, Immediate Retention, Delayed Retention, and Organization) are also calculated.

In order to reduce the possibility of Type I error, only a select number of BQSS variables were studied. Because the current study was focusing primarily on executive functioning, as opposed to learning and memory, only the copy condition was utilized. Specific BQSS variables were chosen based on hypotheses regarding the impact of ADHD on ROCF performance. That is, based on previous work with the BQSS in children with ADHD (Cahn et al., 1996; Conners et al., in press), on other studies of adults with ADHD (e.g., Denckla, 1993), and on a recent study examining the convergent validity of specific BQSS scores developed to assess executive functioning (Somerville et al., 1999), it was hypothesized that performance on the ROCF by adults with ADHD would be characterized by relatively poor visuospatial accuracy, diminished attention to detail, poor planning and organization, perseveration, impulsivity/expansiveness, and messiness. Therefore, the following nine BQSS variables were selected: Configural Accuracy, Cluster Accuracy, Detail Presence, Fragmentation, Planning, Vertical Expansion, Horizontal Expansion, Perseveration, and Neatness. More detailed descriptions of each of these variables are presented elsewhere (Stern et al., 1994, 1999).

36-Point Scoring System. Each ROCF production was also scored using the 36-point scoring system, using the explicit criteria provided by Duley and colleagues (1993). All productions were scored by the same raters who provided the BQSS scores.

Data Analysis

Group differences on the nine BQSS variables were examined with *t* tests, using an alpha level of .05 (one-tailed). Because of the nature of the BQSS variables (i.e., limited range, skewed distribution among normal samples), nonparametric Mann-Whitney *U* tests (comparing mean ranks) were also calculated. In addition, mean differences on the 36-point scoring system scores were examined by both *t* test and Mann-Whitney *U*.

In order to assess the sensitivity and specificity of the BQSS variables when comparing subjects with ADHD and controls, the overall data analysis plan involved a multivariate logistic regression analysis. With this technique, it is traditional to seek the most parsimonious model that still explains the data (Hosmer & Lemeshow, 1989). A more parsimonious model is more likely to be numerically stable, and is more easily generalized, especially in light of the relatively small sample size employed in this study. To this end, the steps

outlined in Hosmer and Lemeshow (1989) for variable selection were followed.

Variable Selection

A univariate analysis of each variable was first conducted. Those variables with *p* values less than 0.25 were selected as candidates for the multivariate analysis. Spearman correlation coefficients were then calculated to examine the intercorrelations among the variables. Because the purpose of the study was to find the best and most parsimonious model for prediction, when variables were highly correlated ($r > .40$) only one variable was chosen to represent each pair according to how well it improved the model using *univariate* logistic regression. In the case where one variable was not better than the other, one was chosen according to which of the two variables achieved the greatest mean differences based on Mann-Whitney *U* statistics. It was determined that the following variables were correlated with each other: Cluster Accuracy and Configural Accuracy ($r = .51$), Detail Presence and Neatness ($r = .64$), Planning and Fragmentation ($r = .41$), and Vertical Expansion and Horizontal Expansion ($r = .48$). The following variables were, therefore, chosen for the initial logistic regression analysis: Configural Accuracy, Horizontal Expansion, Neatness, Planning, and Perseveration.

Multivariate Logistic Regression Analysis

The importance of each of the five variables included in the model was then verified by examining the Wald statistic for each variable and comparing each estimated coefficient with the coefficient from the univariate model containing only that variable. Hosmer and Lemeshow (1989) recommend model respecification to obtain the best fitting model while minimizing the number of parameters. Thus, variables that did not contribute to the model based on these criteria were eliminated and a new model fit. The new model was compared to the old model through the likelihood ratio test. Also, the estimated coefficients for the remaining variables were compared to those from the full model to determine if any variable coefficients had changed markedly in magnitude (indicating that one or more of the excluded variables was important in providing a needed adjustment of the effect of the variable that remained in the model). In accordance with Hosmer and Lemeshow (1989), this process of deleting, refitting, and verifying continued until it appeared that all of the important variables were included in the model.

RESULTS

As seen in Table 1, significant group differences were found for Configural Accuracy, Neatness and Planning, with the ADHD group performing worse than the controls on all variables. The significant differences remained for Neatness and Planning when using the Mann-Whitney *U* statistic. In contrast, there was no significant group difference on the 36-point score.

Using the multivariate logistic regression model entering all five variables of interest, the Wald statistic was significant for Configural Accuracy ($p < .05$), Planning ($p < .01$), and

Table 1. Group Differences on BQSS Variables and 36-Point Scoring System.

	Control $n = 18$			ADHD $n = 18$				
Variable	*M*	(*SD*)	Median	*M*	(*SD*)	Median	*t*	*U*
Cluster Accuracy	3.3	(0.7)	3.0	3.0	(0.9)	3.0	–1.2	131.0
Configural Accuracy	3.1	(0.7)	3.0	2.7	(0.6)	3.0	–2.1*	110.0
Detail Presence	3.9	(0.3)	4.0	3.8	(0.4)	4.0	–0.9	144.0
Neatness	2.7	(0.5)	3.0	2.3	(0.6)	2.0	–2.0*	102.5*
Planning	3.2	(0.9)	3.0	2.6	(0.9)	2.0	–2.0*	106.0*
Fragmentation	2.9	(1.2)	3.0	2.4	(1.4)	3.0	–1.2	124.5
Vertical Expansion	3.7	(1.0)	4.0	3.8	(0.7)	4.0	0.4	161.0
Horizontal Expansion	3.6	(0.8)	4.0	2.6	(0.6)	4.0	–0.2	145.5
Perseveration	3.9	(0.2)	4.0	3.9	(0.3)	4.0	–0.6	153.0
36-point score	30.7	(3.4)	31.0	31.2	(3.4)	32.0	0.4	147.5

* $p < .05$ (1-tailed)

Perseveration ($p < .05$). Neatness approached significance ($p < .06$). The variable not contributing to the model (Horizontal Expansion) was eliminated and a new model fit. In the new model, which contained Configural Accuracy, Planning, Perseveration, and Neatness, the Wald statistic was significant for Configural Accuracy ($p < .05$) and Planning ($p < .05$) (see Table 2).

The reduced model was compared to the full model containing all of the original five variables to determine whether the more parsimonious model was appropriate. No coefficients for the variables in the reduced model changed markedly in magnitude from their coefficients in the full model. Moreover, the full model, compared to the reduced model, did not significantly improve the model nor improve the correct classification rate for the groups.

The effectiveness of the model in describing the outcome variable (i.e., group membership), or ''goodness of fit,'' was assessed using the Pearson residual and its summary statistic, Pearson Chi-square, to show the agreement of the observed and fitted values. The Pearson Chi-square for the final model in this analysis was significant ($p < .01$). A classification table (which compares predicted values to the observed/actual outcome) summarizing the results of the fitted logistic model is presented in Table 2. As can be seen, the model was a ''good fit,'' with 83% of the ADHD subjects and 72% of the controls correctly classified. The overall correct classification rate was 78%. These findings indicate that, based on the four BQSS variables, the model resulted in 75% sensitivity and 81% specificity. In contrast, the 36-point score resulted in only 68% sensitivity and 71% specificity.

DISCUSSION

The results of this study indicate that particular aspects of ROCF performance are reduced in adults with ADHD compared to matched controls. Specifically, the Configural Accuracy, Planning, Perseveration, and Neatness of the copy condition production, as measured by the BQSS, appear to differentiate amongst ADHD and control subjects, with a resulting 75% sensitivity and 81% specificity. Individuals diagnosed with ADHD consistently performed worse than control subjects on most BQSS variables of interest, with significant differences occurring on Configural Accuracy, Neatness, and Planning. These preliminary findings suggest that difficulties in executive functioning may be associated with ADHD in adults, as they are in children (Denckla, 1993).

The strong presence of Planning in the model is of interest, particularly in comparison to Cahn and associates' (1996) findings, where ADHD children performed similarly to controls on the BQSS's Planning score. Cahn et al. postulated that such a measure was more suitable for use with adults, and that a ''floor effect'' may have been observed, as both the ADHD and control groups performed poorly on the measure. Akshoomoff and Stiles (1995) also noted the insensitivity of Planning to developmental change in children. It may be hypothesized that, although individuals without ADHD improve in planning ability as they mature, adults with ADHD continue to show limitations in the skills measured by this variable. Inspection of a larger sample across the lifespan would help clarify this issue. Precise interpretation of this differ-

Table 2. Logistic Regression Analysis of the Selected BQSS Measures for the ADHD and Normal Control Groups.

Variable	β	Wald	Significance
Configural Accuracy	2.46	5.43	.02
Neatness	1.28	2.43	.12
Planning	1.83	6.21	.02
Perseveration	3.69	3.24	.07

Note:–2 Log likelihood = 32.78; goodness of fit = 29.39; Model Chi-square improvement = 17.13*
* $p < .01$

Table 3. Classification Table for ADHD and Normal Controls Using the Final Logistic Regression Model.

	Predicted Membership		Correctly Classified
Actual Membership	ADHD	Normal	
ADHD	15	3	83%
Normal	5	13	72%

Note: Overall classification rate = 78%.

ence must be offered with caution, however, since some revisions have taken place in the BQSS since Cahn and colleagues' (1996) work. A number of scores (including Planning and Neatness) were changed to facilitate improved clinical face validity, to increase interrater reliability, and to more adequately identify ''normal'' performance based on the performance of standardization sample. It may be that the Planning variable has become more sensitive through these revisions.

It was also of interest that the Cahn and associates (1996) study showed that Horizontal Expansion alone provided 84% sensitivity and 67% specificity in their sample of children, aged 6 to 12. In our adult sample neither Horizontal nor Vertical Expansion contributed to the final model. Changes in motor inhibition and ability to modulate output over the years could contribute to such a difference in models derived from child and adult populations. It should be noted that Configural Accuracy and Neatness were significant variables in both studies, strongly suggesting their central role in helping to identify individuals with ADHD throughout the life cycle.

In many clinical settings, differential diagnosis often requires assessment of possible ADHD in association with one or more comorbid disorders. Either ruling out ADHD or identifying associated disorders becomes a complex task, when one or more of these disorders may also impact upon attention and executive functions. Further studies comparing BQSS profiles of deficits, not only between ADHD and controls, but also between ADHD and such conditions as mild traumatic brain injury, depression, anxiety, Post-Traumatic Stress Disorder, dissociative disorders, psychotic disorders and various types of learning disabilities, would be useful in assisting in this differential diagnostic process.

Replication of this study with a larger sample might well be informative in further describing the deficits associated with ADHD in adults. In particular, variation in performance by gender and age would best be explored with a larger sample. Nevertheless, it is of interest that BQSS scores were able to strongly classify ADHD adults and controls even though the sample was small and the ADHD subjects were high functioning and well educated. Such a finding suggests that the selected BQSS parameters accurately identify defining features of this disorder and that the BQSS can be used effectively as a diagnostic tool, when used in the context of a more comprehensive neuropsychological evaluation, in identifying individuals with ADHD. Thus, this scoring system could decrease clinical misdiagnosis, as well as error in research investigations, by providing clinicians and researchers with psychometrically sound information regarding the qualitative nature of ROCF reproductions.

In summary, this exploratory study provides suggestive and positive data in support of the use of neuropsychological tests such as the Rey-Osterrieth Complex Figure in the evaluation of ADHD in adults. It further suggests that adults with ADHD have lingering cognitive deficits, even when the adults with ADHD are considered to be high functioning. With an appropriate neuropsychological tool, one which quantitatively highlights the more neuropsychologically complex but key features of ADHD (e.g., executive dysfunction), those deficits which may persist in adult years can be accurately described. The

utility of the BQSS in the evaluation of the post-secondary student population is suggested by this study. In addition, these results provide evidence of the validity of this comprehensive scoring system for the ROCF. Further studies of varied clinical populations using the BQSS and other neuropsychological instruments with sensitivity to qualitative features of performance could be useful in the development of more accurate tools for differential diagnosis.

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