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Review Article

Executive dysfunction, severity of traumatic brain injury, and IQ in workers with disabilities

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Abstract. *Objective*: To study whether severity of traumatic brain injury and the intelligence quotient are related to executive dysfunction.
Participants: Sixty-two adults with brain injury who were referred for a work capacity evaluation.
Methods: Retrospective review of severity of traumatic brain injury, intelligence quotient from a previously-conducted neuropsychological evaluation, determination of executive function status from the neuropsychological evaluation, and both self-report and informant-report executive dysfunction scores from the Behavior Rating Inventory of Executive Function.
Results: Executive dysfunction and the intelligence quotient are related to severity of traumatic brain injury, but executive dysfunction and the intelligence quotient are not related to each other. Executive dysfunction as determined by a neuropsychological evaluation was not consistent with clients' self-reports but was consistent with informant-reported executive dysfunction. Five types of executive dysfunction were reported by knowledgeable informants, with significant elevations on the Shift, Plan/Organize, Task Monitor, Organization of Materials, and Working Memory BRIEF clinical scales.
Conclusions: The intelligence quotient is not a useful indicator of executive dysfunction. Informant-report executive dysfunction is a reliable and potentially useful adjunct to a neuropsychological evaluation. Working memory is the most severe type of executive dysfunction and may not be adequately measured by current neuropsychological evaluation methods.

Keywords: Traumatic brain injury, IQ, disability, executive function, executive dysfunction, dysexecutive syndrome

1. Introduction

Intelligence is not a unitary construct, but involves the integration of cognitive, emotional, and executive components. The cognitive constructs of attention, memory and language co-exist with the emotional and executive constructs, with the latter facilitating or impeding their expression. In the process to determine work disability, the cognitive constructs usually receive more attention because they "can be so readily conceptualized, measured, and correlated with neuroanatomically identifiable systems and partly because the structured nature of most medical and psychological examinations does not provide much opportunity for subtle emotional and control deficits to become evident. However, brain damage rarely affects just one of these systems... the disruptive effects of most brain lesions... usually involve all three systems" [18, p. 18].

Developing a clear understanding of work-relevant functional limitations that are a consequence of impaired integration of the cognitive, emotional, and executive functions is made difficult by the common misperception that the intelligence quotient (IQ) is an adequate representation of intelligence. "For the general public, IQ is not identified with a particular type of score on a particular test but is often a shorthand designation for intelligence. So prevalent has this usage become that it cannot be merely ignored or deplored as a popular misconception" [2, p. 295]. In the neuroscientific community IQ scores have been known for decades to be unrelated to the size of brain lesions and are considered by neuroscientists as unreliable indicators of neuropathic deterioration [14]. Thus, if one takes IQ as an indicator of brain injury, the broad and disruptive effects of the neuropathology may be missed. Lezak et al. [18, p. 22] recommends, "IQ is inherently meaningless and not infrequently misleading. . . has outlived whatever usefulness it may once have had and should be discarded." However, IQ continues to be used widely as a place-holder for intelligence in a broad array of settings. A PubMed search on "IQ and disability" returned more than 500 references, with several in recent years, including this random sample [1,7,15, 19–21,23].

Whenever the focus on intelligence narrows down to a client's IQ, especially if it is reported to be "within normal limits" without further qualification, the neuropsychological testing process may be less than optimally sensitive to work disability. A previously-employed rehabilitation client whose IQ scores are as expected may be unable to work due to brain impairment that is displayed as emotional dysfunction or executive dysfunction, or both. It appears to be important to include tests that are sensitive to emotional and executive dysfunction in a neuropsychological test battery if the information is going to be useful to understand the presence and extent of work disability due to brain impairment.

Historically, executive function was thought to be sited in the frontal lobes of the human brain, specifically, the prefrontal cortex. "The human prefrontal cortex attends, integrates, formulates, executes, monitors, modifies, and judges all nervous system activities" [28, p. 248]. Disturbance of the ability to handle novel situations and the exercise of judgment was originally termed "frontal lobe syndrome" [26]. However, executive dysfunction is now understood to be a consequence of brain lesions involving other parts of the brain including the parietal cortex and basal ganglia, and may be present when there is no demonstrable impairment of the prefrontal cortex. Additionally, executive dysfunctions may be sequelae of disruptions of neurotransmitters such as dopamine, glutamate, and gamma-aminobutyric acid [17].

A more recent term for impairment of the brain's ability to integrate and synthesize information and experience that results in functional limitations evidenced as behavioral disturbances is "dysexecutive syndrome" [5], often expressed as interpersonal problems with inhibition of emotional impulses and awareness of how one's behavior is affecting others. The dysexecutive syndrome also may be observed as difficulty with flexibility in transitions from one situation or task to another and in other task-oriented behaviors including planning and organization of resources, task initiation, working memory for multi-step activities, monitoring of progress, and error identification and correction. However, Stuss and Alexander [29] have proposed that executive function has three separate attentional processes that are located in different frontal regions and interact to bring about different types of executive dysfunction and have challenged the notion of a dysexecutive syndrome. They argue that there is actually no central executive function; the frontal processes described as *energization*, *task setting*, and *monitoring* individually and in combination better explain neuropsychological and neurobehavioral function. Importantly, their model does not include a construct that involves inhibition, a key component of previous descriptions of executive function. Stuss and Alexander posit that the three attentional processes adequately explain a broad range of their data in persons with brain injury without the need to resort to inhibition as an explanatory phenomenon. They argue against a global dysexecutive syndrome; various combinations of the three processes adequately explain function that previously had been ascribed to a unitary overarching executive.

Thus, within a scientific context in which the validity of the dysexecutive syndrome is being challenged and the boundaries of executive function are not clearly delineated, this study considers the dysexecutive syndrome measured both narrowly and broadly compared with IQ in a sample of work-disabled adults with different levels of brain injury severity. Four research questions are addressed. First, what is the relationship between executive dysfunction and severity of brain injury? Second, what is the relationship between executive dysfunction and intelligence quotient? Third, what is the relationship between intelligence quotient and brain injury severity? Fourth, for those persons with work disability who have executive dysfunction, what are the most frequent types of executive dysfunction? In addition to a traditional neuropsychological test battery approach to identifying executive dysfunction, this study examines the types of executive dysfunction most often reported by clients and their significant others. The relationship between each operational definition of executive dysfunction and IQ will be examined, as will the relationships between both approaches to executive dysfunction.

2. Methods

2.1. Participants

The study sample is comprised of 62 adults of working age (18 years to 65 years) who were referred for work capacity evaluation an average of 3.9 years (SD $=$ 1.70 years) after an accident caused a brain injury that could be classified in terms of severity. Because one of the study parameters is severity of brain injury, cases in which the classification of severity could not be determined were excluded. In the resulting sample, 39 (63%) were males. All were employed outside the home at the time of the accident, with the exception of five (8%) who were college students. Occupationally, at the time of the onset of brain injury this sample had O*NET Job Zone ratings of 2.9 (SD $=$ 1.01), with 15 (24%) reporting terminal professional degrees or graduate school education. Males' mean (SD) age was 43.2 (12.6) years, while females' mean (SD) age was 40.3 (11.1) years. Most of the participants (58 or 92%) had active worker's compensation claims or personal injury lawsuits during the evaluation process. The presence of brain damage was confirmed for 55 (89%) of the participants, with confirmation by CT for 9 (15%), by CT and MRI for 5 (8%), by MRI for 10 (16%), by MRI and PET for 1 (1.6%), and by PET for 30 (48%). Prior to the referral for work capacity evaluation, 14 (22%) of the participants had received more than brief (1–2 weeks) rehabilitation services. Two of the four non-litigants and six of the 58 litigants were working at least 20 hours per week at the time of the evaluation. All of the participants had undergone a neuropsychological evaluation prior to referral for the work capacity evaluation.

2.2. Measures

The severity of traumatic brain injury (TBI) was determined by the author in review of the medical records by applying the Centers for Disease Control and Injury Prevention (CDC) approach, namely, "TBI severity refers to the degree of brain trauma as it is assessed during the acute phase of injury. TBI severity assessment focuses on acute signs and symptoms indicating brain pathophysiology." [11, p. 15]. Unfortunately, the CDC approach does not specify criteria for other than mild TBI. Therefore, the criteria adopted by the United States Veterans Administration (VA) [24] were employed to classify the TBI severity of the participants in the study, as presented in Table 1.

Beginning with 74 potential case records, 12 medical records did not have sufficient information to make a determination of severity and were excluded from the study. Information from the records of emergency medical responders and from hospital emergency room physicians and nursing records were especially helpful in determining the presence or absence of "mild" brain injury. Based on the VA criteria, 43 (69%) of the participants had brain injuries that were classified as mild, 12 (19%) that were classified as moderate, and 7 (11%) that were classified as severe.

Unlike medical records, the neuropsychological records provided on referral of the client for the work capacity evaluation often did not include the actual test materials. Thus, data concerning the intelligence quotient were obtained by review of neuropsychological reports. If there was more than one report in the case file, the latest report was used. If the report did not mention a score or a particular test by name, it usually was not possible to review collateral documents to supplement the reported data. Typically, but not always, the *Wechsler Adult Intelligence Scale* (*WAIS*) [4] was reported by a doctoral-level neuropsychologist as part of a comprehensive test battery. Of the 62 participants, 45 (73%) included *WAIS* full-scale IQ scores. Aside from the use of the *WAIS*, there was wide variability in the inclusion of other instruments, with the most frequently encountered other tests being the *Wisconsin Card Sort Test* [13] in 24 (39%) batteries and the *Trails B* test [22] in 18 (29%) batteries. In this sample the *WAIS* Full-Scale IQ mean (SD) score was 97.4 (14.0), with a range from 59 to 124.

Data concerning executive dysfunction were obtained in two ways. First, executive dysfunction was identified in the neuropsychological report. The neuropsychologist's reported opinion was taken as positive or negative for executive dysfunction. Second, the presence and degree of executive dysfunction was measured by the use of the Self-Report and the Informant-Report adult versions of the *Behavior Rating Inventory of Executive Function* (*BRIEF-A*) [25]. The *BRIEF-A* is a 75-item questionnaire comprising 12 scales with internal consistency coefficients ranging from $r = 0.73$ to $r = 0.96$ and test-retest reliability coefficients ranging

Table 1
Veterans administration criteria: Severity of traumatic brain injury

Mild	Moderate	Severe
Altered or loss of consciousness < 30 min with normal CT &/or MRI	Loss of consciousness < 6 hours with abnormal CT &/or MRI	Loss of consciousness > 6 hours with abnormal CT &/or MRI
Glasgow Coma Scale 13–15	Glasgow Coma Scale 9–12	Glasgow Coma Scale < 9
Post traumatic amnesia < 24 hours	Post traumatic amnesia < 7 days	Post traumatic amnesia > 7 days

from $r = 0.82$ to $r = 0.94$ for the Self-Report version, and internal consistency coefficients ranging from $r = 0.80$ to $r = 0.98$ and test-retest reliability coefficients ranging from $r = 0.91$ to $r = 0.96$ for the Informant-Report version. Convergent and discriminant validity has also been demonstrated for a variety of clinical and healthy adult samples.

The neuropsychological reports resulted in a positive finding of executive dysfunction when the neuropsychologist provided an opinion in the report that supported executive dysfunction. In most cases this was explicit (e.g. the term "executive dysfunction" was used to affirm or deny the presence of the construct), but in other cases the neuropsychologist's opinion required interpretation. For example, "Mr. Jones has slightly impaired working memory and severely impaired ability to shift from one task to another..." was interpreted as positive for executive dysfunction. When the neuropsychologist offered an opinion about the absence of executive dysfunction, this was recorded. Altogether, 60 (97%) of the neuropsychological reports included an opinion (or information that could readily lead to an opinion) with regard to executive dysfunction. In this sample, executive dysfunction was reported by the neuropsychologist to be present in 47 (76%) and absent in 13 (31%) of the cases.

The administration of the *BRIEF* was undertaken by the author who is a licensed psychologist and a certified vocational evaluator. The standard instructions provided in the professional manual [25] were closely followed. After a structured intake interview, when it appeared that the client had adequate cognitive ability to complete the instrument independently, the BRIEF self-report version was administered. When well-informed and apparently competent significant others were available, the BRIEF informant-report version was administered. Both versions of this instrument have 75 statements that describe behaviors that the evaluee must indicate were "never a problem, sometimes a problem, or often a problem" in the prior month. The difference between the self-report and informant-report versions is in the style of instructions; the items are identical otherwise. The ordinal responses are assigned a value of 1, 2, or 3, and summed within nine clinical factors. Four of the clinical factors are grouped to indicate a derived factor titled "Behavior Rating", while the remaining five clinical scales are grouped to indicate a derived factor titled "Metacognition". The total score is used to indicate a derived factor titled "Global Executive Composite". Administration requires 5 to 7 minutes, while scoring requires 2 minutes, facilitated by a simple Excel spreadsheet devised by the author. Standard score application requires an additional 5 minutes. The raw scores in each scale are translated into standard scores with a mean of 50 and a standard deviation of 10 using age-graded tables. Separate tables are provided for self-report and for informant-report. This instrument has three scales that are used to determine bias, unusual responding, or inconsistency. In these instances, such response patterns were reported and the data were not included as indicative of executive function in the work capacity evaluation report. Altogether, 26 (42%) of the participants were able to submit self-reports that were apparently reliable, and 31 of the significant others were able to submit informant reports that were apparently reliable. Approximately 5% of the reports from either clients or informants did not pass one or more of the bias tests and were not included. Of the 26 self-reporting participants, 16 had at least one informant-report as well. Three of the participants who were not able to self-report had well-informed significant others who completed the informant-report version of the BRIEF. In most of the cases in which neither self-report nor informant- report were available, the participant had neither the ability to complete the BRIEF dependably nor a well-informed significant other available for test administration.

Study data were entered into an Excel spreadsheet, with data analysis undertaken with SPSS v. 16.0. The variables recorded were age, gender, years of education, O*NET job zone rating of most recent occupation, current employment status, method of confirmation of brain injury, brain injury severity rating, executive dysfunction yes-no, *WAIS* Verbal IQ, Performance IQ, and Full Scale IQ scores, and twelve *BRIEF-A* scale T-scores (Mean = 50, SD = 10).

Table 2
Concurrence of executive dysfunction and brain injury severity

Brain Injury Severity	Executive Dysfunction? Yes	No	Total
Mild	29	12	41
Moderate	11	1	12
Severe	7	0	7
Total	47	13	60

Table 3
Wechsler adult intelligence scale (WAIS) intelligence quotient scores

WAIS IQ	N	Minimum	Maximum	Mean	SD
Full-Scale	45	59	124	97.4	14.0
Verbal	37	65	125	97.9	14.3
Performance	37	58	132	101.6	14.1

Table 4
WAIS IQ scores by executive dysfunction

Wechsler Adult Intelligence Scale	Executive Dysfunction?	N	Mean	SD
Full Scale	Yes	33	95.7	14.8
	No	11	102.5	11.2
	Total	44	97.4	14.1
Verbal	Yes	27	97.2	14.8
	No	9	100.4	14.2
	Total	36	98.0	14.5
Performance	Yes	27	99.1	14.6
	No	9	108.7	11.1
	Total	36	101.5	14.3

3. Results

3.1. *Executive dysfunction and severity of brain injury*

The first issue to be addressed in this study is the frequency with which executive dysfunction is related to severity of brain injury. In the current sample, 60 of the participants were able to be classified in terms of executive dysfunction and brain injury, with the results presented in Table 2.

The Likelihood Ratio of 6.26 with 2 degrees of freedom is significant at $\alpha = 0.04$, indicating that there is an association between the two methods of categorization.

3.2. *Executive dysfunction and intelligence quotient*

The second issue to be addressed in the analysis is the relationship between reported IQ of the participants and the identification of executive dysfunction. The sample *WAIS* IQ scores are presented as Table 3.

On a sample basis, the *WAIS* IQ scores are consistent with the normal population, in which the mean (SD) for each of the three IQ scales is 100 (15).

Table 5
WAIS IQ scores in each severity group

Wechsler Adult Intelligence Scale IQ Score	Brain Injury Severity	N	Mean	SD
Full Scale	Mild	36	100.5	10.6
	Moderate	8	84.9	20.6
	Severe	1	88.0	
	Total	45	97.4	14.0
Verbal	Mild	30	99.7	12.2
	Moderate	6	89.7	22.7
	Severe	1	94.0	
	Total	37	97.9	14.3
Performance	Mild	30	104.9	9.8
	Moderate	6	88.0	23.2
	Severe	1	87.0	
	Total	37	101.6	14.1

Table 6
Utility of 15-point discrepancy between wais sub-scales for identifying executive

WAIS sub-scale difference $>$ / = 15 Points?	Executive dysfunction? Yes	No	Total
Yes	8	2	10
No	34	11	45
Total	42	13	55

The relationships between IQ scores and the identification of executive dysfunction can be examined through three separate one-way analyses of variance, with descriptive data presented in Table 4.

The Executive Dysfunction group IQ scores are not significantly different for Full Scale IQ ($F_{1,42} = 1.927$, $p = 0.172$), Verbal IQ ($F_{1,34} = 0.326$, $p = 0.572$), or Performance IQ ($F_{1,34} = 3.196$, $p = 0.083$).

3.3. *Intelligence quotient and brain injury severity*

Examination of the relationship among IQ scores and the degrees of brain injury severity can be undertaken through three separate one-way analyses of variance, with descriptive data presented in Table 5.

The Mild Traumatic Brain Injury (MTBI) group IQ scores are significantly different for both Full Scale IQ ($F_{2,42} = 5.137$, $p = 0.010$) and Performance IQ ($F_{2,34} = 5.084$, $p = 0.012$), but not for Verbal IQ ($F_{2,34} = 1.282$, $p = 0.290$).

Neuropsychologists sometimes use the disparity between the Verbal IQ and Performance IQ scores as an indicator of cognitive dysfunction, with the standard deviation (15) of the scaled score as the cut-point. In this sample, 10 of the participants had 15-point differences. The relationships between IQ score disparity and the identification of executive dysfunction can be examined through Chi-Square analysis, with results presented in Table 6.

The Pearson Chi-Square of 0.90 with 1 degree of freedom is not significant at $\alpha = 0.05$, indicating that there is no association between the two methods of categorization. The disparity between the *WAIS* verbal IQ and *WAIS* performance IQ scores was not a useful indicator of executive dysfunction in this sample.

3.4. Most frequent types of executive dysfunction

The final questions addressed in this research study concern the type of executive dysfunction most often reported by clients and their significant others, and the relationship of reports of executive dysfunction to neuropsychological diagnoses of executive dysfunction. Scores from the *BRIEF* can be analyzed in terms of executive dysfunction diagnoses through separate one-way analyses of variance, with data presented in Tables 7 and 8.

Table 7 demonstrates that there are no differences between participants' scores on the self-report BRIEF based on executive dysfunction diagnoses made by a neuropsychologist. Across all of the nine *BRIEF* clinical scales and the three derived summary scales, no significant differences were found based on whether or not the participant had been independently diagnosed with executive dysfunction.

Table 8 demonstrates that there are significant differences between participants' scores on the informant version of the *BRIEF* based on the neuropsychologists' executive dysfunction diagnoses in the *BRIEF* scales Shift, Plan/Organize, Task Monitor, Organization of Materials, and the Metacognition Index. In each of these scales, the participants who had been identified as experiencing executive dysfunction scored significantly higher than those who had not been so identified.

4. Discussion

4.1. Current study results

The present study demonstrated that both executive dysfunction and the intelligence quotient are related to severity of traumatic brain injury, but executive dysfunction and the intelligence quotient are not related to each other. This is in part due to representation of executive function and IQ as sampling parallel systems composed of many discrete constructs, such that certain types of brain function can be preserved while others cannot. Both can be affected by brain injury, but the effects are relatively independent. This finding is supported by several prior studies [8,12,27,30,32].

The current study's finding that executive dysfunction and IQ are not related argues for a broader approach to assessment of persons with brain impairment, which is supported by another finding of this study that, although self-report executive dysfunction is not related to executive dysfunction based on a neuropsychological assessment, informant-report executive dysfunction is consistent with neuropsychological opinions. It seems that attention should be paid to the reports of knowledgeable informants, and this information integrated into the evaluation of persons who may have brain injury.

This study also identified four components of executive dysfunction that are found among persons with work disability due to traumatic brain injury who have also been identified through the use of a neuropsychological test battery as having executive dysfunction. The specification of the neuropsychological opinion in terms of the person's ability to shift and refocus attention and transition to other activities, plan and organize tasks, organize material for tasks, and monitor task performance would certainly be helpful to rehabilitation professionals. Adding an instrument such as the *BRIEF* to a standard neuropsychological test battery would position the neuropsychologist to provide improved direction to rehabilitation colleagues.

The final finding in this study argues for going beyond highly-structured neuropsychological tests or self-reports to assess work disability. This study identified working memory as the highest overall subscale on the informant-report BRIEF, without a significant difference found in terms of executive dysfunction that was identified by neuropsychological assessment. The absence of a group-wise difference is troubling when the sample elevation is so high. Although this may be caused by a regression toward the mean phenomenon, the magnitude of the sample elevation on this subscale points to the importance of this construct and the likelihood that it is not being measured adequately by the neuropsychologist.

4.2. Current study limitations

This study used extensive medical records and closed case files of a convenience sample of working-age adults referred for a work capacity evaluation. These records were available because most of the participants were involved in litigation. Although participants whose test scores indicated less than full effort or dis-

Table 7
ANOVA of self-report BRIEF scale scores by executive dysfunction

BRIEF Scale	Executive Function or dysfunction	N	Mean	SD	df	Mean square	F	Sig.
Inhibit	Dysfunction	18	58.6	11.3	1	40.01		
	Function	7	61.4	10.0	23	119.91	0.334	0.569
	Total	25	59.4	10.8	24			
Shift	Dysfunction	18	71.0	12.8	1	0.93		
	Function	7	70.6	9.9	23	146.86	0.006	0.937
	Total	25	70.9	11.9	24			
Emotional control	Dysfunction	18	63.4	12.4	1	12.70		
	Function	7	61.9	17.1	23	189.80	0.067	0.798
	Total	25	63.0	13.5	24			
Self-Monitor	Dysfunction	18	58.5	13.7	1	43.23		
	Function	7	61.4	14.6	23	193.57	0.223	0.641
	Total	25	59.3	13.7	24			
Behavioral regulation index	Dysfunction	18	65.1	12.8	1	7.63		
	Function	7	66.3	15.3	23	182.02	0.042	0.842
	Total	25	65.4	13.2	24			
Initiate	Dysfunction	18	66.6	15.6	1	1.88		
	Function	7	66.0	10.6	23	210.19	0.009	0.925
	Total	25	66.4	14.2	24			
Working memory	Dysfunction	18	77.1	11.6	1	27.07		
	Function	7	79.4	14.0	23	150.41	0.180	0.675
	Total	25	77.8	12.1	24			
Plan/Organize	Dysfunction	18	67.3	11.9	1	10.17		
	Function	7	65.9	8.0	23	120.63	0.084	0.774
	Total	25	66.9	10.8	24			
Task monitor	Dysfunction	18	68.9	14.8	1	416.20		
	Function	7	59.9	10.2	23	189.47	2.197	0.152
	Total	25	66.4	14.1	24			
Organization of materials	Dysfunction	18	62.1	14.0	1	19.53		
	Function	7	60.1	7.8	23	161.24	0.121	0.731
	Total	25	61.6	12.5	24			
Metacognition index	Dysfunction	18	70.3	13.5	1	8.96		
	Function	7	69.0	7.0	23	147.04	0.061	0.807
	Total	25	70.0	11.9	24			
Global executive composite	Dysfunction	18	69.4	13.1	1	0.76		
	Function	7	69.0	10.8	23	157.84	0.005	0.945
	Total	25	69.3	12.3	24			

simulation were not included, the relationships identified in this study may not be found in a non-litigated sample. Similarly, a representative sample of working age adults with other types of executive dysfunction or ostensible causes of IQ impairment may not demonstrate the relationships among the variables reported in this study.

4.3. Clinical and research implications

The overriding result of this study, that the evaluation of executive dysfunction requires a broad approach beyond structured cognitive testing, runs counter to the Stuss and Alexander [29] recommendations presented earlier. Although their model may be useful for diagnostic and heuristic purposes, it creates potential problems for professionals in work rehabilitation, because of its reliance on structured neuropsychological tests. Research on component function of what is essentially an integrative phenomenon poses a contradiction of types because the structured neuropsychological tests side-step several important neurobehavioral constructs in work rehabilitation, such as Mood and Affect Regulation, Aggression Regulation, Impulse Control, and Coping with Work Stress [10]. Additionally, because the basic structure of a neuropsychological examina-

Table 8
ANOVA of informant BRIEF scale scores by executive dysfunction

BRIEF Scale	Executive Function or dysfunction	N	Mean	SD	df	Mean square	F	Sig.
Inhibit	Dysfunction	22	59.2	12.1	1	21.82		
	Function	9	57.3	9.6	29	132.18	0.165	0.687
	Total	31	58.6	11.3	30			
Shift	Dysfunction	22	68.4	12.4	1	1167.53		
	Function	9	54.9	11.0	29	145.32	8.034	0.008
	Total	31	64.5	13.4	30			
Emotional control	Dysfunction	22	61.5	13.0	1	9.38		
	Function	9	60.3	12.2	29	163.29	0.057	0.812
	Total	31	61.2	12.6	30			
Self-monitor	Dysfunction	22	60.1	13.9	1	42.54		
	Function	9	57.6	9.4	29	164.23	0.259	0.615
	Total	31	59.4	12.7	30			
Behavioral regulation index	Dysfunction	22	63.7	13.4	1	149.52		
	Function	9	58.9	10.4	29	159.22	0.939	0.341
	Total	31	62.3	12.6	30			
Initiate	Dysfunction	22	67.0	13.1	1	390.91		
	Function	9	59.2	12.2	29	165.40	2.363	0.135
	Total	31	64.8	13.1	30			
Working memory	Dysfunction	22	73.5	12.7	1	110.89		
	Function	9	69.3	13.1	29	164.40	0.675	0.418
	Total	31	72.3	12.8	30			
Plan/organize	Dysfunction	22	67.9	12.7	1	1315.90		
	Function	9	53.6	15.9	29	186.21	7.067	0.013
	Total	31	63.7	15.0	30			
Task monitor	Dysfunction	22	68.2	13.4	1	837.29		
	Function	9	56.8	15.5	29	196.74	4.256	0.048
	Total	31	64.9	14.8	30			
Organization of materials	Dysfunction	22	57.9	13.3	1	723.27		
	Function	9	47.2	12.2	29	169.32	4.272	0.048
	Total	31	54.8	13.7	30			
Metacognition index	Dysfunction	22	70.2	13.6	1	989.94		
	Function	9	57.8	15.8	29	203.15	4.873	0.035
	Total	31	66.6	15.1	30			
Global executive composite	Dysfunction	22	67.8	14.2	1	574.60		
	Function	9	58.3	10.9	29	178.39	3.221	0.083
	Total	31	65.1	13.8	30			

tion presumes such a focus; “A major obstacle to examining the executive functions is the paradoxical need to structure a situation in which patients can show whether and how well they can make structure for themselves . . . most cognitive tests allow the subject little room for discretionary behavior“ [18, p. 612].

In the psychiatric literature and in the addictions literature there appears to be broader consideration of these issues. In a recent study, Bak et al. [6] studied the relationships among four cognitive variables that normally are considered components of executive function and the coping skills of persons with schizophrenia. They found no relationship among these cognitive variables and either quantity or quality of coping. It may be that their operational definition of executive function was too narrow (IQ, Trail Making, Zoo Map, and Stroop). These authors discuss the importance of considering mediation of coping for persons with schizophrenia to be a combination of narrowly considered cognitive impairment and affective processes. This research points to the importance of carefully defining executive function and balancing a narrow definition that is tied to established cognitive tests against a more broad definition that addresses behavior in the home and community. The importance of a broader approach is demonstrated in a study of executive dysfunction in patients with chronic alcoholism without amnesia. Ihara, Berrios, and London [16] supplemented a battery of neuropsychological tests with the *Behavioural Assessment of Dysexecutive Syndrome* [31] and found widespread impairment of everyday problem-solving in spite of preserved memory and intelligence. These researchers note that the focus in the DSM-IV [3] on cognitive dysfunction among persons with chronic alcoholism to diagnose either a persisting amnesic disorder or alcohol-induced persisting dementia "leaves the remaining 90% outside the scope of most neuropsychological studies". They argue for inclusion of measures of dysexecutive syndrome to appropriately account for disability in this population, which will be otherwise missed with a narrow focus on cognitive function. Because the dysexecutive syndrome is likely to be an adverse factor in the rehabilitation of these patients, it is important to develop new methods that are adequately sensitive.

This new emphasis is echoed in a broad review of the current status and likely future of assessment and treatment for persons with traumatic brain injury. Flanagan, Cantor, and Ashman [9] point to the importance of ecologically-valid neuropsychological assessment, arguing that the ability to identify dysfunction as it is demonstrated by the patient in the family and community is crucial. They describe several measures that are sensitive to executive dysfunction but point out that, because occupational roles have such diverse demands, the specificity of these measures is inherently lacking. They argue that a shift in the approach of neuropsychological testing to real-world application of test results is crucial. They point out that "this change in focus of the purpose of neuropsychological evaluation is extremely relevant in rehabilitation, where the primary goal is treatment planning rather than determining the type and location of cerebral abnormalities... interventions are designed and tailored to the individual and the primary role of the neuropsychological evaluation is to assess the likely implications of the findings on the person's ability to carry out daily activities".

Unfortunately, ecologically-valid measures are more time-consuming and may not be included in standard neuropsychological batteries due to cost, even when they are sensitive to real-world dysfunction that has been demonstrated to have a neuroanatomical basis. For example, Tranel, Hathaway-Nepple, and Anderson [30] found that the damage to the ventral medial prefrontal cortex was related to dysfunction in strategy application in an unstructured activity that simulated real-world demands. Dysfunction was demonstrated in comparison with participants who had prefrontal brain damage that did not involve the ventral medial prefrontal cortex and with persons who experienced brain damage that was non-prefrontal and with persons without brain damage. These researchers found that the intelligence and memory measures did not correlate significantly with the activity simulation, but found modest correlations between the neuropsychological tests (Wisconsin Card Sort Test and Trail Making) and performance in the activity simulation, suggesting that, while they do share common variance, "there is also a substantial degree of non-overlap". However, they reported that the activity simulation was "somewhat time-consuming and effortful" and expressed doubt over whether the additional diagnostic information would be sufficient to justify their inclusion in a standard clinical assessment.

The potential contribution of ecologically-valid measures of executive dysfunction is supported by Wolf and his colleagues [32] who studied a work-related assessment of dysexecutive syndrome developed to evaluate persons with higher-level cognitive processing deficits. These researchers found that the *Complex Task Performance Assessment* results significantly differentiated between persons with mild stroke and matched controls in terms of task monitoring and performance efficiency, even though there were no significant differences between the participant groups in terms of a neuropsychological test battery that had been designed to measure the components of executive dysfunction.

The differences between a global approach and a component approach are logically related to the different purposes of professionals involved with persons who have experienced brain injuries. Professionals who focus on diagnosis and find neuroanatomical impairment important are more likely to take a component approach, while professionals who focus on functional limitations and disability are more likely to take a global approach. These differences are inherent in the study of executive dysfunction, with the current study supporting the global approach and a broadening of the definition of executive function so that problems with work disability can be identified and either remediated or accommodated. New measures that are ecologically valid must be developed. In the interim, this study demonstrates that informant-report measures of executive dysfunction can be used to reliably increase the validity of neuropsychological assessment in terms of work disability.

The demonstrated utility of the informant-report version of the *BRIEF* is especially important to occupational therapists, speech and language therapists, and physical therapists who are working with patients soon after the onset a brain injury. The family's ability to identify problems with executive dysfunction can be harnessed inexpensively and without immediate need for a comprehensive neuropsychological evaluation. Recall that, although the participants in this study continued to have problems with work disability 4 years after injury, 78% had not received more than 1 to 2 weeks of rehabilitation services. Perhaps the use of the *BRIEF* informant-report would identify more patients who require ongoing rehabilitation. It may also be helpful to educate primary care physicians to screen for executive dysfunction; the *BRIEF* items are straightforward and provide good operational definitions of the nine clinical types of executive dysfunction that it is designed to identify.

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