Measurement of Problem-Solving Deficits in Adults with Acquired Brain Damage

Objective: To compare the relative utility of conventional neuropsychological and social problem-solving approaches to measuring functional problem solving deficits in individuals with acquired brain damage (ABD). **Design:** In Study I, scores for individuals with ABD were compared to scores for control and normative samples. In Study II, pre- and posttest scores were compared for individuals with ABD who completed a program of outpatient cognitive rehabilitation. **Participants:** In Study I, individuals with ABD were compared to healthy controls. In Study II, pre- and posttreatment assessments were obtained for 34 individuals with ABD. **Main Outcome Measures:** Two approaches were used, conventional neuropsychological (WAIS-R/II Comprehension subtest and Wisconsin Card Sorting Test) and social problem solving (Problem Solving Inventory and Rusk Problem Solving Role Play Test). **Results:** In Study I, the ABD group demonstrated significant deficits on both social problem solving measures; however, neither conventional neuropsychological measure detected significant deficits in the ABD group, relative to control and normative groups. In Study II, significant treatment gains were demonstrated on both social problem-solving measures, however neither conventional neuropsychological measure was sensitive to improvements in functional problem-solving ability. **Conclusions:** In higher-level cognitive rehabilitation settings, the evaluation of functional problem-solving deficits in individuals with ABD can be facilitated by augmenting neuropsychological test data with results from social problem-solving measures. Key words: *brain injuries, neuropsychology, problem solving*

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INDIVIDUALS with acquired brain damage (ABD) due to traumatic brain injury (TBI) or stroke tend to exhibit similar deficits in everyday functional problem-solving ability.[1] Beginning with Luria's[2] seminal observations, researchers consistently have noted that people with TBI have difficulty analyzing problematic situations. After TBI, the ability to identify important relationships and connections may be impaired, and the preliminary step of investigating the conditions and constraints of problems often is omitted or truncated. As Luria noted, the system of cognitive

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operations that usually leads to the solution of a problem may be disrupted and systematic intellectual processes replaced with impulsive actions.[3] In rehabilitation settings, Luria's observations about people with TBI have been extended to include individuals with stroke who exhibit nonlateralized neuropsychological profiles.

How problem-solving deficits can impair real-life functioning is easy to understand. For example, people with ABD may encounter difficulties performing everyday tasks such as organizing the preparation of meals, scheduling and keeping appointments, and prioritizing and paying bills.[4] Because intact problem-solving abilities are necessary to maintain a home, function in the community, and/or return to work,[5] researchers have noted that problem-solving deficits can prevent individuals with ABD from returning to productive personal and vocational lives.[1] Several authors have suggested that the remediation of problem-solving deficits should be a primary goal in the cognitive rehabilitation of individuals with ABD.[6]

Although researchers have linked problem solving to the frontal lobes, specific neuroanatomical correlates for problem-solving abilities are difficult to identify.[7,8] Higher-order mental operations, such as problem solving, are not localized to circumscribed areas of the brain.[2] Instead, complex mental processes exist as interrelated cognitive subsystems diffusely represented in the brain, and disruption of any number of neurological systems may lead to deficits in problem-solving ability.[3] In fact, although real-life functional problem-solving deficits are common in individuals with less severe brain injuries, modern neuroimaging techniques indicate that diffuse axonal damage is the major form of neuropathology in this population.[9]

Within a traditional neuropsychological framework, problem-solving deficits have been approached as impairments in executive functions (ie, the selection and execution of cognitive plans) and/or impairments in the cognitive aspects of social judgment and comprehension (ie, understanding social situations, knowing what is appropriate or inappropriate, and applying reasoning to social situations). Attempts to assess problem-solving deficits have typically utilized tests of social judgment such as the Wechsler Adult Intelligence Scale-R/III (WAIS-R/III)[10,11] Comprehension subtest and tests of executive functioning such as the Wisconsin Card Sorting Test (WCST) [12]

Real-life functional problem-solving deficits, however, are difficult to assess with traditional neuropsychological measures, and discrepancies between the results of conventional tests and clinicians' observations regarding real-life problem-solving deficits are common. Scores on standard neuropsychological tests may misrepresent everyday functional behaviors.[13] In addition, evidence exists that normal-level test scores do not necessarily indicate full recovery from injury.[14] As Varney and Menafee aptly noted of individuals with frontal-orbital cortex injuries, "even the most state-of-the art testing fails to identify the manifestly disabled 50% of the time or more."[15] Conventional neuropsychological methods of assessment thus are of limited value in devising interventions for improving real-life problem-solving behavior or for evaluating the effectiveness of cognitive rehabilitation programs geared toward the remediation of everyday functional problem-solving deficits.[16]

Considerable concern has been raised about the ecological validity of neuropsychological tests because of difficulty generalizing from samples of behavior several steps removed from behaviors generated in specific real-life contexts.[17] In discussing the limited utility of conventional tests for measuring deficits in complex neuropsychological functions, Lezak[18] noted that the

task requirements of standard tests are highly structured, well-defined, impersonal, and emotionally neutral. In contrast, real-life problems are unstructured; their conditions and constraints must be defined, interpersonal pressures must be managed, and emotional reactions must be regulated. Similarly, Galotti[19] distinguished between tests of formal logic and everyday reasoning. Tests of formal logic involve the identification of fixed solutions to closed-end problems, but in contrast, everyday reasoning is less structured and involves going beyond the information given. Structured tests are insensitive to deficits in the diffuse cognitive operations that underlie such everyday, real-world functions. Thus, while conventional neuropsychological tests provide objective scores that can be matched against norms, these tests may not adequately represent behaviors that occur in natural or less contrived settings.

Higher-level cognitive remediation typically is directed toward the rehabilitation of real-world functional behaviors. Therefore, the goal of assessment in rehabilitation settings is to accurately describe the individual's functional status and underlying cognitive deficits within a framework that facilitates the generation of effective rehabilitative strategies. One approach to the problem of poor ecological validity has been to develop test items that sample the content of the domain in question. For example, the Rivermead Behavioural Memory Test incorporates items from real-world tasks in addition to the decontextualized tasks of conventional memory tests.[20] Others have attempted to study executive functions by examining real-life behaviors such as meal preparation or gift wrapping in controlled settings.[21]

Although most studies of individuals with ABD have investigated problem-solving deficits from a neuropsychological perspective,[4] social-behavioral approaches may provide valuable additional information. One such approach is D'Zurilla and Goldfried's[22] social problem-solving model. This model has proven useful for the conceptualization, development, and evaluation of rehabilitative interventions in a variety of medical and rehabilitation populations. For example, measures of social problem-solving ability have been related to health expectancies and complications in surgical patients, and to levels of depression, psychosocial impairment, caregiver acceptance of responsibility, and pressure sore occurrence in adults with spinal cord injury.[23,24]

As noted by D'Zurilla, Maydeu-Olivares, and Kant,[25] the construct of social problem solving deals with all types of problems in living, including intrapersonal/nonsocial problems, impersonal problems, interpersonal problems, and broader community and societal problems. The adjective "social" does not restrict problem solving to any particular domain, but instead indicates that problem solving occurs in the everyday social environment and that all real-life problem solving is likely to have social implications. Social problem solving has been conceptualized as a process involving five recursive and interacting skills:

- Problem-solving orientation (ie, maintaining a rational and adaptive attitudinal, motivational, and affective approach to everyday problems);
- Problem definition and formulation (ie, identifying the conditions and constraints of a problem and setting realistic goals);
- Generation of alternatives (ie, brainstorming a range of possible alternatives);
- Decision making (ie, examining the potential consequences of options and selecting one that is optimal given the conditions and constraints of the problem); and

- Solution implementation and verification (ie, carrying out the solution, monitoring its effectiveness, and making modifications as necessary).[22]

Although people with ABD may have impairments in any of the five steps identified in the social problem-solving model, with the notable exception of work by Kendall, Shum, Halson, Bunning, and Teh,[26] remarkably little research investigating the measurement of social problem-solving deficits in persons with ABD has been published to date.

In this paper, the relative merits of various methods for assessing functional problem-solving deficits in a higher-level outpatient cognitive rehabilitation setting were investigated in two related studies. In Study I, conventional neuropsychological measures (ie, WAIS-R/III Comprehension and WCST) were compared to social problem-solving measures for their ability to detect functional problem-solving deficits in individuals with ABD relative to healthy controls. In Study II, sensitivity of the various measures to improvement in functional problem-solving ability following higher-level cognitive rehabilitation was evaluated.

METHOD

Participants

All participants with ABD met prescribed minimum criteria for inclusion in higher-level cognitive remediation groups on the Neuropsychology Service of the Outpatient Psychology Department of the Rusk Institute of Rehabilitation Medicine, New York University (NYU) Medical Center. These criteria include the ability to sustain attention for an hour-long session, take organized notes, give and receive feedback, state strengths and weaknesses, and relate to others with adequate social skills. All participants with ABD had documented impairments in social/vocational functioning, but potential participants who exhibited active substance abuse, psychosis, deteriorating neurological conditions, or severe lateralized deficits (ie, left visual neglect or aphasia) were ineligible for inclusion in the studies.

Study I

Participants in Study I were 44 individuals with ABD and 83 healthy controls without ABD, all between the ages of 21 and 65 years. The ABD group consisted of 20 men and 24 women (33 were White, 5 Black, 2 Hispanic, and 4 Asian), who all were at least one year post-ABD. Thirty-six individuals sustained their brain damage as a result of TBI and eight due to stroke. The mean period post-ABD was 2.9 years (SD = 2.8, range, 1.0 to 17.6). The mean age for the ABD group was 43.7 years (SD = 11.0; range, 23 to 64), and the mean level of education was 15.7 years (SD = 2.5, range 11 to 20).

The non-ABD controls represented a sample of convenience recruited from the community. Participants included friends of individuals in the ABD group, as well as students, staff members, and trainees from various programs at NYU Medical Center. None of the participants exhibited neurological problems, overt physical disabilities, psychiatric conditions, or active substance abuse. A subset of 74 controls completed a social problem-solving self report measure; this group consisted of 28 men and 46 women (53 were White, 4 Black, 3 Hispanic, 11 Asian, and 3 other). The mean age was 26.4 years (SD = 9.3, range = 21 to 58 years), and the mean level of education was 15.9 years (SD = 1.4, range = 12 to 20). A subset of 18 controls completed the conventional neuropsychological measures; this group consisted of 7 men and 11 women (12 were White, 2 Black, 3 Asian, and 1 other). The

mean age for this group was 38.3 years (SD = 10.6, range = 24 to 58 years), and the mean level of education was 16.2 years (SD = 2.5, range = 12 to 20). A subset of 11 controls completed a role-play based measure of social problem solving; this group consisted of 4 men and 7 women (10 were White, 1 other). The mean age for this group was 36.9 years (SD = 13.0, range = 23 to 58 years), and the mean level of education was 16.3 years (SD = 2.5, range = 12 to 19).

Study II

Participants in Study II were 34 individuals with ABD, 21 men and 13 women (24 were White, 4 Black, 3 Hispanic, and 3 Asian). The mean age was 44.8 years (SD = 13.8; range, 23 to 79), and the mean period post-ABD was 2.5 years (SD = 1.6, range, 0.6 to 7.7). Twenty-two participants sustained their brain damage as a result of TBI, 11 as a result of stroke, and 1 due to other neurological conditions. The mean level of education in Study II was 15.6 years (SD = 2.3, range 11 to 20).

Measures

The Problem Solving Inventory[27] (PSI) is a self-report measure of social problem solving that has been used in more than 100 published studies. The PSI consists of 32 six-point Likert-type items, derived from D'Zurilla and Goldfried's[22] model, in which subjects are asked to agree or disagree with statements describing their problem-solving behaviors and attitudes. The PSI has high discriminant validity with measures of intelligence and social desirability and convergent validity with behaviors and attitudes, such as locus of control, typically associated with problem solving. Reliability estimates indicate that the PSI is internally consistent (alpha = .90) across a number of populations and cultures and that it is temporally stable (r = .89) over a two-week period.[27] Although scores corresponding to three factor scores can be computed, the PSI total score is the most commonly used metric.[28]

The Rusk Problem Solving Role Play Test[29] (RPSRPT) is a functional assessment measure that consists of five brief scenarios representing the domains of family life, work/school, and friendship previously identified as important components of everyday life for persons with ABD.[30] The RPSRPT elicits real-world functional problem-solving behaviors while being sufficiently standardized to capture a focused domain of responses on videotape. In contrast to the predefined goals set forth in traditional neuropsychological tests, the goals in each scenario of the RPSRPT must be defined by the subject. The subject also must elicit, from a trained confederate, key information crucial to resolving the problem. Thus, as in real-life, the resolution of the problem is dynamic, arising from the subject's interaction with the environment. The RPSRPT is reliable (interrater reliability = .96) and temporally stable (two-week test-retest reliability = .99). Support for the construct validity of the RPSRPT was found in its high correlation with experienced clinicians' global ratings of patients' functional problem-solving ability (r = .85).

The Wisconsin Card Sorting Test[12] (WCST) perseverative response score is used extensively in rehabilitation settings as an indicator of problem-solving ability in individuals with ABD.

The WAIS-R/III Comprehension subtest[10,11] commonly is used in rehabilitation settings to measure social judgment relevant to everyday problem-solving ability.

Procedure

Study I

Data were collected during the course of an ongoing program of study designed to investigate the nature of problem-solving

deficits in adults with ABD. Independent *t*-tests were calculated to examine pretreatment differences between the ABD and control groups on the four problem-solving measures. In addition, comparisons were made to normative values where available, using one-sample *t*-tests. (For WAIS-R/WAIS-III Comprehension subtest and WCST, comparisons were made to overall mean values for US census-matched normative samples.[10-17] For the PSI, a comparison was made to the mean value reported for adults with spinal cord injury[23].) To minimize Type 1 error, an alpha level of .01 was adopted for the analyses.

Study II

Pre- and post-treatment data were collected from successive cohorts of individuals with ABD who participated in a six-month outpatient program of higher-level individual and group cognitive rehabilitation. Four paired-sample *t*-tests were calculated to examine pre- and post-treatment test scores for individuals with ABD who completed a six-month outpatient program of higher-level individual and group cognitive rehabilitation.

RESULTS

Study I

Table 1 summarizes the means and standard deviations, and corresponding effect sizes, for the ABD, control, and normative groups on the four measures. On the two conventional neuropsychological measures (ie, WAIS-R/III Comprehension, WCST), the ABD group performed near or above the mean of both the normative and control groups. In fact, as can be seen in Table 1, compared to the overall US census-matched normative value, the ABD group performed significantly *above* the mean on the WAIS-R/III Comprehension subtest ($t = 6.59$, $p < .001$).

Table 1. Mean scores on problem-solving measures for ABD, control, and normative groups

	ABD			Control				Normative*		
Measure	**n**	**Mean**	**(SD)**	**n**	**Mean**	**(SD)**	**ES**	**Mean**	**(SD)**	**ES**
WAIS	43	12.51	(2.50)	17	12.88	(3.06)	.13	10.00	(3.00)†	−.91
WCST	42	12.60	(12.14)	18	10.78	(10.15)	−.16	15.78	(16.57)	.22
PSI	41	97.66	(36.14)	74	73.26	(19.09)†	−.83	72.46	(20.79)†	−.86
RPSRPT	20	102.25	(28.05)	11	130.55	(24.45)‡	1.08			

*Normative values for the WAIS and WCST are overall mean values for US census-matched samples.[10-12] Normative value for the PSI is for adults with spinal cord injury (n = 90).[23]

† $p < .001$.

‡ $p < .01$.

WAIS = WAIS-R/III Comprehension subtest age-corrected scaled score; WCST = WCST perseverative error score; PSI = Problem Solving Inventory total score; RPSRPT = Rusk Problem Solving Role Play Test total score. Higher scores indicate better performance on WAIS and RPSRPT. Lower scores indicate better performance on PSI and WCST.

Table 2. Mean pre- and post-treatment scores on problem-solving measures

		Pre		Post		
Measure	**(n)**	**Mean**	**(SD)**	**Mean**	**(SD)**	**ES**
WAIS	(29)	12.45	(2.03)	12.79	(2.24)*	.16
WCST	(27)	11.55	(8.66)	9.96	(8.34)*	−.19
PSI	(31)	103.34	(39.03)	90.69	(32.43)†	−.35
RPSRPT	(14)	111.21	(32.03)	127.36	(35.87)†	.47

*not significant.
†$p < .05$.
WAIS = WAIS-R/III Comprehension subtest age-corrected scaled score; WCST = WCST perseverative response score; PSI = Problem Solving Inventory total score; RPSRPT = Rusk Problem Solving Role Play Test total score. Higher scores indicate better performance on WAIS and RPSRPT. Lower scores indicate better performance on PSI and WCST.

In contrast, on the two social problem-solving measures, the ABD group demonstrated significantly more deficits than either the control or normative groups. As can be seen in Table 1, the ABD group obtained significantly poorer scores on the PSI compared to the control group ($t = 4.01$, $p < .001$) and compared to a normative group of adults with spinal cord injuries ($t = 4.46$, $p < .001$). In addition, the ABD group performed significantly below the mean of the control group on the RPSRPT ($t = -2.81$, $p < .01$).

Study II

Table 2 summarizes the pre- and post-treatment means and standard deviations, and treatment effect sizes, for the four problem-solving measures. The two conventional neuropsychological measures were not sensitive to improvements in functional problem-solving ability following outpatient cognitive rehabilitation. In contrast, significant improvements were demonstrated on the social problem-solving measures following treatment. Treatment gains in functional problem-solving abilities were reflected on both the PSI ($t = 2.12$, $p < .05$) and the RPSRPT ($t = -2.50$, $p < .05$).

DISCUSSION

Individuals with ABD who participate in higher-level outpatient cognitive rehabilitation programs sometimes perform within normal limits on conventional neuropsychological measures of problem solving, but exhibit deficits in real-life problem-solving ability. These deficits can lead to substantial impairments in self-determined behaviors and activities of daily living, rendering these individuals functionally disabled. The discrepancy between test performance and real-life behavior suggests that rehabilitation psychologists cannot rely on data from neuropsychological tests alone, but instead must supplement such data with information from other sources.

This study demonstrated that evaluation of functional problem-solving deficits can be enhanced by using social problem-solving approaches to augment neuropsychological test data. Specifically, it was found that: (1) functional assessment (RPSRPT) and self-report (PSI) measures can identify deficits in

problem-solving ability that are undetectable with conventional neuropsychological tests; and (2) these social problem-solving measures are sensitive to improvements in functional problem-solving ability to which traditional neuropsychological measures are generally insensitive.

The utility of the self-report data is consistent with recent reports in the literature which suggest that self-report in individuals with ABD—particularly those with less severe deficits—may be more meaningful than previously reported and therefore a potential source of valuable information.[31,32] These findings also are supportive of the recent empowerment movement, in which researchers and clinicians have advocated for greater consideration of the self-report of individuals with disabilities. Reflecting changing perceptions about the value of patients' perspectives, and in accordance with Commission on Accreditation of Rehabilitation Facilities (CARF) standards of care, people with ABD are being given an increasing role in treatment planning. The current findings contribute to the empirical basis for the trend toward increased consideration of patients' self-report, especially in higher-level outpatient cognitive rehabilitation.

From a remediation standpoint, the PSI's virtue is that it elicits the individual's acknowledgment of functional difficulties within a model that provides a framework for guiding remedial efforts. The PSI is thus an appropriate tool for use in outcome-driven cognitive rehabilitation (ie, rehabilitation directed toward specified goals relevant to the person with ABD).[33] However, although individuals with ABD should, and can, play a role in determining rehabilitation goals, difficulties can arise if there are disagreements between the person with ABD and clinicians about appropriate goals. This is apt to occur when individuals with ABD are unaware of their deficits. In such circumstances, an array of indicators—including neuropsychological, observational, and self-report data—can be combined to develop an individual profile. In this context, objective functional assessment measures such as the RPSRPT may prove useful.

The differential utility of conventional neuropsychological and social problem-solving measures for assessing functional problem-solving deficits may be a reflection of intrinsic differences in the two theoretical approaches. Within a neuropsychological framework, conventional neuropsychological tests focus on the cognitive infrastructure of problem solving and involve finding fixed solutions to specified problems. Neuropsychological measures therefore do not tap the motivational, attitudinal, or affective aspects of real-life problem solving. In contrast, within a social problem-solving framework, motivational, attitudinal, and affective factors (ie, "problem-solving orientation"[22]) are crucial aspects of problem solving. Thus, these factors form an integral component of social problem-solving approaches to assessment.

Ben-Yishay and Prigitano[6] indicated that improvement of problem-solving skills should be a major goal of cognitive rehabilitation. However, the current findings suggest that the concept of "problem solving" is imprecise and requires clarification. Further research is needed to examine the relationship between the cognitive infrastructure of problem solving; the motivational, attitudinal, and affective components of social problem solving; and the pragmatics of everyday real-life functional problem solving.[34] The potential utility of the social problem-solving model as a framework for the conceptualization, development, and evaluation of higher-level cognitive rehabilitation strategies also should be explored.

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