J Head Trauma Rehabil
Vol. 22, No. 1, pp. 48–55

Models of Exceptional Adaptation in Recovery After Traumatic Brain Injury: A Case Series

Larry E. Schutz, PhD, ABPP

Objective: The remarkable persistence of disablement in chronic traumatic brain injury and the dearth of accommodation define the condition as a disorder of adaptation. This construct is extended to explain exceptional recoveries after postacute treatment. **Method:** Nine severely injured graduates of holistic cognitive rehabilitation were selected for their exceptional postmorbid academic, vocational, and social accomplishments. **Results:** In interviews, they attributed their successes to continuing reliance on, and ongoing elaboration and modification of, cognitive compensation strategies. Unlike their disabled cohorts, they implement a deliberate procedure for self-corrective self-management that minimizes the functional impact of their permanent deficits. **Keywords:** *acquired brain injury*, *adaptation*, *central executive*, *cognitive rehabilitation*, *executive functions*, *head injury*, *neurorehabilitation*, *rehabilitation outcome*, *supervisory attentional system*, *traumatic brain injury*

DEFECTIVE ADAPTATION is a prominent residual of traumatic brain injury (TBI): Survivors cling to their habitual action schemata even though acquired neurocognitive deficits render them grossly inadequate.[1,2] While early recovery restores physical competencies for activities of daily living, cognitive/behavioral deficits[3] endure to impose continuing disability.[4–6] The residual defects are almost never self-corrected even years later, nor are goals and expectations reset to permit pursuit of more modest, attainable objectives.[7,8] As such, the adaptative deficiency can be described as TBI's core long-term consequence, the ultimate cause of persisting disability.

Resumption of adaptation is widely described as the ultimate goal of rehabilitation.[9–12] Cognitive remediation, in its most sophisticated, intensive form, restores adaptive skills well enough to allow half of its graduates to return to mainstream employment.[13–15] A few achieve and maintain unusually effective, comprehensive adaptations. This article presents 9 such extreme cases. Each was taught compensation strategies specifically targeting adaptative functions, and each one continues to rely on these strategies to pursue personal goals many years later. These exceptional individuals demonstrate that a surprisingly high level of recovery can be attained.

ADAPTATION AND TBI

Adaptation has been described as the central purpose of life and the standard of behavioral fitness, a concept so thoroughly integrated into modern psychology that it is often an unspoken assumption. Herbert Spencer's pioneering texts on psychology and other social sciences describe adaptation's 3 major facets: maximizing long-term happiness (instrumental), advancing the happiness of kin and comrades (social), and enhancing abilities and actualizing potentials (developmental).[16,17] Major figures in the history of psychology elaborate these concepts, specifying that the mind sets goals, plans, and problem-solves to optimize the pursuit of opportunities while maintaining vigilant protection against risks and emergent hazards.[18–20]

A more detailed model of adaptation emerges from advances in theoretical neuroscience. Most organisms depend on a system of conditioned adaptive habits to pursue the particular opportunities for gratification afforded by their environmental niche.[21] Discrimination learning tailors these automatized "default" responses[22] to meet highly specific, predictable patterns of task demand.[23,24] Virtually the entire behavioral repertoire is programmed

From the Departments of Speech Sciences and Communication Disorders and Psychology, University of Central Florida, Orlando, and GiveBack, Inc., Orlando, Fla.

Some case material in this article is abstracted from case studies presented at the National Academy of Neuropsychology's annual conference in Tampa, Fla, in 2005, and in L. Schutz and M. Schutz (unpublished data, 2006).

Corresponding author: Larry E. Schutz, PhD, ABPP, Communication Disorders Clinic, Research Pavilion, 12424 Research Pkwy #155, University of Central Florida, Orlando, FL 32828 (e-mail: edsyke@earthlink.net).

and implemented in this automatized manner, even in humans.[25]

A second, more intentional process intervenes when the habitual response is incomplete or insufficiently skilled to ensure success (as in a novel situation), or incurs unacceptable risk of harm.[26] The recursive feedback loop interconnecting the most advanced afferent and efferent processing centers[23,27] (sometimes labeled as the central executive,[28] the supervisory attentional system,[26] or the cognitive cycle[29]) monitors to anticipate these situations and tests alterative or innovative plans to upgrade any adaptively inadequate default response.[30,31] This network not only mediates instrumental problem-solving and the learning of new skills but also monitors and applies the complex stream of social signals cuing expected conduct.[5,27,32,33]

Most assume that the enduring sequelae of TBI are maladaptive. Some distinguish high-level cognitive[32,34,35] or executive impairments[27,33] as particularly damaging to adaptation:

> If behavior is not planned it becomes purely responsive and impulsive, lacking in thought and judgment; behavior will be unpredictable and inconsistent; life will be stressfully disorganized; there will be poor management of problems that require carefully planned solutions, even everyday things like money management; and there will be greater reliance on old, well-established plans, upon which there will be perseveration. If hypothesis-testing behavior is difficult then patients will fail to make proper use of evidence, totally undermining rational, logical action and accurate perception both of the environment and of themselves.[36(p198)]

The absence of insight precludes self-correction, which preserves this maladapted state.[37]

The extent of the adaptive loss is revealed by long-term outcome research: As few as 10% of survivors maintain jobs and friendships through the second decade.[38–41] Most could find new work or friends, but they fail to exchange their preinjury expectations[42] for lowered ones that could be viable.[28] Thomsen[43] followed a cohort of discharges for 20 years, noting their lack of progress in solving their postmorbid problems or rebuilding their empty lives. Many veteran clinicians specify that chronic survivors almost never show any adaptation to disability.[7,12,44]

Most treatises on TBI attribute the executive and other higher cognitive sequelae to frontal lobe contusions, but this localizationist explanation accords poorly with current theories of brain organization as well as with the clinical facts.[2,28,45] Partial disconnection of the central network is expected after diffuse trauma,[46] and the signal degradation that results is sufficient to halt the network's recursive cycling,[4,47,48] imposing a full dysexecutive syndrome.[49,50] Diffuse injury also slows and disorganizes the execution of habitual, automatized responses.[51,52]

This partial disconnection syndrome has profound implications for TBI rehabilitation: If the network's processing stations remain intact, function can be restored by simply activating the dormant network.[53] The network's anterior (prefrontal) work station, which orchestrates adaptive responding,[54,55] evolved from and remains yoked to other efferent structures, including the basal ganglia, anterior cingulate, and supplementary motor area, allowing them to work in tandem to activate responses.[56,57] In turn, the activation of the entire anterior system is controlled by effort level, adjusted via a pathway extending from the hippocampus.[58] Consequently, recalling that the present situation requires extreme effort can trigger hyperactivation of the anterior cortex, charging it to slowly "walk" through the steps of careful planning.[59] By substituting a hyperactivated, meticulously implemented response in place of the impulsive release of a dysexecutive symptom, a survivor reverses disability.[27,41,47] As an example, adults whose chronic attention deficit/hyperactivity disorder is under good symptom control show this pattern of hyperactivation on functional magnetic resonance imaging.[60] On this basis, a rehabilitation protocol that teaches a patient to anticipate when to recruit very high levels of effort should restore adaptation.

COGNITIVE REHABILITATION METHODOLOGIES FOR ADAPTATION

Pioneering TBI programs reconditioned overlearned habits for greater quality control, upgrading activities of daily living to full functionality; however, these gains were sharply delimited by the habitual system's very low level of response generalization.[61] Widespread restoration of more complex functions such as competitive employment awaited the direct treatment of cognitive processes, as developed by the National Head Injury Program of Israel in 1974.[6] This program and its diverse second-generation variants have achieved impressive success in building insight, motivation, and effort by saturating trainees with evidence and peer feedback about deficits, integrated through psychotherapy.[2,30] Cognition is addressed by multiprocess compensatory models[10,37] focused sharply on the attentional and executive impairments.[28,30] Approximately half of the graduates prove sufficiently motivated and insightful to resume competitive employment and to retain it over an extended follow-up interval,[13,14] suggesting that this treatment has made inroads into improving adaptive abilities.[38]

Unfortunately, this adaptative recovery is usually incomplete: The full, recursive process of the central network is neither restored nor fully replaced.[29] Competent self-management requires a consistent, accurate anticipation of likely errors and personal flaws, which is rarely

achieved.[2,28] Most of the successful graduates show adequate anticipation, preparation, planning, execution, and self-monitoring in only a limited range of situations and/or tasks.[29]

The third-generation program in which the subjects of the present study were treated retained the insight-training model and the compensatory training of cognitive processes. It provided systematic training in the use of external aids for memory and time management. It also introduced a specific procedure to restore the central adaptive skills of self-monitoring, self-correction, and self-management. The first step, Targeted Deficit Recognition Training, identifies and labels a set of prototypic errors (such as responding automatically without preparatory planning, rushing, or becoming overloaded by excessive arousal, each linked to its own specific compensation strategy) made during massed response-selection exercises. Simple procedural learning and associative conditioning thus create habits to monitor, identify, and correct each deficit in the clinic.[62] The second step, Error Analysis, chains these responses to the use of a printed checklist for recording the errors and selecting strategies to prevent their recurrence. The third step, Targeted Situation Recognition, uses these records to induct a list of contexts in which the errors occur so that anticipatory self-triggers for these situations can be programmed into the corrective plans. The fourth step, Team Meetings, reviews the checklists for quality control, follows up the error-prevention results adjusting strategies accordingly, and adapts the checklists to pursue short- and long-term personal goals. Patients are called self-therapists, taught to watch ardently for their errors, prescribe their own self-corrective procedures, and review and revise their methods continuously to upgrade the quality of their adaptive repertoire. The team meetings begin in therapy group but are transferred to the family at the time of graduation. The response to these assignments varies across subjects, as with other aspects of cognitive rehabilitation, but most patients and family members recognize by the second month that once-common mistakes are not being repeated and that the survivors are assuming some control over their own recoveries.

The overall success of this third-generation program proved comparable to that of the second-generation programs after 5 years of operation, with 50% retention of competitive jobs at 18-month follow-up. In addition, program revisions mandated by changes in the healthcare marketplace slightly improved the competitive employment rate while reducing contact hours by 80%.[28] The revised model placed greater emphasis on self-therapy as the basis for recovery, shifting much of the training activity to home practice with family assist.

While the most frequent response to therapy was typical for a mature, holistic program, some of the most successful trainees achieved unusually complete recoveries, both in terms of the quality of their real-world functioning and their adaptive skills *per se*. In preparing a manuscript on TBI recovery, the author interviewed 9 of the 12 most exceptional graduates (selected from a follow-up sample of 204) to provide a phenomenological perspective on highly successful recovery. These 9 cases (4 from the original and 5 from the streamlined program) are presented below.

CASE SERIES

Case 1

This college student sustained a left frontal contusion in a high-speed bicycle crash and remained in coma for 11 days, followed by markedly disinhibited behavior. After therapy, she completed college with a 4.0 grade point average and then resumed her job as a wellness instructor. Nine years later, she became a middle-school teacher and was recently nominated for Teacher of the Year. She married a man she met during her recovery and has 2 children. She has also won toastmaster competitions. At 15 years postonset, she lists her current deficits as impulsivity and impaired organization, memory, and visual information processing.

I learned to be compulsive about thinking ahead . . . I've learned to be careful about what I say—to the kids, the parents, my coworkers . . . It's become a habit to keep my guard up all the time . . .You have to admit the areas of your deficiency or you can't get better . . . My memory would be a problem for me now if I let it, but I use my methods of organization to handle it . . . I have to try harder than ordinary people to get everything done correctly, to be aware of myself and my actions. I have to have higher standards than other people do . . . I've learned [to] be prepared for anything, do your best, learn from your mistakes to improve yourself . . .You make a plan for how you're going to [control symptoms], and a backup plan, and a backup plan for that . . . You can keep working on it and you can get better and better, and it gets easier to do . . . It's not like you finish a race and you're done—you're never done; you can't say "I've conquered this." You conquer it as you go.

Case 2

In a motor vehicle accident, this 40-year-old, high-school-educated carpentry subcontractor suffered left frontal, temporal, and parietal contusions and emerged from 3 days of coma with global aphasia, severe amnesia, and dense left hemiparesis. After graduation, he earned a BA in business with honors and is completing another in speech therapy with highest honors. He recovered without significant family support. At 11 years postonset, he acknowledges deficits in memory, planning, processing speed, and expressive and receptive language and susceptibility of cognition to emotional overload.

I'm driven by my desire to overcome my impairments and limitations, by my desire to be a complete person again. It

comes down to being tough-motivated, strong, disciplined, accept small steps in your recovery, [and] learn from your mistakes . . . I try to get myself well prepared to speak clearly before I start talking . . . I've learned to take more time to think about what I'm going to do before taking any action. I inspect and review my plans to make sure they're adequate . . .You have to learn to do things the best that you can do them, which involves doing them a different way. You have to be willing to try new methods of doing everything until you find a method that fits you. Every day, I realize there is room for improvement in my methods—a better way of doing things . . . on my drive home from school, and when I'm jogging, I review my life, and see what I've done well and what I need to do better. I come upon a lot of things I want to improve on. I even do it at home, when I'm walking around the house. When I get negative feedback, I . . . use it as motivation to work on myself.

He faithfully uses emotional control procedures and the program's academic strategy set: tape-recording and transcription, underlining, outlining, and self-testing. He has found a way to jog by hiking his hip and locking the left knee, using it to finish a half-marathon. He plans to study for his MA in speech and to specialize in working with autistic children.

Case 3

An auto accident produced a coma of 2 days, multiple left frontal contusions and a small right parietal contusion, associated with right hemiparesis, expressive speech deficits, impulsivity, perseveration, stimulus boundness, and ataxia. After returning to work as a junior executive at a theme park, this 30-year-old was promoted to open and manage a new, high-tech department. Another Fortune 500 company hired her to manage an innovative Internet service. After working as statewide marketing director for a nonprofit youth program, she was rehired by her previous company to manage still another new high-profile, high-tech service. She has a large circle of friends and is dating but has not found a partner. At 11 years postonset, she identifies continuing impairments in memory, planning, organization, expressive speech, and social perception.

Preparing . . . has been a key to my success in the workplace . . . I role-play a big conversation . . . When I don't get enough sleep, or when I get too hungry, or when I've allowed myself to have too much caffeine, I get moody, I don't think as clearly . . . I can avoid these problems when I'm careful, and my goal is to make myself careful more consistently . . . I told myself not to try to do so much at one time . . . I took myself to task in terms of mental quality control. I triple-checked everything I did . . . . Even today, more than ten years later, I still question my perceptions of people and situations . . . Therapy . . . taught me the compensation strategies that I have fine-tuned over the years and incorporated into my life. Everything I do today depends on those strategies. It's become so natural that I am not even aware of "using strategies"any more, but there is not a day, and probably not an hour, that goes by without my employing a compensation strategy . . . I think this is why I feel compelled to make everything perfect—because if it's perfect, it can't be defective or impaired . . . No matter how small, I didn't want to fail . . . I prefer to plan so that I know what is going to happen and can anticipate challenges.

Case 4

This high-school honors student returned to earn straight As after a motor vehicle accident resulted in left parietal contusion and intraventricular bleed and being in coma for 17 days. Testing revealed severe verbal comprehension and memory deficits. She will graduate from a major university 7 years postonset with a 3.9 grade point average and is planning to teach English. She dated sporadically and maintains a limited circle of friends. She cites current deficits in learning, organization, comprehension, and emotional control.

I figured out how to change my expectations so that the things that used to frustrate me were no surprise. No surprise—no emotional reaction . . . I went back to self-testing as I was trained in rehab. I highlighted my books . . . I had learned quickly that I had to curb my tendency to rush. Only if I slowed down could I be accurate . . . Because of the injury, I have to work twice as hard as the average person to get what I want. If I had to credit my recovery to a single strategy, that's it . . . I can't just stick with the strategies I've developed up to this point . . . I need to keep changing how I do things . . . I had to learn how to adapt. It's like having been born a second time.

Case 5

In a high-speed car crash, this high-school honors student sustained bifrontal contusions and a 14-day coma and emerged with severe memory, planning, impulse control, and problem-solving deficits. He returned to school to earn a 4.0 grade point average, resumed playing varsity baseball, and now plays for his college. He maintains an A-average, a large friendship network, and had his first serious romantic relationship.

I always plan—never want to be caught unprepared . . . Planning out every minute of your day is essential . . . When I talk with people, I always think about what I'm going to say, put ideas together, get ready to talk . . . Preparation takes more time and work than ever before. If I don't work ahead of the class in the book, I'm likely to miss some of the things the teacher says . . . Over the summer, I try to get the textbook, read it, highlight it, and then outline it. That makes me better at picking out the main points. I outline all my notes. Then I concentrate on studying the stuff I don't know already . . . To prevent myself from getting impulsive, I try to analyze the situation, the person, and try to teach myself not to do it again. I think about it long enough to make sure not to do it again.

Case 6

An athletic fall caused this 25-year-old college graduate's blown right temporal lobe requiring surgical removal,

right parietal bruising, and 8 days of coma. Five years later, she describes left inattention, anosagnosia, impulsivity, and poor social perception and judgment. She maintains her former job as a community projects manager for a sports complex, and her position has been upgraded. She has developed innovative programs for her company, served on the boards of charitable organizations, and become a founding executive of 2 nonprofit corporations. She has started many new friendships and 2 serious romantic relationships.

I make sure I don't do any impulse buying . . . I'm really strict on the scheduling. If there was anything coming up where I thought there was potential for emotional overload, something . . . to upset me or put me on the defensive, I would . . . find a good strategy for how to respond . . . It always goes back to planning. If I forget anything, it's because I wasn't organized enough or didn't write notes that were detailed enough . . . I use my alarm watch to keep myself on schedule . . . It keeps me on task, and meeting my priorities . . . The single most important strategy for my recovery is the Error Analysis: that's what protects me from doing head-injured things . . . There is no other way to handle this injury—nothing else works. Then, when I know what I should do, the next time I'm in that situation, I sound a warning to myself. "Watch out!" I mentally sound warnings a lot. Those will keep you from repeating stupid mistakes—the result of doing an EA . . . I'll keep making mistakes and I'll keep catching them . . . Keep your radar on, be humble and say, "That was a brain-injured mistake" and don't let yourself make any excuses.

Case 7

At 27, this newly-graduated MSW psychotherapist was criminally assaulted in her workplace. She suffered a fractured frontal bone and bifrontal contusions and remained in coma for 13 days. She presented a marked dysexecutive syndrome with moderate recent memory impairments. She has returned to her position and provides crisis therapy to high-school students, passed her licensure examination, and now also sees family therapy cases in private practice. A new relationship has progressed to marriage; her family includes a new, teenage stepdaughter. At 5 years postonset, she acknowledges problems with emotional control, organization, planning, memory, and endurance.

To keep myself from blurting out things I wouldn't want to say, I guess I say less now and think about it more . . . [when] my mind blanks out, I [take] the time I need to pick up the thread of my thoughts where my mind got off track . . . I now take much more detailed notes during the session . . . My progress notes are also more thorough, which I use to review what we talked about before the next session. If I think of an intervention I want to use later in the session, I'll jot that down on my note pad to make sure I remember to do it. I used to have back-to-back-to-back sessions, but now I usually give myself time to absorb what happened in the last session . . . I've arranged for a time-out time right after I get home—I need it . . . I'm always striving to learn new techniques . . . I continue to learn more about my injury . . . I see little quirks, little "brain-injury moments" that I keep having . . . The challenge is there for me to fix each one and fix it right because I'm a perfectionist. Sometimes the first fix I try doesn't work, but I don't quit tinkering with it until I get it right. If it's something I can't fix until the situation comes up again, I write down what I did wrong to remind me when I revisit it to figure out a different way to handle it. I write down the failed actions so I won't repeat them . . . I know I have to figure out ways to do things differently if I'm going to do them better. I can do self-rehab.

Case 8

This 34-year-old computer engineer sustained bifrontal contusions in a highway crash and remained in coma for 15 days. With his marked dysexecutive symptoms, physicians were certain he could not return to his job, which involved supervising 100 professional employees for a Fortune 500 technology firm. However, he resumed work after 6 months with no accommodations, later helped to plan a complete reorganization of his division, and continues to earn top ratings in his fourth year. His wife has contracted a terminal illness, leaving him as the primary caregiver for her and for their 2 schoolchildren. He reports deficits in memory, planning, and organization.

I always plan my meetings, my memos, and my actions carefully ahead of time. I have become more serious, more focused and more organized than I ever was before. I've done it because I had to.

According to his wife,

He's confident but cautious. We rely on using all of the strategies the therapists helped us to learn—taking notes, putting things down on paper to get organized, and being extra alert about how he goes about doing things . . . He makes up a to-do list, which was never his style.

Case 9

This 40-year-old attorney from Zimbabwe planned to take courses on the American legal system to prepare for the most stringent of the state bar exams. Five years ago, a motor vehicle accident caused bifrontal/bitemporal contusions and he remained in coma for 2 days. He cites deficits in recent verbal memory, problem solving, and organization. After discharge, he took the classes, passed the bar, and now works as a public defender.

Whatever you used to do, don't trust it . . . I'm not the same old guy I used to be . . . "Bow down to your deficits" may be . . . the best advice I ever got . . . My friends told me "Maybe it's not that bad," but it is . . . Now I rely on my [daily] schedules. [For the bar exam], I scheduled every moment for 3 months. I took the practice questions again and again until I could answer them all. When I failed, I tried to figure out what I had done wrong so I could correct it [On essay exams], I stopped giving automatic answers and thought about what the fellow who wrote the test was looking for. I read each question and thought about it first. Then I wrote a detailed outline . . . only then did I start writing my answers. I checked the first one over when I was mid-way

through and found I'd gotten off on the wrong track . . . The Error Analysis—if I keep at it I can figure out how to make it work.

DISCUSSION

Nine exceptional outcomes out of 204 follow-ups hardly prove the generic viability of a treatment protocol; however, strong recoveries can indicate that a therapeutic regimen contains necessary ingredients without demonstrating that they are also sufficient. Successes that reach the top echelons of mainstream competition are virtually absent from the clinical literature, limited to a few single case studies and incidental references. In this case series, each injury impaired specific skills essential for the execution of the survivor's adaptive roles, yet the individuals went on to excel in those roles. Each subject demonstrated superior instrumental adaptation in school and/or work, sustained across a period of many years. They also demonstrated many accomplishments in developmental adaptation, including the acquisition of skills for new levels of education, new job duties, new avocational pursuits, and new locales. Their social adaptation has been more variable. Some trainees entered new marriages, undertook new parenting duties, added new friends, and established successful new supervisor, coworker and/or customer relationships. While others resumed and retain limited social and romantic lives, none is socially handicapped. By falling so far outside of normative outcome expectations, they establish that recovery to a superior level of functioning is possible.

The descriptive methodology of the present study can support only speculation about how these striking recoveries were achieved. Since the restoration of adaptation was an explicit target of their rehabilitation, and the subjects describe deploying and customizing these strategies for the purpose of achieving their own adaptive objectives, a successful treatment effect is one plausible hypothesis. It mandates more rigorous investigation with a parametric research design.

Individual differences associated with the outcome suggest a trait-by-treatment interaction. Above average in intelligence, the subjects are better educated than the modal patient, many having earned college degrees or, if younger, pursued a college track. At the same time, they are not among the program's brightest, best-educated, or most accomplished participants. This group's levels of family support and premorbid mental health are favorable, although there are exceptions in both respects. Their most distinctive characteristics are intolerance of error and embarrassment and fierce determination to curtail them, driving them to apply the error-prevention strategies with the necessary vigor and vigilance. Greater reliance on interventions enhancing the determination and/or failure intolerance in training less-motivated patients, such as role modeling, goal clarification, and building self-efficacy,[4,38,39,63] may aid a wider variety of personalities to reap the benefits of the adaptation training.

CONCLUSION

As unlikely as satisfactory adaptive recovery appears to be under normal conditions, the 9 severely injured individuals described in this study were able to achieve it, handling even difficult and sustained mainstream adaptive challenges effectively. They were taught compensatory techniques for adaptation, and they pursued them with uncommon persistence and self-discipline. In view of the natural intractability of the problem, the therapeutic solution seems surprisingly simple, at least for well-motivated, well-endowed trainees. Since adaptation is so necessary for quality of life and so unlikely to be restored in any other way, devoting therapy time to its direct treatment seems well justified.

REFERENCES

1. Halstead WC. *Brain and Intelligence.* Chicago: University of Chicago Press; 1947.
2. Prigatano GP. *Principles of Neuropsychological Rehabilitation*. New York: Oxford University Press; 1999.
3. Bond MR. Assessment of psychosocial outcome after severe head injury. *Outcome of Severe Damage to the Central Nervous System*. Amsterdam, The Netherlands: Elsevier; 1975.
4. Levin HS. Neurobehavioral sequelae of head injury. In: Cooper PR, ed. *Head Injury.* Baltimore: Williams and Wilkins; 1987:442–463.
5. Shallice T, Burgess P. Deficits in strategy application following frontal lobe damage in man. *Brain.* 1991;114:727–741.
6. Boake C, Diller L. History of rehabilitation for traumatic brain injury. In: High WM, Sander AM, Struchen MA, Hart KA, eds. *Rehabilitation for Traumatic Brain Injury*. New York: Oxford University Press; 2005:3–13.
7. Jacobs HE. Identifying post-traumatic behavior problems: data from psychosocial follow-up studies. In: Wood RL, ed. *Neurobehavioral Sequelae of Traumatic Brain Injury*. London: Taylor and Francis; 1990.
8. DeJong G, Batavia AI, Williams JM. Who is responsible for the lifelong well-being of a person with a head injury? *J Head Trauma Rehabil.* 1990;5:18–28.
9. Wood RL. Neurobehavioral paradigm for brain injury rehabilitation. In: Wood RL, ed. *Neurobehavioral Sequelae of Traumatic Brain Injury*. New York: Taylor and Francis; 1990:3–17.
10. Wilson B. Future directions in rehabilitation of brain-injured people. In: Christiansen AL, Uzzell B, eds. *Neuropsychological Rehabilitation*. Boston: Kluwer; 1988:69–86.
11. Glanville HJ. What is rehabilitation? In: Illis LS, Sedgwick EM, Glanville HJ, eds. *Rehabilitation of the Neurological Patient*. Boston: Blackwell; 1982:1–10.

12. Horn L. Systems of care for the person with traumatic brain injury. In: Berrol S, ed. *Physical Medicine and Rehabilitation Clinics of North America: Traumatic Brain Injury*. Philadelphia: W. B. Saunders; 1992:475–492.
13. Schutz L, Barry P, Gross Y, Tupper D. Can we predict (or even explain) the functional outcomes of cognitive rehabilitation treatment? Paper presented at: Symposium on Models and Techniques in Cognitive Rehabilitation; 1984; Indianapolis, Ind.
14. Ezrachi O, Ben-Yishay Y, Kay T, Diller L, Rattok J. Predicting employment in traumatic brain injury following neuropsychological rehabilitation. *J Head Trauma Rehabil*. 1991;6:71–84.
15. Cicerone KD, Dahlberg C, Kalmar K, et al. Evidence-based cognitive rehabilitation: recommendations for clinical practice. *Arch Phys Med Rehabil*. 2000;81:1596–1613.
16. Spencer H. *The Principles of Psychology*. London: Longman; 1855, reprinted 1897.
17. Spencer H. *An Autobiography.* London: Williams and Norgate; 1904.
18. Hartmann H. *Ego Psychology and the Problem of Adaptation*. New York: International University Press; 1939.
19. Jahoda M. *Current Concepts of Positive Mental Health*. New York: Basic Books; 1959.
20. Bandura A. *Self-Efficacy: The Exercise of Control*. New York: Freeman; 1997.
21. Konorski J. *Integrative Activity of the Brain: An Interdisciplinary Approach*. Chicago: University of Chicago Press; 1967.
22. Mesulam MM. The human frontal lobes: transcending the default mode through contingent encoding. In: Stuss DT, Knight RT, eds. *Principles of Frontal Lobe Function*. New York: Oxford University Press; 2002:8–30.
23. Bernstein NA. *The Coordination and Regulation of Movements*. New York: Pergamon Press; 1967.
24. Locke EA, Latham GP. Building a practically useful theory of goal setting and task motivation: a 35-year odyssey. *Am Psychol.* 2002;57:705–717.
25. Gazzaniga MS. *The Mind's Past*. Berkeley: University of California Press; 1998.
26. Norman DA, Shallice T. Attention to action: willed and automatic control of behavior. In: Davidson RJ, Schwartz GE, Shapiro D, eds. *Consciousness and Self-Regulation*. Vol 4. New York: Plenum Press; 1986:1–18.
27. Luria AR. *The Making of Mind: A Personal Account of Soviet Psychology*. Cambridge, Mass: Harvard University Press; 1979.
28. Schutz L. Closed head injury as a network disorder. In: Plishe VN, ed. *Research Focus on Cognitive Disorders*. Hauppauge, NY: Nova Science Publishers Inc; 2006.
29. Gross Y, Schutz L. Intervention models in neuropsychology. In: Uzzell B, Gross Y, eds. *Clinical Neuropsychology of Intervention*. Boston: Martinus-Nijhoff; 1986.
30. Miller G, Galanter E, Pribram K. *Plans and the Structure of Behavior*. New York: Holt, Rinehart and Winston; 1960.
31. Calvin WH. *The Cerebral Symphony: Seashore Reflections on the Structure of Consciousness*. New York: Bantam Books; 1989.
32. Goldstein K. *The Organism*. New York: Zone Books; 1934, reprinted 2000.
33. Pribram KH. The subdivisions of the frontal cortex revisited. In: Perecman E, ed. *The Frontal Lobes Revisited*. New York: IRBN Press; 1987:11–39.
34. Jackson JH. *Evolution and Dissolution of the Nervous System*. Bristol: Thoemmes Press; 1882, reprinted 1998.
35. Symonds C. *Studies in Neurology*. London: Oxford University Press; 1970.
36. Powell GE. *Brain Function Therapy*. Aldershot: Gower; 1981.
37. Prigatano GP, Schachter D. Introduction. In: Prigatano G, Schachter D, eds. *Awareness of Deficit After Brain Injury*. New York: Oxford University Press; 1991:3–16.
38. Prigatano GP, Ben-Yishay Y. Psychotherapy and psychotherapeutic interventions in brain injury rehabilitation. In: Rosenthal M, Griffith ER, Kreutzer JS, Pentland B, eds. *Rehabilitation of the Adult and Child With Traumatic Brain Injury*. 3rd ed. Philadelphia, Pa: FA Davis; 1999:271–283.
39. Crepeau F, Scherzer P. Predictors and indicators of work status after traumatic brain injury: a meta-analysis. *Neuropsychol Rehabil*. 1993;3:5–35.
40. Dawson PA, Chapman M. The disablement experienced by traumatically brain injured adults living in the community. *Brain Inj*. 1995;9:339–353.
41. Lezak MD, O'Brien KP. Chronic emotional, social and physical changes after traumatic brain injury. In: Bigler ED, ed. *Traumatic Brain Injury*. Austin, Tex: Pro-Ed; 1990:345–380.
42. Grosswasser Z, Stern MJ. A psychodynamic model of behavior after central nervous system damage. *J Head Trauma Rehabil*. 1998;13:69–79.
43. Thomsen IV. Recognizing the development of behaviour disorders. In: Wood RL, ed. *Neurobehavioral Sequelae of Traumatic Brain Injury*. London: Taylor and Francis; 1990:52–68.
44. Mayer NH. Acute care to rehabilitation: concepts in transition. In: Bach-y-Rita P, ed. *Traumatic Brain Injury*. New York: Demos Publications; 1989:135–146.
45. Stein DG, Brailowski S, Will B. *Brain Repair*. New York: Oxford University Press; 1995.
46. Geschwind N. Disconnection syndromes in animals and man. *Brain*. 1965;88:237–294.
47. Edelman G, Tononi G. *A Universe of Consciousness: How Matter Becomes Imagination*. New York: Basic Books; 2000.
48. Goldberg E, Barr WB. Three possible mechanisms of unawareness of deficit. In: Prigatano G, Schachter D, eds. *Awareness of Deficit After Brain Injury*. New York: Oxford University Press; 1991:152–175.
49. Cooper R, Shallice T. Contention scheduling and the control of routine activities. *Cogn Neuropsychol.* 2000;17(4):297–338.
50. Stuss DT, Mateer CA, Sohlberg MM. Innovative approaches to frontal lobe deficits. In: Finlayson MA, Garner SH, eds. *Brain Injury Rehabilitation: Clinical Considerations*. Baltimore, Md: Williams and Wilkins; 1994:212–237.
51. Levine B, Katz D, Dade L, Black SE. Novel approaches to the assessment of frontal damage and executive deficits in traumatic brain injury. In: Stuss DT, Knight RT, eds. *Principles of Frontal Lobe Function*. New York: Oxford University Press; 2002:448–465.
52. Schutz L. Response optimization: a central issue in recovery from traumatic brain injury. *Arch Clin Neuropsychol.* 2005;20(7):938–939. Abstract.
53. Burgess PW, Wood RL. Neuropsychology of behaviour disorders following brain injury. In: Wood RL, ed. *Neurobehavioral Sequelae of Traumatic Brain Injury*. London: Taylor and Francis; 1990:110–133.
54. Stuss DT, Murphy KJ, Binns MA, Alexander MP. Staying on the job: the frontal lobes control performance variability. *Brain*. 2003;126:2363–2380.
55. Szameitat A, Schubert T, Muller K, Von Cramon D. Localization of executive functions in dual-task performance with fMRI. *J Cogn Neurosci*. 2002;14:1184–1199.
56. Duncan J, Miller EK. Cognitive focus through adaptive neural coding in the primate prefrontal cortex. In: Stuss DT, Knight RT, eds. *Principles of Frontal Lobe Function*. New York: Oxford University Press; 2002:278–291.
57. Goldberg G. From intent to action. In: Perecman E, ed. *The Frontal Lobes Revisited*. New York: IRBN Press; 1987:273–306.
58. Pribram KH, MacGuinness D. Arousal, activation, and effort in the control of attention. *Psychol Rev.* 1975;82(2):116–149.

59. Fuster J. Physiology of executive functions. In: Stuss DT, Knight RT, eds. *Principles of Frontal Lobe Function*. New York: Oxford University Press; 2002:96–108.
60. Schulz K, Tang C, Fan J, et al. Differential prefrontal cortex activation with and without childhood attention-deficit/hyperactivity disorder. *Neuropsychology*. 2005;19(3):390–402.
61. Diller L, Ben-Yishay Y. Outcome and evidence in neuropsychological rehabilitation in closed head injury. In: Levin H, Grafman J, Eisenberg HM, eds. *Neurobehavioral Recovery From Head Injury*. New York: Oxford University Press; 1987:146–165.
62. Giles GM, Clark-Wilson J. *Brain-Injury Rehabilitation: A Neuro-Functional Approach*. San Diego, Calif: Singular; 1993.
63. Braunling-McMorrow D. Promoting effective socialization for persons with brain injury. In: Deutsch P, Fralish KB, eds. *Innovations in Head Injury Rehabilitation*. White Plains: Ahab Press; 1998:1–32.