



AOTA Critically Appraised Topics and Papers Series Traumatic Brain Injury

**A product of the American Occupational Therapy Association's
Evidence-Based Literature Review Project*

CRITICALLY APPRAISED TOPIC (CAT)

Focused Question #1

What is the evidence that challenging demands to the brain, such as therapy, activity, or sensory stimulation reorganizes brain function beyond spontaneous recovery after traumatic brain injury?

Clinical Scenario:

Experimental studies on focal brain injuries in rats have demonstrated that environmental enrichment significantly improves functional outcome, increases dendritic branching and the number of dendritic spines in the contralateral cortex, influences expression of many genes, and modifies lesion-induced stem cell differentiation in the hippocampus (Johansson, 2003; Will, Galani, Kelche, & Rosenzweig, 2004). The environmental enrichment gives the rats the opportunity to solve motor problems; that is, their thinking processes are challenged to learn new ways of behaving and morphological changes concurrently occur in the cortex in response to those demands (Ivanco & Greenough, 2000). The capacity to change seems to be a fundamental characteristic of the nervous system, and when the nervous system changes, there is often correlated behavioral change such as learning, memory, recovery, and so on (Kolb, 2003). Few humans with brain injury or stroke have been studied. Some preliminary functional MRI (Magnetic Resonance Imaging) studies that have been done on patients with traumatic brain injury indicate alterations in the pattern of brain activation, suggesting recruitment of more extensive cortical regions to perform tasks which stress computational resources (Levin, 2003), similar to the effects of enriched environment on the rats' brains. Occupational therapy makes demands on people with brain injury to learn new strategies and to relearn old activities and tasks under new environmental conditions. We are interested in knowing whether there is evidence that the types of demands that we make on patients actually contribute to recovery of brain organization as well as the recovery of behavior that we can observe.

Summary of Key Findings:

Summary of Levels I, II, and III

Only studies that examined the effects of therapeutic demands on humans were included. One Level III study was retrieved during the literature search and that did not directly answer the question concerning the plastic effects of the therapy. Page and Levine (2003) studied the effects of modified constraint-induced therapy (mCIT) on three recruited volunteers. All three subjects improved to some degree in their ability to pinch, grip, and grasp and in the amount of use and quality of movement of the less-affected upper extremity after 10 weeks of therapy. If we can extrapolate from the studies of the effects of constraint-induced therapy (CIT) on rat brain reorganization (Tillerson & Miller, 2002), then the demands of CIT to relearn use of the weak extremity may not only result in behavioral changes but neurogenesis as well. This question needs to be studied directly.

Summary of Levels IV and V

Three Level V studies (case reports) were retrieved (Laatsch, Jobe, Sychra, Lin, & Blend, 1997; Laatsch, Thullporn, Kriskey, Shobat, & Sweeney, 2004; Scheibel, Pearson, Faria, Kotrla, Aylward, Bachevalier, et al., 2003, 2004). Nine participants with TBI in total were studied; five were in acute phase of recovery and four were in the chronic (little to no spontaneous recovery) phase. All three studies examined whether brain reorganization occurred during cognitive rehabilitation therapy (CRT) using various methods of functional brain imaging. The two studies by Laatsch, et al., found increased brain activity immediately after the CRT program as compared to immediately before. It was interpreted as a redistribution of cognitive workload. Scheibel, et al., recorded during the cognitive tasks and concluded that the person with diffuse TBI recruited additional neural resources for cognitive control compared to control subjects. These studies provide weak evidence because of their small samples and lack of experimental control, but taken together they provide some support that tasks which require cognitive manipulation do affect brain organization. The researchers did not report a difference due to time since injury; that is, spontaneous recovery was not addressed. Again, much more research is required to answer the focused question definitively.

Contributions of Qualitative Studies:

No studies using qualitative methodology were included.

Bottom Line for Occupational Therapy Practice:

There is tentative evidence to suggest that therapeutic interventions that place challenging demands on the brains of people with traumatic brain injury reorganize brain function, both in the acute or chronic stage of recovery. Interventions that place challenging demands include demands that require mental manipulation of information in short-term memory, demands that are non-routine, demands that involve solving novel problems (relearning to use a weak limb to accomplish activities of daily living is solving a novel problem for these patients), or demands that require reallocating attention or selecting a response. In other words, brain reorganization is associated with learning new things and relearning old things in a new way.

Review Process:

Procedures for the selection and appraisal of articles

- Titles of those studies retrieved by online database searches were reviewed
- Abstracts of those studies whose titles addressed the topic were retrieved and printed
- Abstracts were read and those studies that did not address the question or did not meet inclusion criteria were deleted
- The remaining studies (N = 51) were retrieved either from the Boston University library system, interlibrary loan, or online sources
- Each study was read and those not meeting inclusion criteria were further deleted (N = 11)
- Those reviews that turned out to be general instructive papers were eliminated (N = 11)
- Studies in which the participants were animals were eliminated (N = 13)
- Those reviews that were nonspecific to the question or were reviews of animal research were eliminated (N = 12)
- Each of the remaining studies was analyzed and the evidence table was completed. For this question, 4 studies were analyzed.

Inclusion Criteria:

- Published between 1990 and 2004
- Meta-analysis or systematic review
- All levels of evidence, including case reports {Level V} were located, but only Levels I-III were reviewed if they provided adequate evidence. If not, then all levels were included to portray the best evidence available at this time.
- Participants were persons with traumatic brain injury
- Participants were adults (> 18 years)
- Written in English
- At least one intervention must be current occupational therapy practice or could become occupational therapy practice.

Exclusion Criteria:

- Prediction or correlational studies
- Longitudinal observational studies of natural history of recovery
- Descriptions of programs or of treatments without testing effects
- Animal studies

Search Strategy

Categories	Key Search Terms
Patient/Client Population	Traumatic brain injury
Intervention	Occupational therapy, enriched environment, use-dependent plasticity, plasticity, rehabilitation, problem solving,
Comparison	Critical reviews, meta-analysis, randomized control trial , randomized controlled study
Outcomes	Not searched

Databases and Sites Searched
PubMed (Medline)
OTSeeker.com
OTCATS.com
DARE (agatha.york.ac.uk/darehp.htm)
Cochrane Collaboration website
PsychINFO
CINAHL
Web of Science (Science Citation Index & Social Science Citation Index)

Quality Control/Peer Review Process:

Only the author reviewed the studies. The studies were read twice; they were reviewed further if a question arose.
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Results of Search:

Summary of Study Designs of Articles Selected for Appraisal

Level of Evidence	Study Design/Methodology of Selected Articles	Number of Articles Selected
I	Systematic reviews, meta-analysis, randomized controlled trials	0 [5 rat studies]
II	Two-group, nonrandomized studies (e.g., cohort, case-control)	0 [5 animal studies]
III	One-group, nonrandomized (e.g., before and after, pretest–posttest)	1
IV	Descriptive studies that include analysis of outcomes (single subject design, case series)	0
V	Case reports and expert opinion, which include narrative literature reviews and consensus statements	3 [1 rat study]
	Qualitative Studies	0
		TOTAL = 4

Limitations of the Studies Appraised:

Levels I, II, and III

No random assignment to condition; small sample; reliability of outcome measures not reported and questionable; no statistical analysis of data; no information about compliance with the use of the restraint at home.

Levels IV and V

No random assignment to condition; small samples; samples not representative of most people with brain injury; no statistical analysis of data; possible confound of spontaneous recovery in the longitudinal study; testing effects.

Articles Selected for Appraisal

Laatsch, L., Jobe, T., Sychra, J., Lin, Q., & Blend, M. (1997). Impact of cognitive rehabilitation therapy on neuropsychological impairments as measured by brain perfusion SPECT: A longitudinal study. *Brain Injury, 11*, 851–863.

Laatsch, L. K., Thulborn, K. R., Krisky, C. M., Shobat, D. M., & Sweeney, J. A. (2004). Investigating the neurobiological basis of cognitive rehabilitation therapy with fMRI. *Brain Injury, 18*, 957–974.

Page, S. & Levine, P. (2003). Forced use after TBI: Promoting plasticity and function through practice. *Brain Injury, 17*, 675–684.

Scheibel, R. S., Pearson, D. A., Faria, L. P., Kotrla, K. J., Aylward, E., Bachevalier, J., et al. (2003). An fMRI study of executive functioning after severe diffuse TBI. *Brain Injury, 17*, 919–930.

Scheibel, R.S., Pearson, D. A., Faria, L. P., Kotrla, K. J., Aylward, E., Bachevalier, J., et al. (2004). Erratum: An fMRI study of executive functioning after severe diffuse TBI. *Brain Injury, 18*, 219–220.

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Ivanco, T. L., & Greenough, W. T. (2000). Physiological consequences of morphologically detectable synaptic plasticity: Potential uses for examining recovery following damage. *Neuropharmacology, 39*, 765–776.

Johansson, B. B. (2003). Environmental influence on recovery after brain lesions—Experimental and clinical data. *Journal of Rehabilitation Medicine (Suppl. 41)*, 11–16.

Kolb, B. (2003). Overview of cortical plasticity and recovery from brain injury. *Physical Medicine and Rehabilitation Clinics of North America, 14*, S7–S25.

Levin, H. S. (2003). Neuroplasticity following non-penetrating traumatic brain injury. *Brain Injury, 17*, 665–674.

Tillerson, J. L., & Miller, G. W. (2002). Forced limb-use and recovery following brain injury. *The Neuroscientist, 8*, 574–585.

Will, B., Galani, R., Kelche, C., & Rosenzweig, M. R. (2004). Recovery from brain injury in animals: Relative efficacy of environmental enrichment, physical exercise or formal training (1990–2002). *Progress in Neurobiology, 72*, 167–182.

This work is based on the evidence-based literature review completed in June 2005 by Catherine Trombly, ScD, OTR/L, FAOTA.

CAT format adapted from a template provided by Dr. Annie McCluskey and freely available for use on the OT-CATS website (<http://otcats.com>).

For more information about the Evidence-Based Literature Review Project, contact the American Occupational Therapy Association, 301-652-6611, x 2052.



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