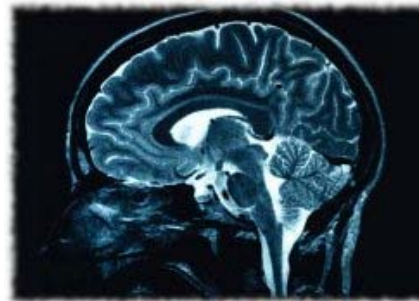


*Neuroplasticity Guided
Approach to
Neurorehabilitation after
Traumatic Brain Injury*

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Traumatic Brain Injury

- “An insult to the brain caused by an external physical force than may produce a diminished or altered state of consciousness resulting in impairment of cognitive abilities, emotional control, or functioning.” ¹



Significance of TBI

- \$60 billion direct and indirect costs ⁱ
- \$560/day for acute-rehabilitation ⁱⁱ
- 33% of TBI patients utilize PT x1 year following the injury ⁱⁱⁱ



ⁱ "Traumatic Brain Injury" National Center for Injury Prevention and Control, Centers for Disease Control and Prevention Website, November 08, 2007. Available at <http://www.cdc.gov/ncipc/tbi/TBI.htm>. Accessed January 20, 2008.

ⁱⁱ Mayer, N. H., J. Pelensky, et al. (2003). "Characterization and correlates of medical and rehabilitation charges for traumatic brain injury during acute rehabilitation hospitalization." *Arch Phys Med Rehabil* 84(2): 242-8.

ⁱⁱⁱ Hodgkinson, A., A. Veerabangsa, et al. (2000). "Service utilization following traumatic brain injury." *J Head Trauma Rehabil* 15(6): 1208-26.

Current Rehabilitation Treatment Approaches for TBI

- 1999 Cochrane review ⁱ
 - PT is effective
but
 - Unclear which treatment approach is best

ⁱ Chesnut, R. M., N. Carney, et al. (1999). "Summary report: evidence for the effectiveness of rehabilitation for persons with traumatic brain injury." *J Head Trauma Rehabil* 14(2): 176-88.

Similarities of Stroke and TBI

- Pathophysiology
- Impairments
- Proposed mechanism of recovery (MOR)
and possibly...
- Effective neurorehabilitation approaches



Impairments and Problems in Brain Injury

Problems Common to Stroke and TBI	Problems More Common In TBI
Impaired affect	Impaired consciousness/coma
Impaired arousal and attention	Impaired autonomic nervous system
Impaired expressive/receptive communication	Impaired motivation and behavior
Impaired cognition	Executive functioning impairments
Impaired learning	Seizure disorder
Hemiplegia	Quadriplegia
Problems Physical Therapists Directly Treat	
Impaired motor function	Impaired respiratory function
Impaired sensory integrity and perception	
Impaired balance and anticipatory reactions	
Altered muscle elastic properties	

Table 1. Common problems in brain injury

Impairments and Problems in Brain Injury

- Diffuse axonal injury \Rightarrow \downarrow declarative learning [i](#),[ii](#)
- But implicit learning remains intact [iii](#),[iv](#),[v](#)
- Despite memory problems, they can still learn

[\[i\]](#) Ding, Y., B. Yao, et al. (2001). "Impaired motor learning and diffuse axonal damage in motor and visual systems of the rat following traumatic brain injury." *Neurol Res* **23**(2-3): 193-202.

[\[ii\]](#) Umphred, D.A. *Neurological rehabilitation*. 4th edition. Mosby, 2001. Chapters 6 and 14.

[\[iii\]](#) Kleim, J. A., T. A. Jones, et al. (2003). "Motor enrichment and the induction of plasticity before or after brain injury." *Neurochem Res* **28**(11): 1757-69.

[\[iv\]](#) Holden, M. K. (2005). "Virtual environments for motor rehabilitation: review." *Cyberpsychol Behav* **8**(3): 187-211; discussion 212-9.

[\[v\]](#) Sanes, J. N. and J. P. Donoghue (2000). "Plasticity and primary motor cortex." *Annu Rev Neurosci* **23**: 393-415.

Theoretical Mechanisms of Recovery (MOR) from Brain Injury

Motor Learning

Practice

**Neuroplastic
Changes**

Recovered and Compensatory Function

Primary Question

Foreground (Intervention) Question

- This evidence-based practice review aims to determine if adults with TBI benefit from participating in a neuroplasticity guided approach to neurorehabilitation.

Foreground Question Components

(PICO)

Patient: Survivor of TBI receiving rehabilitation.

Intervention: Neuroplasticity-guided approach to neurorehabilitation.

Comparison Intervention: Other or no therapy.

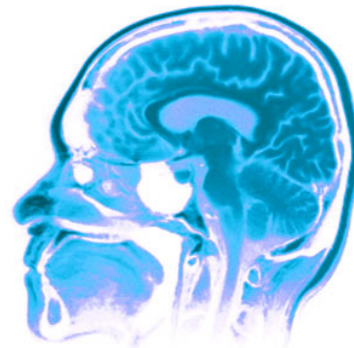
Outcomes: Anything relevant to PT.

Why This Question?

- Formulated after
 - Noticing impairment and lesion similarities between survivors of TBI and stroke in the rehabilitation setting
then
 - Finding success in the use of motor-learning principles in the treatment of patients with TBI.

Hypothesis

- H_0 : Patients with TBI can derive benefit from participating in neurorehabilitation guided by neuroplasticity and motor-relearning principles.



Expected Findings

- Paucity of research to support this approach in TBI as compared to Stroke.
- Minimum of strong evidence in studies that exist.
- Neuroplasticity-guided neurorehabilitation is effective in patients with TBI...
because the TBI MOR similar to stroke.

Background Information

- What does the current literature support for treatment of TBI?
- What is a neuroplasticity-guided or motor-relearning approach?
- Is it supported?

Current Literature: Tx of TBI

- 1999 Cochrane summary report ⁱ of TBI rehabilitation research
 - Poorly constructed experiments
 - Limits of TBI research:
 - Limits of TBI research:
 - Research design
 - Methods of analysis
 - Patient selection
 - Render the results inapplicable to guidelines/standards.
 - ∅ observed treatment effect 2°: inadequate design, not to lack of treatment efficacy.

ⁱ Chesnut, R. M., N. Carney, et al. (1999). "Summary report: evidence for the effectiveness of rehabilitation for persons with traumatic brain injury." J Head Trauma Rehabil 14(2): 176-88.

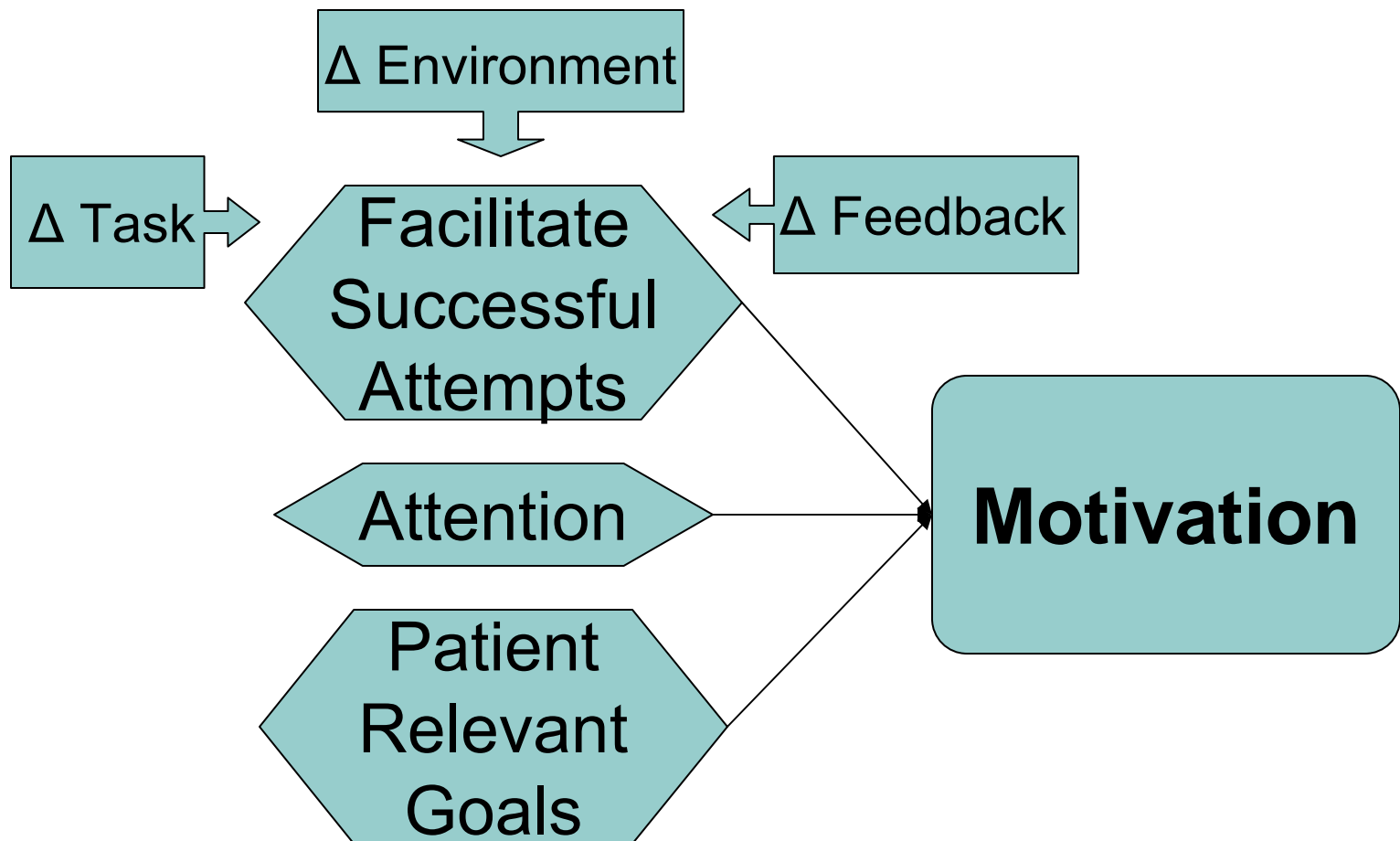
Current Literature: Tx of TBI

- Systematic review [!]
 - Variety of treatment strategies to manage motor impairments and activity limitations following TBI
but
 - Most are only supported by limited evidence
so
 - So there is a need for studies of improved methodological quality in this area.

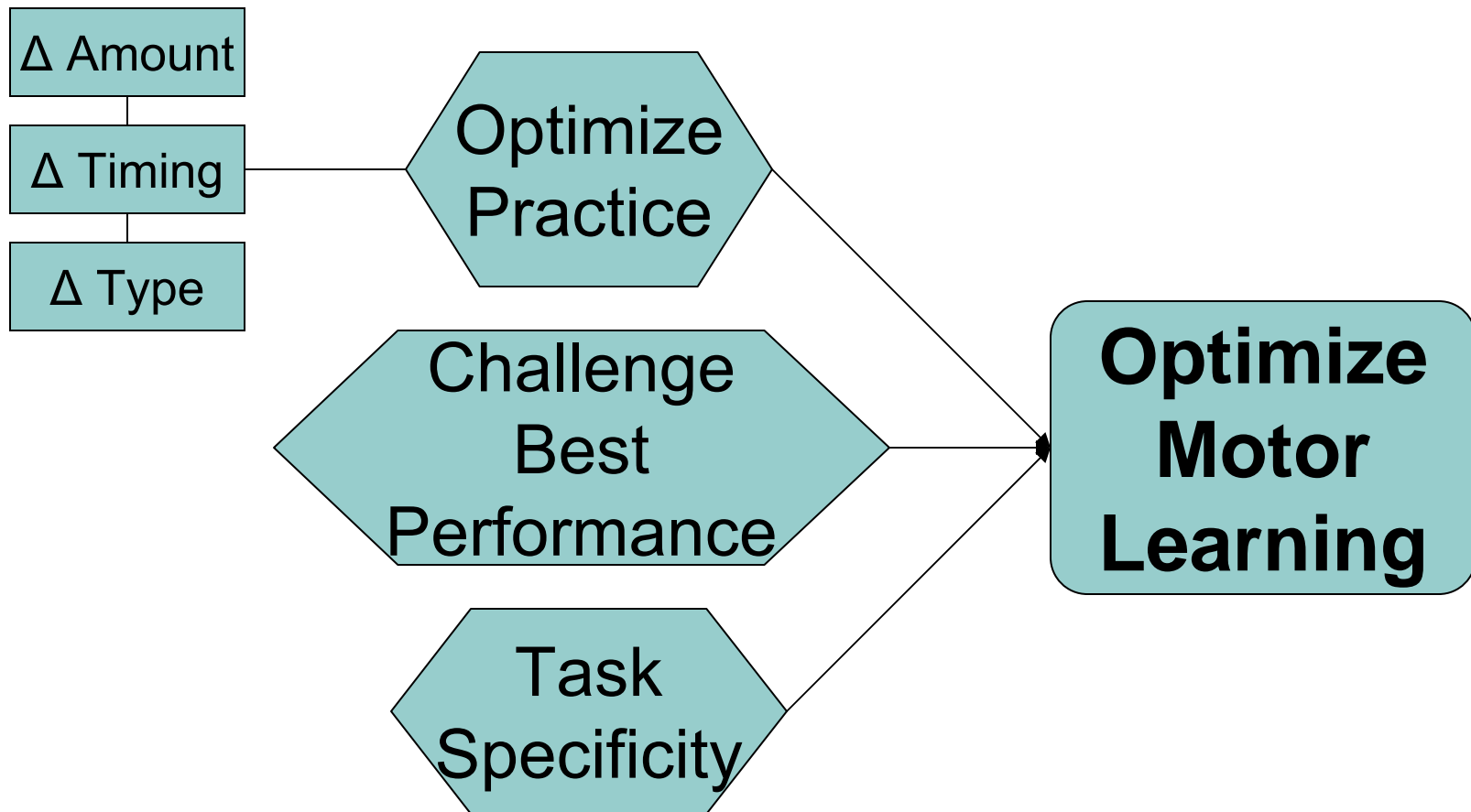
Neuroplasticity-Guided Approach

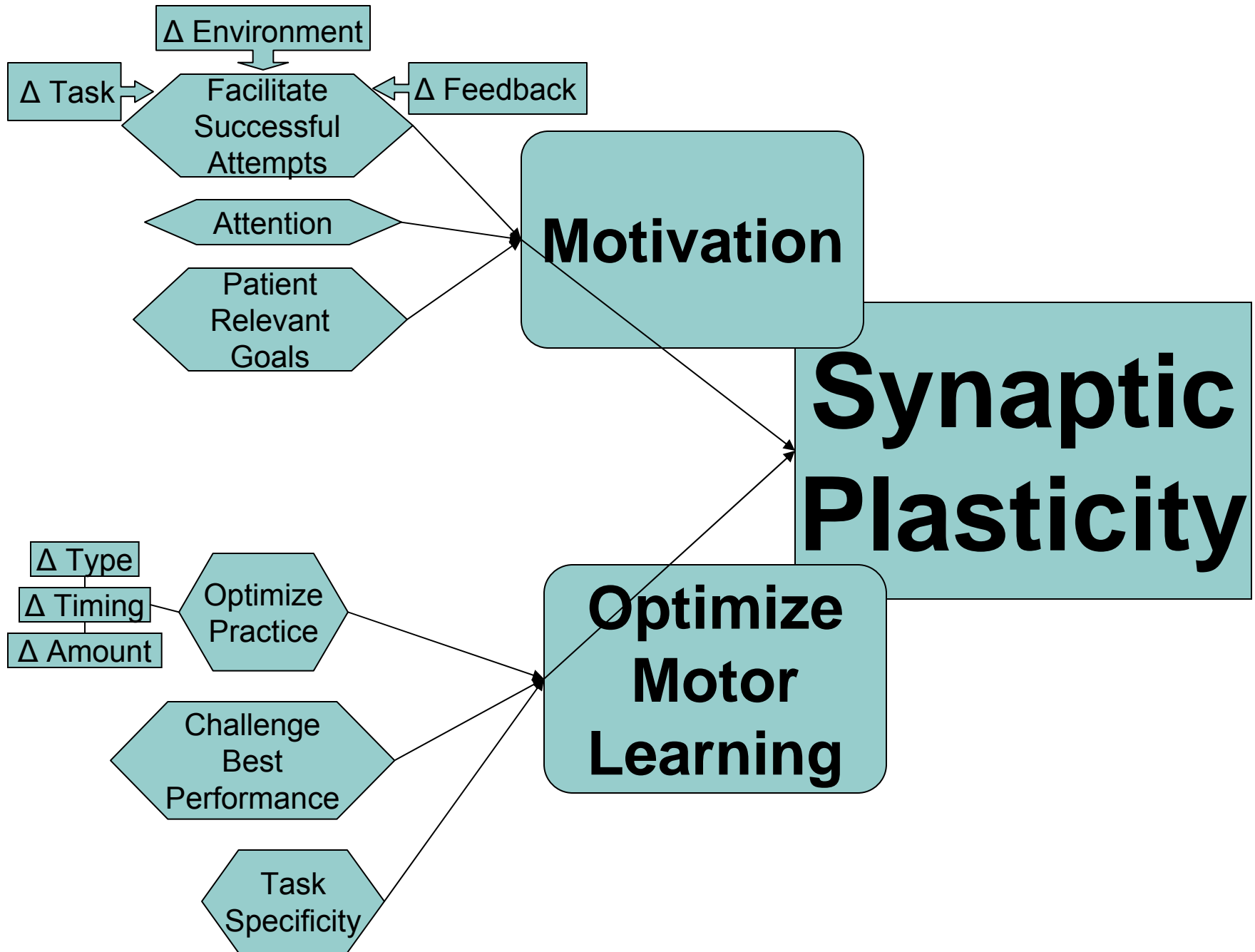
- Includes:
 - Motor-relearning Program (MRP)
 - Motor learning approach
 - Problem-solving approach
 - Task-oriented training
 - Constraint Induced Movement Therapy
 - Mixed approaches

Common Principles and Techniques:



Common Principles and Techniques:



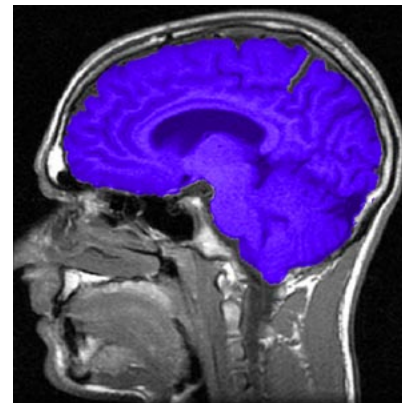


Sources of Evidence

- Database Sources:
 - CINAHL Plus
 - Cochrane Library
 - PEDro
 - MEDLINE/PubMed@UCSF

Search Keywords

- Rehabilitation
- Physical Therapy
- Physiotherapy
- Motor Learning
- Motor Relearning
- Problem Solving
- Task Oriented
- Mixed Approach
- Activity Based Therapies
- Traumatic Brain Injury
- Brain Injury
- Acquired Brain Injury
- Stroke
- Hemiparesis



Article Acceptance Criteria

- Inclusion:
 - Adults
 - TBI
 - Subjects receiving PT treatment
 - “Neuroplasticity-guided” spectrum
 - Any PT related outcome measure

Article Acceptance Criteria

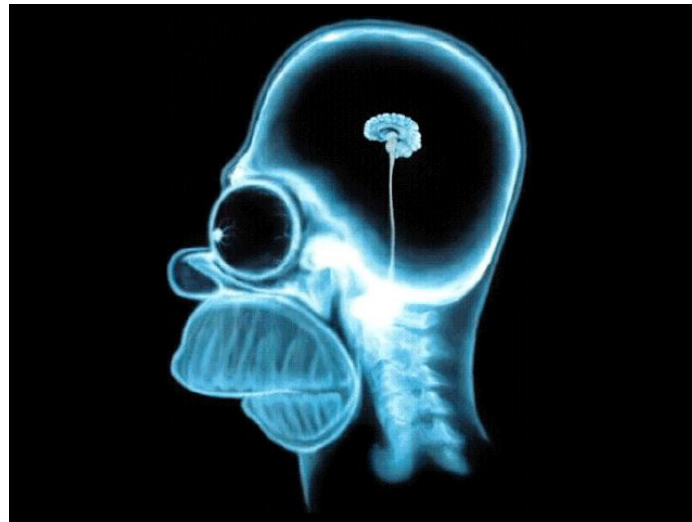
- **Exclusion:**
 - Child (<16)
 - Non-English

Level of Evidence Accepted

- Levels 1-4 accepted

Agreement Between Searchers

- Found 14 articles that fit search criteria (more than I would have thought!)



Evidence-Based Statistics

- Effect Size
 - Small: .2
 - Medium: .5
 - Large: .8
- For t, significance set at
 - $\alpha = .05$
 - $\beta = .20$

Evidence-Based Statistics

- $NNT = 1/(EER-CER)$
- Percent Difference

Type & Level of Evidence Found

- 2 level 1b
 - Randomized controlled trials
- 6 level 2b
 - 3 Individual cohort studies
 - 3 Low quality RCTs
- 2 level 3b
 - Case-controlled studies
- 4 level 4
 - Case reports

Level 1b Evidence

Author (Year)	Study Intervention	Control	Outcomes measured
Canning, <i>et al</i> (2003)	n=13 Task-specific training <ul style="list-style-type: none"> • sit↔stands • max # in 3 min • KR • Δ task • Δ environment • ↑performance 	n=11 ∅ additional sit↔stand training	Total # of sit↔stands in 3 min
Platz, T., <i>et al</i> (2001)	n=9 Arm ability training with KR	n=14 Regular IP rehab	Time to complete unilateral TEMPA

Level 2b Evidence

Individual Cohort Studies

Author/year	Study Intervention	Control	Outcomes measured
Morris, D. M., <i>et al</i> (2006)	n=29 CIMT	Pre-Post	Fugl-Meyer (FMA)
Shaw, S. E., <i>et al</i> (2005)	n=22 CIMT	Pre-Post	Fugl-Meyer (FMA)
Sterr, A., <i>et al</i> (2002)	n=15 CIMT	Pre-Post	Wolf Motor Function Test (WMFT)

Level 2b Evidence

Individual Cohort Study, Lower Quality RTCs

Author/year	Study Intervention	Control	Outcomes measured
Brown, T.H., <i>et al</i> (2005)	n=19 BWSTT	Pre-Post	Step width
Wilson, D. J., <i>et al</i> (2006)	n=19 PWBGT	n=19 Conventional Gait Training	Rivermead Mobility Index (RMI)
Sietsema, J. M., <i>et al</i> (1993)	n=20 Game-based reaching practice	Repeated Measures (rote reaching task)	ROM (Hip to Wrist)

Level 3b Evidence

Case Controlled Studies

Author/year	Study Intervention	Control	Outcomes measured
Giles, <i>et al</i> (1997)	n=3 Task-oriented training •behavioral observation •task analysis •consistent practice •cue fading	Pre-Post	# of verbal cues to complete tasks
Page, S. and Levine, P. (2003)	n=3 Modified CIMT	Multiple baseline	The Action Research Arm Test (ARA)

Level 4 Evidence Case Studies

Author/year	Study Intervention	Outcomes measured
Betker, <i>et al</i> (2007)	COP-Controlled Video Game-based Exercise Tool	Static sitting balance stability: Fall or no fall
Kim, Y. H., <i>et al</i> (2004)	CIMT	Fugl Meyer Assessment (FMA)
Scherer, M. (2007)	BWSTT and goal- directed therapy	Missouri Assisted Gait scale (MAG)
Seif-Naraghi, and Herman (1999)	Task-specific gait training with PBWSGT	Percent of body weight supported

Level 1b Results

Author/year	Duration of follow-up	Results
Canning, <i>et al</i> (2003)	End of 4-wk training program.	ES: 1.98 (1.53-2.43) NNT: (3) 2.28(1.91-2.65)
Platz, <i>et al</i> (2001)	At 1-year follow up.	ES: .810* (.507-1.113) NNT: (10) 9.37(9.21-9.53)

*Statistically significant effect size for sample size

Level 2b Results

Author/year	Duration of follow-up	Results
Morris, <i>et al</i> (2006)	After 2 weeks of treatment	ES: .3597* (.222-.497)
Shaw, <i>et al</i> (2005)	2-year follow up	ES: 1.30* (1.24-1.37)
Sterr, <i>et al</i> (2002)	4x in month after tx sessions	ES: 1.81 (1.07-2.55)

*Statistically significant effect size for sample size

Level 2b Results

Author/year	Duration of follow-up	Results
Brown, <i>et al</i> (2005)	Within 2 weeks of end of 3-month intervention	ES: .379* (.169-.589)
Sietsema, <i>et al</i> (1993)	Immediately after training	ES: .606* (.401-.811)
Wilson, <i>et al</i> (2006)	After 8wks tx	ES: .208* (.001-.415)

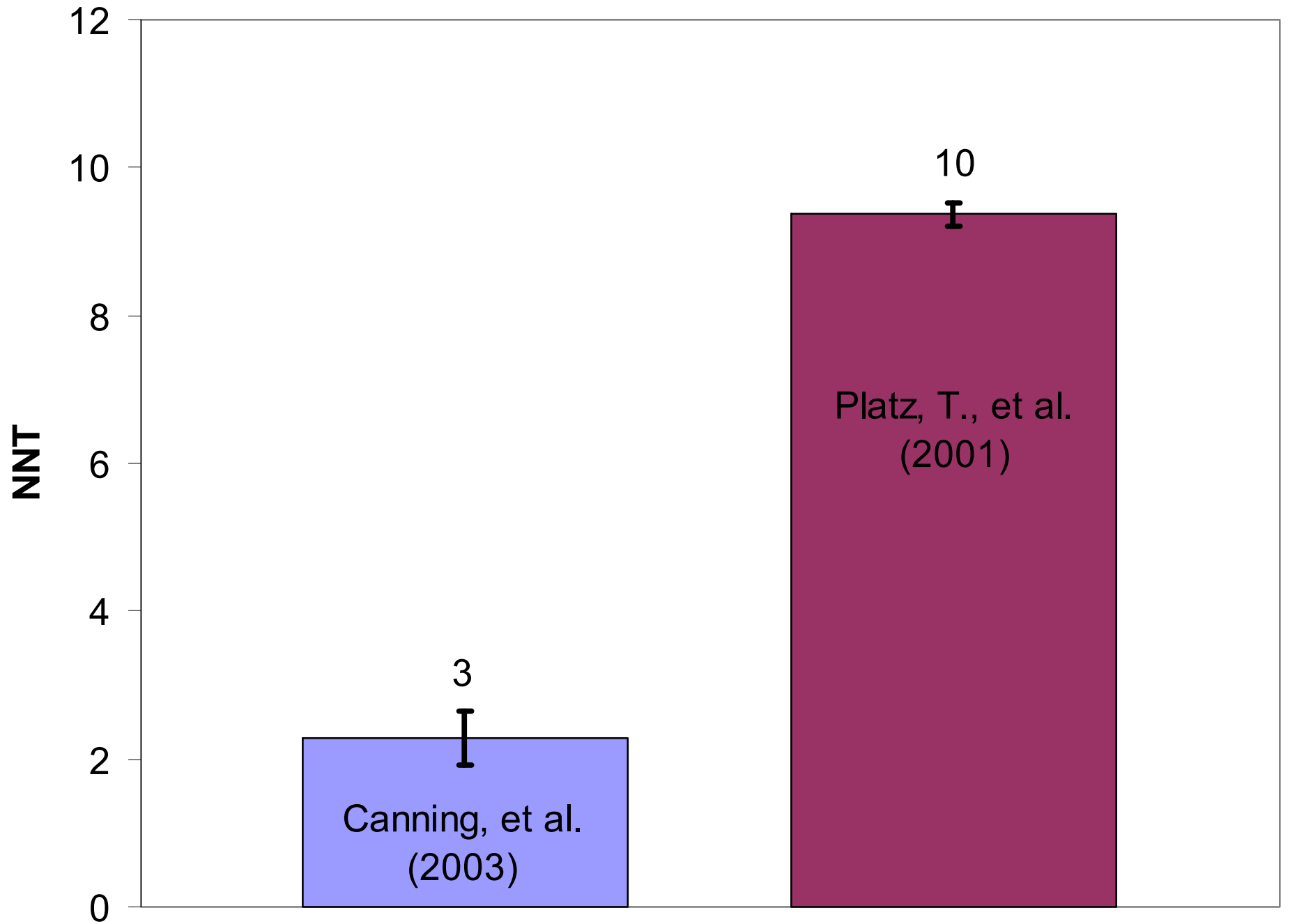
*Statistically significant effect size for sample size

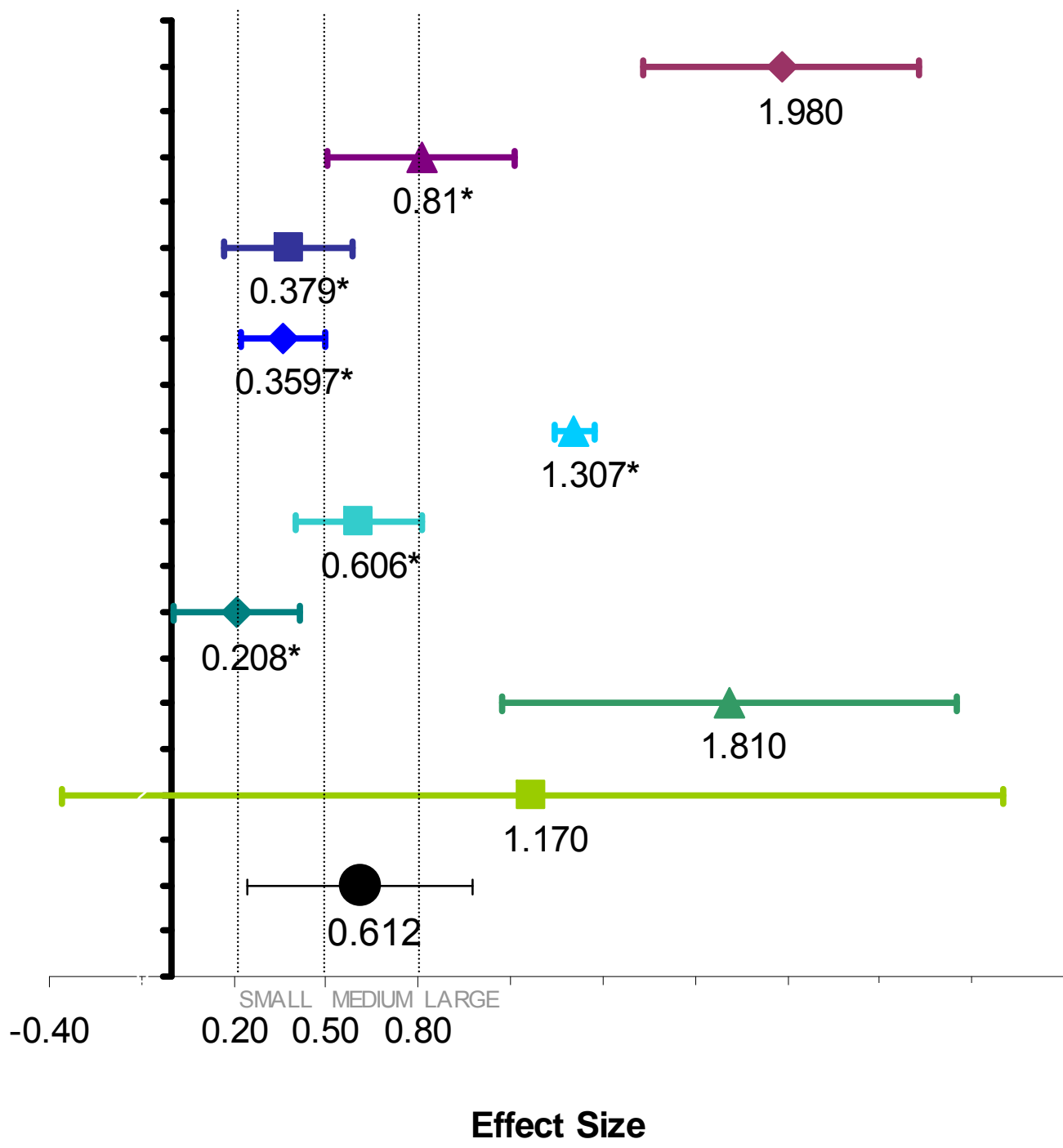
Level 3b Results

Author/year	Duration of follow-up	Results
Giles <i>et al</i> (1997)	At end of 11-37 days of treatment	ES: 6.47 (1.91-11.02)
Page and Levine (2003)	End of 10wk tx period	24.40% ARA

Level 4 Results

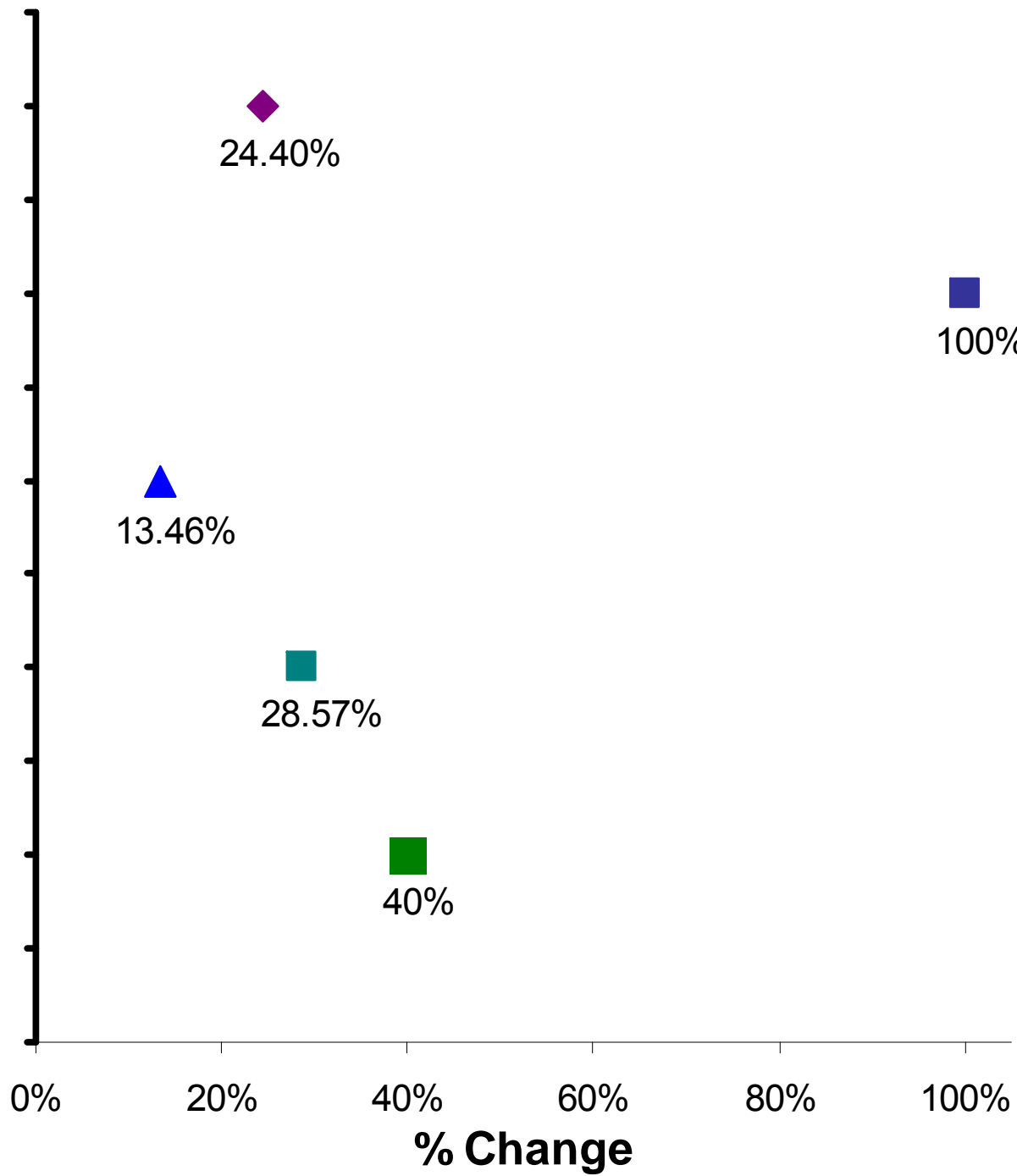
Author/year	Duration of follow-up	Results
Betker, <i>et al</i> (2007)	Immediately post training	100% # of Falls 12 trials
Kim, <i>et al</i> (2004)	2 mos	13.46% FMA
Scherer, M. (2007)	End of 11wks of tx	28.57% MAG
Seif-Naraghi and Herman (1999)	End of 3 mos of tx	40% % of Body Weight Supported





- ◆ Canning, et al. (2003)
- ▲ Platz, T., et al. (2001)*
- Brown, T.H., et al. (2005)*
- ◆ Morris, D. M., et al. (2006)*
- ▲ Shaw, S. E., et al. (2005)*
- Sietsema, J. M., et al. (1993)*
- ◆ Wilson, D. J., et al. (2006)*
- ▲ Sterr, A., et al. (2002)
- Giles, G. M., et al. (1997)
- AVERAGE EFFECT SIZE

*Statistically significant effect size for sample size



- ◆ Page, S. and P. Levine (2003)
- Betker, A. L., et al. (2007)
- ▲ Kim, Y. H., et al. (2004)
- Scherer, M. (2007)
- Seif-Naraghi and Herman (1999)

Harm, Adverse Effects

- Only one separate study reported harm ⁱ
 - Stroke, not TBI
 - Forced-use therapy (gait)
 - Torn gastrocnemius as measured by MRI

ⁱ Fisher, S. R., L. L. Wiggs, et al. (2007). "Forced use as a potential cause of gastrocnemius tears during neurologic rehabilitation: a report of 2 cases." Arch Phys Med Rehabil 88(3): 386-8.

Cost Effectiveness

- Not able to directly calculate
- May include increased education for some practitioners
 - Con Ed Course: \$395
 - NNT: 3-10
 - TBI pts/yr/clinician: 10
 - Over 10 years
 - Cost: ~\$12 - \$40 per patient



Integration and Summary of Studies

- Medium average effect size
- NNT was better for whole-body (3) vs. UE (10) task-training
- All case studies demonstrated improvement from baseline
- Trend: Improvements in TBI patients with neuroplasticity-guided > standard neurorehabilitation approaches

Integration and Summary of Studies

- Many studies used mixed approaches
- Those that specifically addressed motor-learning techniques usually lacked adequate power to substantiate effect size (small n)

Conclusions

- Reject H_0
 - H_0 : Patients with TBI do not benefit from participating in neurorehabilitation guided by neuroplasticity and motor-relearning principles.
- Accept H_1
 - H_1 : Patients with TBI can benefit from participating in neurorehabilitation guided by neuroplasticity and motor-relearning principles.

Conclusions

- Neuroplasticity-guided rehabilitation approaches have been examined and shown to be effective in research of patients with TBI.
- Absence of large effect sizes likely due to heterogeneity of population, and small research samples.
- Further research is needed to determine appropriate sub-populations and outcome measures.

Limitations

- Neuroplasticity-guided approach is a new envelope term
- No consistent outcome measures
- One study included stroke patients in the calculations
 - Platz, T., T. Winter, et al. (2001)

Ideal Patient Characteristics

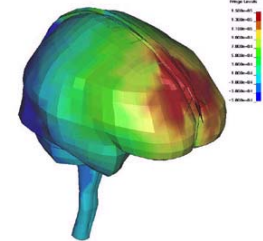
- Motivated
- Able to follow simple commands
- Able to express needs
- Rancho Level \geq V
- Neuromuscular > Musculoskeletal impairments
- In acute rehabilitation
 - Adult
 - Family/Caregiver support
 - Able to tolerate full tx session
 - Voluntary movement
 - Minimal medical complications


Recommendations for Practice

- Do not shy away from using this approach in the TBI population—it's not just for stroke rehab!
- TBI patients have the ability to learn!
- Clinicians should judge how the principles of these approaches can best be applied each individual patient.
- It's okay to mix approaches

Recommendations for Practice

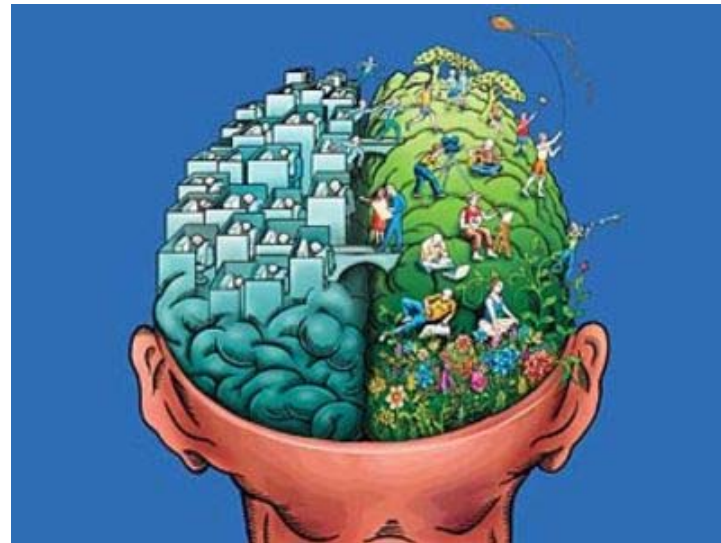
- Use the entire rehabilitation Team!
- Patients with impaired cognition and behavior:
 - Behavioral plan
 - Implicit learning > explicit for motor learning
 - Focus on task repetition > task understanding
- TBI patients use PT > psychological counseling !



 Phillips, V. L., A. I. Greenspan, et al. (2004). "Severity of injury and service utilization following traumatic brain injury: the first 3 months." J Head Trauma Rehabil 19(3): 217-25.

Recommendations for Future Research

- Use of unifying outcome measure(s)
- Identify characteristics of sub-populations that benefit most



Recommendations for Future Research

- Rehabilitation is effective, so non-treatment controls may not be ethically acceptable.
 - Case-matched control trials with large n
or
 - Single-subject design with multiple baselines

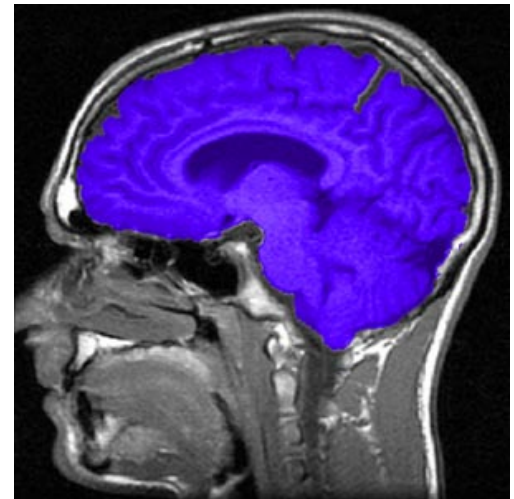
Thank You!

Dr. Nancy Byl, PT, PhD

Dr. Diane Allen, PT, PhD

Dr. Joanne Wagner, PT, PhD

DPT Classmates



Questions?

