

# Effects of Systematic Neurocognitive Rehabilitation after Moderate to Severe TBI- Results from a Randomized Controlled Trial

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# NeuroCognitive Disorders Lab: Miami University, Ohio, USA

- Total of 18 graduate students and 30 undergraduate students have participated on projects relating to the series of studies on categorization.



# NeuroCognitive Disorders Team-MU



# The Categorization Program (CP)

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- Robin D. Thomas
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# Contributing Research Sites

- Bancroft NeuroHealth, NJ
- Bancroft NeuroHealth, LA
- ReMed, PA
- Casa Colina Centers for Rehabilitation, CA
- Centre for Neuro Skills, CA
- Centre for Neuro Skills, TX
- Center for Comprehensive Services, IL
- Drake Rehabilitation Center, OH
- Special Tree Neurorehabilitation, Romulus, MI

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# Presentation Objectives

- To present general facts on the global significance of traumatic brain injury.
- To provide background information on human categorization and the Categorization Program.
- Present current findings on the effects of categorization training in brain injury rehabilitation.
- Provide information on current and future research directions with the Categorization Program training.

# Definition of TBI

- Traumatic brain injury (TBI) is defined as a blow (or jolt) to the head or a penetrating head injury that disrupts the function of the brain. The severity of a TBI may vary in range from “mild” (i.e. a brief change of mental status or transient loss of consciousness) to “severe” (i.e. a loss of consciousness or amnesia that lasts more than 24 hours). A TBI can result in various neuropsychological problems that interfere with independent function at the work, educational, and/or social setting.

(Brain Injury Association of America, 2005; Centers for Disease Control, 2005)

# The Significance

TBI has significant financial and social implications for the patient, the family, and the society at large. While acute medical care has improved the survival rates of patients with serious brain injuries, the cognitive, emotional, and behavioral outcomes resulting from TBI pose major lifelong limitations for social, educational, and vocational reintegration. Consequently, the National Institutes of Health proclaimed TBI as a disorder of major public health significance (NIH, 1998).

# Neuropsychological Outcomes of TBI

The survivor of brain injury is often faced with a variety of neuropsychological challenges including:

- Attention
- Organization and categorization problems
- Learning difficulties
- Memory deficits
- Information processing impairments
- Executive functioning deficits
  - Higher Reasoning
  - Decision Making
  - Problem Solving
- Psycho-social Problems
  - Anxiety
  - Depression
- Social-Communication Issues
  - Self awareness
  - Emotional control
  - Initiation
  - Inhibition

# Rehabilitation and Management

- Acute
- Post-Acute
- Community Re-Entry
- Comprehensive Rehabilitation Services
  - Neuropsychological rehabilitation
    - Cognitive Rehabilitation
  - Counseling
  - Speech-language Therapy
  - Physical Therapy
  - Occupational Therapy
  - Vocational/Educational Training
  - Nursing
  - Rehabilitation Medicine
  - Neurology

# Long Lasting Neuropsychological Effects

- Persisting memory and learning problems were reported at one, two, and six years post injury in moderate to severe CHI (Constantinidou & Neils, 1995; Constantinidou et al., 1996; Dikmen, Machamer, Temkin & McLean, 1990; Tate, Fenelon, Manning, & Hunter, 1991).
- Categorization and problem solving difficulties along with difficulties in managing stress and emotional upsets were reported for more than a year post injury (Constantinidou & Kreimer, 2004; Corrigan et al., 2004; Thurman, 2001)

# Rationale for Clinical Trials and Outcome/Efficacy Research

- Need to establish theoretical constructs on cognition based on scientific evidence and by integrating bodies of literature across disciplines.
- Need for innovative rehabilitation protocols and outcome research in cognitive rehabilitation.
- Lack of outcome research contributes to the current trends in reimbursement methods that compromise rehabilitation efforts and patient needs.

(Cicerone et al.,2005; Cicerone et al., 2000; NIH Consensus Statement, 1998)

# Rationale for Categorization Training

- Categorization is a fundamental cognitive process.
- There is a scarcity of investigation specific to the rehabilitation of classification behavior in patients with TBI in comparison to other domains such as attention and memory for which there is a substantial body of work.
- This line of research proposes to fill some of this gap in knowledge and to contribute to the growing body of evidence supporting cognitive rehabilitation efforts in general.

# Human Categorization

- Common Object Recognition incorporates semantic memory. Deficits in this system due to brain injury often lead to dissociations in categorization ability as a function of stimulus type. For example, subjects with specific lesions may not be able to categorize animate objects (such as animals) even though their ability to recognize artifacts (non living objects) remains unimpaired.
- Novel Category Learning incorporates mappings from object to category that can be described verbally, in terms of logical rules or hypotheses. It utilizes the left-hemisphere language centers and executive (attention and short-term memory) processes of the frontal lobes.

# Categorization and Brain Injury

- Constantinidou and Kreimer (2004) reported that moderate-severe traumatic brain injury interferes with the ability to extract and use attributes in order to describe common objects.
- However, subjects with moderate-severe TBI were able to learn how to describe objects effectively and improve their categorization. Therefore, the effects of a systematic rehabilitation program to improve categorization abilities in subjects with moderate-severe TBI should be explored (Constantinidou & Kreimer, 2004).

# The Categorization Program (CP)

- The CP tasks were developed to target both areas of categorization:

- Recognition and categorization of every day objects
- New category learning

Principles of learning, concept formation and rehabilitation were incorporated in order to develop the hierarchical tasks

(Adamovich, Henderson, & Auerbach, 1985; Coelho, DeRuyter, & Stein, 1996; Constantinidou, et al., 2004; Lezak, 1995; Levin, 1992; Luria 1963).

# Structure of the CP

## PART A of CP. Object Categorization Tasks.

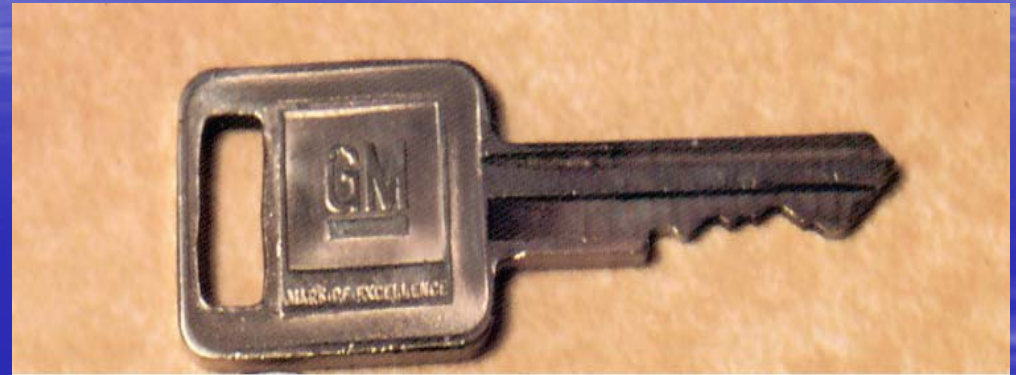
This part consists of 5 different levels. The tasks begin with teaching perceptual features in order to describe objects or living things and move to higher levels of abstraction. Cuing hierarchies are applied under each step to facilitate learning.

## B. New Category Learning Tasks.

The new category learning tasks consist of three levels. Under each level there are 5 steps that increasingly demand a higher level of rule-governed responses. Errorless learning principles and cueing hierarchies are applied under each step to facilitate learning.

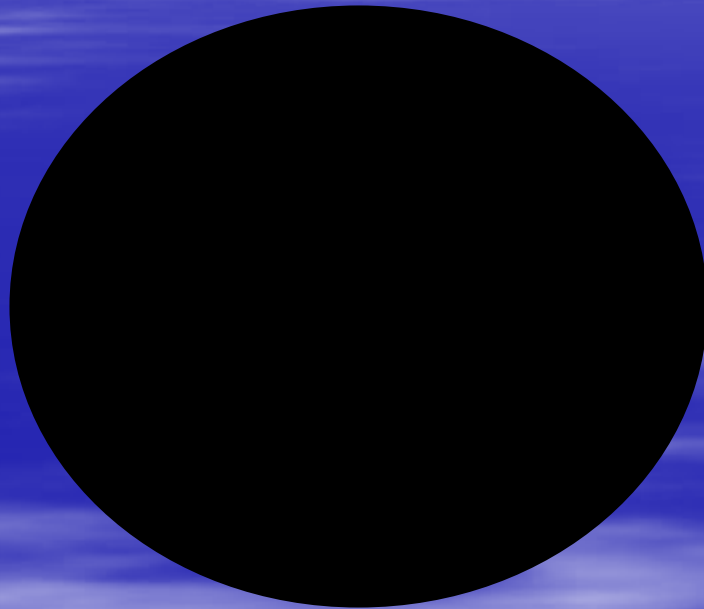
# Artifacts versus Living Things

- Key- focus on function



- Mouse-focus on perceptual properties than functional





A

B

Constantinidou, F., Thomas, R., Scharp, V.L,.... (2005).

*Journal of Head Trauma Rehabilitation, 20, 115-129.*

- Constantinidou et al. (2005) conducted a preliminary study with subjects with TBI and non injured adults who received the Categorization Program (CP) training.
- Results demonstrated that subjects who received the CP improved in their categorization abilities. Categorization abilities of subjects with TBI were compared to the performance of non-injured subjects. All subjects with TBI improved in their categorization abilities with non-injured subjects performing significantly better across all tasks.
- In some measures, after their training, participants with TBI were able to reach the baseline performance of non-injured participants.

# Purpose

- To demonstrate that:
- Post-acute rehabilitation is beneficial to patients with moderate-severe TBI as evidenced by improved functional outcome and neuropsychological performance.
- Systematic categorization training, the Categorization Program (CP) is an effective method to improve categorization abilities in patients with moderate-severe TBI.

# Hypotheses

- Post acute rehabilitation will result in improved functional and neuropsychological performance in patients with TBI.
- Patients who receive the CP training will demonstrate greater improvement in their categorization abilities and in their neuropsychological performance as compared to patients in the control group.
- Patients who receive the CP training will demonstrate a greater degree of generalizability to new tasks as compared to patients in the control group.

# Methods

## *Subjects*

Group 1: Subjects with TBI-Experimental: Twenty-one subjects with brain injury were included in the experimental group. The ages of the subjects ranged from 19-54 years with a mean age of 29.75 (SD=11.00). Education ranged from 12-17 years, with a mean of 13.81 (SD=1.83).

Group 2: Subjects with TBI-Control: Fourteen subjects with brain injury were included in the control group. The ages of the subjects ranged from 19-48 years with a mean age of 27.9 (SD=10.49). Education ranged from 12-15 years with a mean of 13.1 (SD=1.45). The two groups were matched for age, education, and severity indices.

# Procedures

- TBI subjects were matched on critical variables and severity indices and were randomly assigned to the experimental or the control group.
- The experimental group received the CP training. The control group did not receive the CP training; instead they received cognitive tasks traditionally used in their facility.
- Subjects were monitored in order to receive similar amounts of cognitive treatment. Subjects received about 6.5 hours of cognitive therapy per week for 12-17 weeks. Two of the 6.5 hours of treatment were spent on the CP training for SS in the experimental group.

# Procedures (continued)

- Subjects were administered a neuropsychological assessment, which included functional outcome measures (FOMs) at the beginning of their participation in the project. The FOMs were the Mayo-Portland Adaptability Inventory-III (MPAI-3) (Malec et al., 2000) and the Community Integration Questionnaire (CIQ) (Willer, et al., 1993). These measures were included in response to the current insurance climate requiring the use of FOMs.
- Following the neuropsychological testing, subjects were administered two categorization tests designed for this project.

# Research Design

			Part A							Part B	
	Pre-Tests	P r o b e 1	Level 1 Feature Training	Level 2 Similarities and Differences	P r o b e 2	Level 3 Functional Categorization	Level 4 Analogies	Level 5 Abstract Concepts	P r o b e 3	Levels 1-3	Post- Tests
Group 1 TBI Experimental	X	X	X	X	X	X	X	X	X	X	X
Group 2 TBI Control	X	X			X				X		X

# CP Tests and Probe Tasks

## CP Test 1.

- The first test relates to the categorization of common objects (Part A of the CP).
- Subjects are required to describe pictures of objects and identify core attributes such as their primary function and alternate uses of the object.

## CP Test 2

- This test relates to the new category learning portion (Part B of the CP).
- Subjects are required to follow a logical rule in categorizing objects. These objects are not part of the CP. There are a total of 5 rules with increased complexity.

## CP Probe Tasks.

- The probe tasks were designed to assess how subjects generalize information learned on the CP to other tasks not directly related to the CP training tasks. The order of the three tasks was counterbalanced.

# Neuropsychological Battery

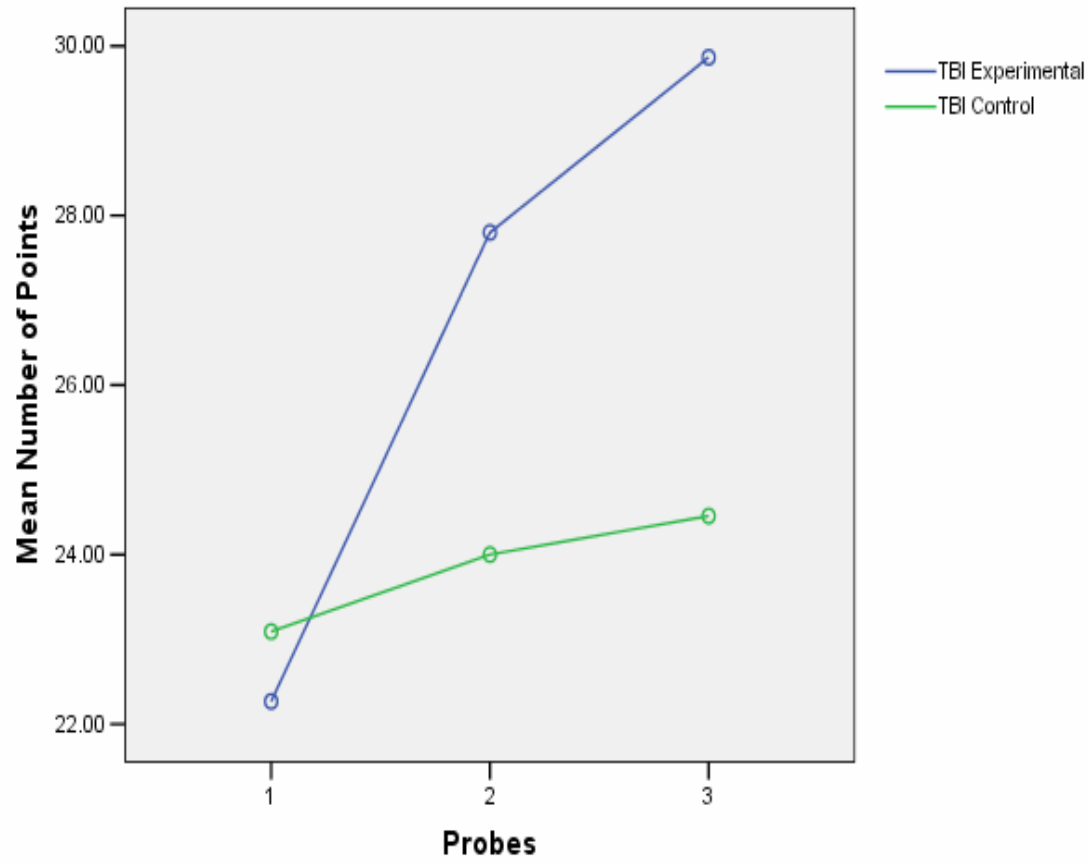
Intelligence	Wechsler Abbreviated Scale of Intelligence
Perception/Discrimination	Perception and Discrimination Scale Scales of Cognitive Abilities for TBI (SCATBI)
Organization	Organization Scale (SCATBI) Copy administration of the Rey Complex Figure Test
Attention and Concentration	Trail Making Tests A & B (also processing speed) Digit Span Forwards and Backwards Spatial Span Forwards and Backwards
Working Memory	Rey Complex Test-Recall Portion California Verbal Learning Test II
Executive Functioning	Wisconsin Card Sorting Test The Category Booklet Test
Processing Speed	Symbol Digit Modalities Test Controlled Oral Word Association Test
Visual Processing	Picture Recognition portion of the Woodcock Johnson Psycho-Educational Battery Revised (WJ-III)
Concept Formation & Reasoning	Reasoning Scale (SCATBI)
Fluid Reasoning	Analysis and Synthesis, Verbal Analogies, Concept Formation, Spatial Relations (WJ-III)
Word Finding	Boston Naming Test

# Results: CP Results

- There was no significant difference between groups at baseline on any of the dependent measures.
- At post test, MANOVA analyses resulted in a group by test interaction for CP Test 1,  $F(1,24)=6.110$ ,  $p=.021$ . Results indicate that subjects in the experimental group improved at a faster rate than the subjects in the control group.
- In addition, at post test, there was a significant between group effect for CP Test 2,  $F(1,24)=8.188$ ,  $p=.009$ , indicating that subjects in the experimental group benefited more by receiving the CP training as evidenced by their greater improvement on post-test performance.
- Furthermore, subjects in the experimental group improved greatly across the 3 probe tasks as they progressed on the CP training  $F(2,14)=6.517$ ,  $p=.010$ . In contrast, controls did not demonstrate generalizability to new tasks, and their performance did not change  $F(2,11)=.030$ ,  $p=.971$ .

Constantinidou, Thomas, & Robinson, 2008, Journal of Head Trauma Rehabilitation

# Probes 1-3



# Results: Neuropsychological Measures

- A paired sample t-test with alpha level of .01 was completed for each group for each of the neuropsychological measures. Subjects in the experimental group showed significant improvement on 12 neuropsychological measures including the SCATBI, WJ-III, CVLT, TMTA, SDMT, COWAT, SDMT, and the RCFT. In contrast, control subjects, improved on 7 measures including the BCT, RCFT, and one portion of the WJ-III.

# Correlation between Neuropsychological Measures and Categorization Measures

- Several neuropsychological measures correlated significantly with CP categorization tasks. The subtests that correlated assess lexical knowledge, language development, visual relations, spatial relations, induction ability, sequential reasoning, and semantic processing speed.
- As subjects who received CP training improved in categorization abilities, they also showed improvement in the cognitive abilities listed above.
  - Specifically, subjects in the experimental group showed improvement on the SCATBI reasoning scale, the WASI-Full 4, and 4 of the 6 subtests of the WJ-III, which also significantly correlated with CP Test 1.
  - These findings suggest that several cognitive linguistic skills are interrelated and the CP may tap into cognitive areas other than categorization.

# Discussion

- The present study demonstrated that post acute rehabilitation after TBI results in improved neuropsychological performance.
- Subjects who received the CP demonstrated greater improvement on certain aspects of cognitive abilities as compared to those subjects who received traditional post-acute rehabilitation.
- Another important objective was to determine the effects of the CP on improving categorization abilities in participants with TBI. Participants in the experimental group scored significantly better on the CP tests (after their training), demonstrating improvement in categorizing common objects and in classifying objects based on pre-determined rules. The CP training also facilitated their ability to generalize their categorization skills to novel tasks as evidenced by performance on the probe tasks.
- What are the “Active Ingredients” or the CP?
  - The CP program is based on neurobiological principles of cognitive skill acquisition and begins with concrete tasks and proceeds to incorporate high levels of abstraction. The redundancy of stimuli and the cuing levels provided support and facilitated learning. Consequently, patients were able to learn strategies and improve their classification skills.
  - Incorporates episodic memory during all of the levels.
  - Facilitates executive functioning abilities such as divergent thinking, problem solving, decision making.

# Limitations and Future Research

- In conclusion, systematic cognitive training implementing the CP protocol is an effective tool to train categorization skills in patients with TBI.
- Studies in this area need to continue in order to expand the sample size and replicate the findings.
- Need for larger RCT
- One of the strengths of the present study is the environment in which it takes place (issue of effectiveness and efficacy). However, this creates difficulties with attrition due to reduced lengths of stay in rehabilitation centers.
- Given the current financial climate and the challenges imposed by short length of stay, future research may want to modify the length of CP training. The current “dose” of the CP training appears to be effective. However, what is the optimal “dose”? Will a shorter version of the CP yield similar results?
- The use of the CP in older patients, in patients who completed post acute rehabilitation, and in pediatric patients who sustain brain injury may also be a fruitful line investigation (Constantinidou & Popplewell, 2007)-RPF funding..
- As neuroimaging and electrophysiologic methodologies continue to develop, future research should investigate the effects of neurocognitive training on brain reorganization and neuroplasticity. Can neuropsychological recovery be correlated with brain reorganization?

