Basic Research

- In the early 1980's, Dr. Edward Taub and a team of researchers began in animal research with study of the brain and movement.
- When a single forelimb receives a surgical abolition of somatic sensation, the monkey never uses the deafferented extremity again.

Basic Research

- Extensive purposeful use of the limb can be restored by two techniques.
  - Intensive training of the affected limb by shaping
  - Uninterrupted restraint of the intact forelimb for one week.
- A useless limb is thereby converted into a limb that can be used extensively.
- The use of this approach for rehabilitation of movement after CNS damage is now termed Constraint-Induced Movement Therapy or CI therapy.

Disclosure Statement

I am an invited speaker to MSHA and have received a stipend for this presentation.

I have also received compensation for travel related expenses.

Basic Research

- The treatment effect produced by CI therapy was said to be due to the overcoming of a mechanism termed Learned Nonuse (LNU).
- LNU involves a strong learned inhibition of attempts to use the affected extremity or speech that develops in the early post-injury period.

Does it make sense???

- That there is a degree of nonuse in persons who have aphasia.
- That SLPs using "traditional" therapies could have fostered this non-use?
- That CIAT research suggests that many persons with a lesion in Broca's area may have a degree of learned nonuse when attempting to use verbal production of speech.
- That a mixture of failed attempts at verbal language and reinforcement of alternative communication strategies, both of which are overcome during CIAT (disclaimer about AAC; we do NOT condemn the use, but we do not allow it during therapy)
The Learned Nonuse (LNU) Formulation

- The operation of LNU was confirmed in two experiments.
- The LNU formulation predicted that CI therapy, which overcomes LNU, would be efficacious after the loss of function resulting from many different types of damage to the CNS in humans.
- The initial application of the CI therapy approach to humans was for arm use in patients with chronic stroke.
- Subsequently, CI therapy was applied to many deficits caused by CNS damage of varied origins with success, as predicted by the LNU formulation.

Successful applications of the CI therapy approach to CNS injury in humans

- **Upper extremity**
  - Stroke in adults (first application)
  - Cerebral Palsy in young and older children (Pediatric CI therapy)
  - Traumatic Brain Injury
  - Multiple Sclerosis
- **Lower extremity**
  - Stroke
  - Spinal cord injury
  - Fractured hip
- **Aphasia** (CI Aphasia therapy – CIAT) (CIAT II)
- **Focal Hand Dystonia in Musicians**
- **Phantom Limb Pain**

CI Therapy Methodology: Arm

1. **Intensive training by a behavioral procedure termed 'shaping'**
   - Shaping involves requiring progressive improvements in motor performance or speech in small increments.
2. **A restraining device** on the unimpaired arm for a target of 90% of waking hours (in laboratory and at home)
   - The least important of the 3 components in adult humans
   - Physical restraint is very important in monkeys and in young children where self-discipline is reduced or absent.
   - It is not used at all in CI therapy for the legs or CI Aphasia Therapy. For them, we use only the Constraint imposed on a participant by the requirements of the training protocol.

3. **The Transfer Package**
   - Of central importance; distinguishes CI therapy from other therapies
   - A set of behavioral techniques used to promote transfer of treatment gains to life situation
   - Behavioral contract to use impaired arm/speech at home
     - With patient
     - With caregiver
   - Daily administration of Motor Activity Log (MAL) or Verbal Activity Log (VAL)
   - Progress on 30 ADLs or 12 situations using speech
   - Daily home diary
   - Monitoring success on Behavioral Contract
     - Problem solving
     - To circumvent perceived barriers to use of affected arm or speech/language in life situation
   - Weekly phone contact (MAL/VAL)
     - For first month after treatment
   - Home practice
     - During treatment & after treatment

Mark & Taub, 2004
CI Therapy Methodology

- The daily monitoring and problem solving are particularly important.
  - The transfer package makes patients/parents/caregivers responsible for adherence to the requirements of the therapy when they are out of the laboratory/clinic.
  - Therefore, in effect, patients/parents/caregivers are made responsible for their own improvement.
  - Rehabilitation becomes an active process rather than a passive one where patients come into a clinic and are ‘zap-rehabbed’.
  - In CI therapy, there is no ‘magic bullet’.

Real-World Arm Use: Motor Activity Log

CI Therapy and Neuroplastic Change

- CI therapy for impaired arm movement after stroke produces marked increases in grey matter volume in the sensorimotor cortex, more anterior motor areas, and hippocampus on both sides of the brain.

Constraint-Induced Therapy of Chronic Aphasia after Stroke – CIAT I

- Pulvermüller, Neinninger, Eibert, Mohr, Rockstroh, Köbbe, & Taub.

Origins of CIAT

- According to the Learned Nonuse formulation, the CI Therapy approach ought to apply to speech/language after brain damage as well as movement.
- Therefore, Dr. Taub translated part of the CI therapy protocol for the rehabilitation of movement to speech/language at the University of Konstanz in Germany with Dr. Friedemann Pulvermüller.
- They used some of the same basic components as in CI Movement Therapy:
  - Massed practice – 3 hours for 10 days
  - Shaping to constrain the participant to keep improving performance
  - Shaping constraints used:
    - Increase in complexity of objects to be named in cards
    - Accuracy of naming
    - 1 or 2 words vs. sentences
  - Enthusiastic reward for improved performance
Origins of CIAT

- However, because of Dr. Taub’s brief semiannual visits to Germany, the translation of the therapy protocol was only partial.

- In Germany, patients were trained using only one exercise—a language game (Go-Fish).
  - They did not use a full range of exercises in the laboratory to more closely approximate real-world speech/language than can be accomplished in a language game.
  - In CI Movement therapy, there was “shaping” of movement on many different tasks.

- Probably most important—they did not use a transfer package to translate gains in the laboratory to the real world; once therapy was over, the patient was done for the day.

The results were very good—17% improvement on the Aachen Aphasia Battery vs 2% for control patients given the same amount of conventional treatment.

-30% improvement in amount of real-world speech/language in everyday life vs. 0% improvement for control conventional treatment patients.

- These results were replicated in other laboratories with similar results and this resulted in new interest in the technique.

- However, the results were disappointing in a sense, because real-world improvement in speech was far less than after CI Movement therapy.

CI Movement therapy produces more than a 5 times improvement in movement in chronic stroke patients (500% plus).

Pulvermuller et al., 2001
Bhogal, et al., 2003

EBP Articles from CIAT I

CIL T (CIAT I) Studies
Berthier et al., 2009
Breier et al., 2006, 2007, 2009
Farooq-Shah et al., 2009
Goral & Kempler, 2010
Kremen & Maher, 2010
Maher et al., 2008
Pulvermuller et al., 2001, 2005
Richter et al., 2008
Szaflarski et al., 2008

• Intensity studies (CIL T)

Bakheit, et al., 2007
Basso & Cacporali, 2001
Denes et al., 1996
Harnish et al., 2008
Hinckley & Carr, 2005
Hinckley & Craig, 1993
Pulvermuller et al., 2001
Ramsberger & Marie, 2007
Raymer et al., 2006

The summary of EBP Data from CIAT I

- 19 studies with 202 participants
- Language impairment measures: CIL T (CIAT I) resulted in positive changes
- Communication activity/participation measures: CIL T resulted in positive language outcome measure changes; one large effect size
- Data available mostly for people with chronic aphasia. One study showed positive effect for 3 individuals with acute aphasia.
- Maintenance of CIL T effects: reported to lead to positive changes; again no effect sizes calculable
- Evolution of studies: Reduce time; pharmacotherapy; RH activation; syntax module; multiple activities

Data from EBP on CIAT I

(Intensity measures)

- 9 studies with 120 participants
- Language impairment measures: Increased treatment intensity was associated with positive changes in both chronic and acute aphasia.
  - BUT—Bakheit et al., with 97 participants (more than ½) showed no effect with intensity
- Activity/Participation measures: Bakheit et al., results notwithstanding, equivocal results, favoring neither more intensive nor less intensive treatment for persons with chronic aphasia.

Observations suggest that there can be complex interactions among intensity of treatment schedule, type of treatment, and type of outcome measure.

Maintenance of treatment: little data; also equivocal, favoring more intense treatment for one outcome measure and less intense for the other.
Data from EBP on CIAT I

(systematic review; Cherney, Patterson, Raymer, Frymark and Schooling, 2010)
24 databases reviewed (2006 – 2010)
English only, CI-LT and/or CIAT
18 years of age or older (202 total participants); (both fluent & nonfluent aphasias)
10 studies that met criteria
Review outcome
• Still exploratory
• p values still not significant

Origins of CIAT II

• The results of studies thus far led the UAB CIAT II team to ask whether increasing the similarity of CI Aphasia therapy to CI Movement therapy could improve the treatment results of CIAT so that they were more similar to those for CIMT.
• Accordingly, Dr. Taub, myself, Jamie Wade, and Leslie Harper extensively restructured the first CIAT protocol (CIAT I) to more closely resemble the protocol of CIMT, resulting in a new version of the treatment (CIAT II).
• We hoped that this would improve the results.

Modifications in the Technique

• Increased variety and range of the exercises – expanded from one to five
• Increased emphasis on shaping – timing rate of response, feedback
• Increased involvement of each participant’s caregiver
• Introduction of a transfer package

3 Main Principles Supporting CIAT II

• Massed-practice
  • 3.5 hours per day (x15 days) of repetitive tasks using successive approximation (shaping)
• Constraints
  • Visual barriers
  • Social demand
  • Time
• Transfer Package
  • Behavioral contract
  • Counseling
  • Demand for practice OUTSIDE of therapeutic environment

3 Basic Rules During CIAT II

Repetitive practice using principles of neuroplasticity
Make them talk; break their habits (and the family’s)
Make activities functional for their own personal environment

Who are the good candidates for CIAT II?

• Persons with left hemisphere CVA
• Persons with chronic aphasia
  • (at this time)
• Persons with non-fluent aphasias
  • Several studies have included persons with Wernicke’s aphasia and Global aphasia
• Persons with good motivation
• Persons with good family/caregiver support
Measuring Non-Use

- Verbal Activity Log
  - Amount – This one is paramount to measurement of non-use
  - How well – This measure gives you an idea of the patient’s perception of his/her language/speech use

- 5 point scale
  - Amount – measured pre- and post-therapy
  - How well – measured pre-, post-, and each day of treatment

The Verbal Activity Log (VAL)

- The Verbal Activity Log (VAL) is a novel assessment tool designed to be the primary outcome measure used in CIAT-II
- Designed to measure real-world speech & language
- Different from current measures which assess both verbal and nonverbal communicative behaviors
- A scripted structured interview administered to the patient and caregiver
- Measures how much and how well the patient currently uses speech in the life situation compared to before stroke
- Modeled after the Motor Activity Log (MAL) used in CI Movement Therapy

The Verbal Activity Log

- 12 items that address only speech/language output in the life situation
- Administered to patients and caregivers jointly
- Rated on two 6-point Likert scales comparing current amount and quality of speech use to before the stroke
- Items encompass a wide variety of situations
- Speaking to friends/family
- Telephone use
- Speech-related tasks in public

The Verbal Activity Log (VAL)

**Amount Scale**

- 0. Did not use speech (not used) (0%)
- 1. Occasionally used speech, but only very rarely (very rarely used) (10%)
- 2. Sometimes used speech, but rarely (rarely, or not often used) (25%)
- 3. Used speech about half as much as before the stroke (half the time) (50%)
- 4. Used speech almost as much as before the stroke and did not rely on my caregiver very often (frequently) (75%)
- 5. Used speech as often as before the stroke (normal amount of use) (100%)

**How Well Scale**

- 0. My speech was not used at all for that activity (0%)
- 1. My speech was used for that activity but was not helpful (very poor) (10%)
- 2. My speech was of some use during that activity but I required help from my caregiver and speech was slow (poor) (25%)
- 3. My speech was used for that activity but it was slow and I only used 2-4 words (fair) (50%)
- 4. My speech was used for that activity and was almost normal but not quite as fast or as accurate as normal (almost normal) (75%)
- 5. My speech for that activity was as good as before the stroke (normal) (100%)

Validation of the Verbal Activity Log

- This study is complete
- 40 individuals with aphasia were evaluated with the VAL
- Scores on each VAL scale (Amount and How Well) are compared to:
  - A previously-validated measure of functional communication, i.e. speech plus other means of communication (the CETI)
  - A digital recording of real-world speech
- Validity was supported by Pearson correlations between spoken language recordings and both VAL scales (.67, p<.002)
- We felt that this was preliminary evidence for both reliability and validity of the outcome measure
What are the Language Tasks?

- Repetition of functor words & pronouns in short phrases
- Repetition of familiar ADL phrases
- CIAT I card game which resembles “go fish”
- Sequenced verbal expression task utilizing Life Interest & Value (LIV!) cards
- Naming, carrier phrase, “tell me what you see”
- Functional Role Play tasks

How is CIAT II different from traditional therapy?

- SHAPING!
- This was the hardest concept to grasp in terms of how small the increments actually were
- Intense timing is involved
- Task by task and daily data points are imperative
- Motivating & yet challenging encouragement after each response
- “The idea of shaping is grounded in operant conditioning principles and refers to the gradual, successive approximation of behavior in small steps toward achieving the desired goal.” - B.F. Skinner

How is CIAT II different from CIAT I therapy?

- Adherence-enhancing behavioral strategies
  - Called the “transfer package”
  - Daily administration of the Verbal Activity Log
  - Home diary
  - Problem-solving
  - Behavioral contract
  - Caregiver contract
  - Home skill assignment
  - Home practice
  - Daily schedule

The transfer package

- To insist the patient be actively engaged in and adherent to the intervention without constant supervision from the SLP, especially in the life situation where the SLP is not present
- I truly believe this is what made the difference in our patients

CIAT II results

- 4 pilot subjects (we have now 10 who have completed the study with MRI data)

WAB-R Scores Aphasia Quotient

- Mean gain was 67.0 to 79.3
- Post-treatment gains approached significance with $p = .67$

- Patient 1
  - Pre = 61.8
  - Post = 82.9
- Patient 2
  - Pre = 75.6
  - Post = 91.8
- Patient 3
  - Pre = 66.8
  - Post = 77.6
- Patient 4
  - Pre = 64.0
  - Post = 64.8

- Clinical scores using the WAB-R
- Verbal Activity Log (VAL) scores
  - Amount
  - How Well
- Imaging data
  - MRI with Voxel Based Morphometry (VBM) applied for statistical significance
VAL Scores

- **Patient 1**
  - Pre amount = 0.3
  - Post amount = 3.6
  - Pre how well = 0.7
  - Post how well = 2.8

- **Patient 2**
  - Pre amount = 1.8
  - Post amount = 3.8
  - Pre how well = 1.3
  - Post how well = 2.9

- **Patient 3**
  - Pre amount = 1.4
  - Post amount = 3.6
  - Pre how well = 0.6
  - Post how well = 3.6

- **Patient 4**
  - Pre amount = 2.9
  - Post amount = 3.8
  - Pre how well = 2.2
  - Post how well = 3.8

CIAT-II: Extent and Location of Lesions

- **Lesion Location**
  - A: Frontoparietal superior temporal
  - B: Posterior frontal & parietal
  - C: Inferior parietal posterior frontal
  - D: Lateral frontotemporal medial parietal

VBM Processing: Lesion Tracing

- Difference images are created by subtracting the pre-treatment grey matter image from the post-treatment grey matter image
- Stats code conducts a t-test to determine if there is statistically significant change in grey matter amount anywhere in the brain
- Then a map of t-values is created to reflect the greatest amount of grey matter change
Grey Matter Change: Conclusions

- Grey matter change present in bilateral frontotemporal areas associated with language function
- Results not significant due to small sample size
- Pattern of change suggests that CIAT II produces grey matter modification in language areas analogous to modification of motor cortex by CIMT
- Additionally, there may be a link between modification of language cortex and neuroplasticity in motor areas

Future Directions with MRI studies

- Replicate this analysis with a larger sample size and a control group
- Analysis of white matter tracts before and after administration of CIAT II
- Analyze effects of lesion size and location
- Larger sample size will also allow an analysis of correlation between structural change and functional speech recovery

Whole-brain analysis revealed grey matter gains (synaptogenesis) in frontotemporal areas subserving language function in both the left and right hemispheres. Since the current series consists of only four patients, the changes were not statistically significant (max tobs = 4.58, tcrit = 5.29), but approaching significance. We now have 10 brains in the study and our numbers are improving.

SLPS view/opinions on CIAT I & II

- 167 SLPS completed survey
- 16 questions querying
  - Ease of utilization
  - CI concerns (duration, feasibility, adherence...)
  - Reimbursement of CI by managed care companies
  - Easy vs. difficult to administer

Page & Wallace (2014)

SLPS view/opinions on CIAT I & II

- 60% reported very unlikely that patients would adhere to CI "rules"
- 49% reported concerns over number of hours in therapy
- 35% reported concerns over number of days spent in therapy
- 34% reported concerns over number of hours of therapy that they would have to provide
- 32% reported concerns over the number of consecutive days that patients would be in therapy
- Almost 100% of respondents stated that their facilities did not have resources to provide CI therapy sessions
- Greatest concerns when allowed open ended comments:
  - Personnel for coverage of other patients
  - Resources ($$$)
  - Group setting of therapy
  - Prohibition of other compensatory strategies
  - Patient frustration
  - Patient motivation
  - Patient and clinician boredom (repetitive nature of TX)

Page & Wallace (2014)
Future Directions with CIAT II

- Continuing to run patients (in groups of 2 or 4)
- Continuing to apply for NIH Federal grants
- Continuing to provide information regarding CIAT II at conferences

- 2 CIAT II studies currently running; 1 in Canada and 1 in Australia (our hope is that the outcome data will be similar and numbers will be somewhat validated)

Questions/Comments

A short clip

- [http://vimeo.com/26364432](http://vimeo.com/26364432)