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# Constraint Induced Movement Therapy

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# The Brain that Changes Itself

Stories of Personal Triumph from the Frontiers of Brain Science

Norman Doidge, MD, 2007, Penguin Group, NY, NY

- Midnight Resurrections-Stroke victims learn to move and speak again
    - Edward Taub laid the foundation in 1981 CI movement therapy
    - Ahead of his time-claim chronic stroke pts could be helped by a plasticity based treatment
    - Born in 1931, studied “behaviorism” Columbia Univeristy
    - Job as a RA experimental lab studied nervous system. Lab was doing “deafferentation” experiments with monkeys
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## Nobel Prize winner Sir Charles Sherrington 1895 use “deafferentation”

- An “afferent N” or “sensory N” conveys sensory impulses to the spine and the brain. **Deafferentation** is a surgical procedure in which incoming nerves are cut so **none** of the sensory input can make this trip.
  - Deafferented limbs – can’t sense where its affected limbs are in space, or feel sensation, or pain when touched.
  - Sherrington idea- all of our movement occurs in response to some stimulus, we move not because our brains command it, spinal reflexes keep us moving “**reflexological theory of movement**”  
ie. Knee tap- sensory receptor picks up—sensory neurons, conveys to motor neuron in the spine, making knee to contract involuntarily. He believed reflexes were the foundation of all movement.
  - Proposed movement is based on and initiated by, sensory part of the spinal reflex, and monkeys couldn’t move because destroyed sensory part of reflex by deafferentation
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## Questions asked by Taub

- Deafferented sensory nerves in a monkey's arm were cut prior to entering the spinal cord....so no sensory signals could go to the monkey's brain
  - Found monkey stopped using the limb
  - But they cut the sensory nerves (transmit feeling), not the motor nerves from the brain to the muscle which transmit movement
  - So the monkey couldn't feel but why couldn't they move?
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**Taub's findings:** if monkeys can move their deafferented arms without feeling or sensation, then Sherrington's theory is wrong. Believed there is an independent motor program in the brain that initiated voluntary movement. Possible implication for stroke recovery

- Open the idea of Plasticity
  - Deafferented whole spinal cord, no spinal reflex, and no sensory input into its limb, still able to use limb.
  - Reflexological theory was proved wrong
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# Studied deafferentation of forelimbs of monkeys

- Loss of sensation but not affect motor innervation
  - Unilateral, no attempt to use the deafferented extremity
  - Stereotyped position of shoulder add, elbow and wrist flexion
  - Bilateral, monkeys able to use
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# Taub: research with monkeys

- Bilateral -motivation high to use limb
  - Unilateral, intact limb restrained-monkey able to reach with deafferented limb
  - Restrained removed 1-2 days, return of nonuse
  - Restrained for 3 days, use of deafferented limb continued
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## Attempts to use deafferented limb leads to aversive consequences

- Loss of balance
  - Falling during ambulation or climbing
  - Loss of food or objects
  - Failure in attempt to use the limb
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- Deafferented arm becomes weak and atrophy
  - Plasticity principle of “use it or lose it”
  - Monkey learns not to use the limb. Which is based on a learning mechanism termed “LEARNED NONUSE”
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- 1981, Taub worked Behavioral Biology Center in Silver Spring, Maryland..to transform work from monkeys into a treatment for stroke
  - A volunteer worked in his lab, who was president of PETA People for the Ethical Treatment of Animals (PETA), militant animal rights group
  - Taub was arrested and put on trial for cruelty to animals, spent next 6 yrs of life to clear himself
  - Was exonerated in a unanimous decision
  - Hired in 1986 at the University of Alabama
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**Constraint Induced Movement  
Therapy has been derived from  
research with monkeys.**

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**Taub, E. (1980).**

**Somatosensory deafferentation research with monkeys:  
Implications for rehabilitation medicine, In L.P. Incen  
(ed.), Behavioral psychology in rehabilitation medication:  
Clinical applications**

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**CI movement therapy is an intervention that involves motor restriction of the unaffected UE in a sling and training of the affected arm**

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**Taub, E. and Wolf, S. (1997)**  
**Constraint induced movement**  
**techniques to facilitate upper extremity**  
**use in stroke patients**, **Top Stroke**  
**Rehabil.**

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## **Protocol for developing techniques from research to human patients after stroke**

- Restraining unaffected arm with a sling during waking hours for 14 days
  - For 10 days pts given 6 hrs practice using impaired arm
  - Attention-comparison group received procedures to focus attention on use of impaired arm
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# Minimum motor criterion

- 10° finger extension
  - 20° wrist extension
  - Restraining unaffected limb in sling for 2 weeks
  - Sling worn during waking hours
  - Sling removed for sleep and ½ hour exercise
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**Results: prolonged restraint of unaffected UE and practice of functional movements of impaired arm proved to be effective in restoring motor function**

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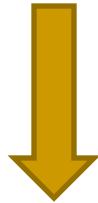
**Results: positive changes in amount of use of affected arm in ADL outside of clinic, persisted for 2 year measure to date.**

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## Forced Use

## Constraint- Induced Therapy

- **Restraint**



- **Unstructured Practice**

- **Restraint**

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### **Structured Practice**



**Shaping**

**Repetitive Practice**

Charles J & Gordon AM. 2005. A critical review of constraint-induced movement therapy and forced use in children with hemiplegia. *Neural Plasticity*. 12 (2-3), 245-261.

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Children often tend not to  
use the affected UE

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Resulting in developmentally learned  
non-use of the affected UE, termed  
**“developmental disuse”**

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**Eliasson A, et al. (2005). Effects of constraint-induced movement therapy in young children with hemiplegic cerebral palsy: an adapted model. Dev Med & Child Neurol. 47 (4), 266-275.**

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# Objective

- Evaluate modified CI therapy could improve functional use of the hand compared to conventional treatment
  - Make a comparison with conventional treatment
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# Design

- **21 children completed CI and 20 children served as a control group**
  - **Inclusion criteria were hemiplegia CP between 18 months and 4 years**
  - **Children with all degrees of impaired hand function were accepted**
  - **Children were matched for age and degree of hand function**
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# Intervention

- Dominant hand was restrained with a glove, inhibiting ability to grasp.
  - Children wore the gloves for 2 hours each day for 2 months, 7 days a week
  - Training based on motor learning and used in a playful setting
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## Results

- Children receiving CI improved ability to use hemiplegic hand compared to control group
  - Adapted CI model seems to improve use of hemiplegic hand
  - Influence of the results could be that the treatment was tailored to suit each child's capacity and interest
  - Children felt less frustrated
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**Willis JK, Morello A, Davie A, Rice JC, Bennett JT. Forced use treatment of childhood hemiparesis. Pediatrics, 2002**

- 12 children with hemiparesis (1-8 yrs) received plaster cast on unimpaired arm for 1 month
  - 13 children with hemiparesis control did not.
  - PDMS performed on all treatment and control before and after casting and 6 months later when controls crossed over to receive cast
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## Results:

- Greater improvements were seen in the treatment group, which was reconfirmed when the plaster cast was applied to the control group.
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**Taub et al. 2004. Efficacy of constraint-induced movement therapy for children with cerebral palsy with asymmetric impairment. Pediatrics 113: 305-312**

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Randomly assigned 18 children between  
7 mo. & 8 yrs to treatment and control groups

- TX group bivalve plaster cast was applied to the unaffected arm for 21 days
  - Functional training activities given to the affected arm for 6 hrs a day
  - RESULTS: improvements in both amount of use and functional abilities in the treatment group
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**Naylor CE & Bower E. 2005. Modified constraint-induced movement therapy for young children with hemiplegic CP: a pilot study. Dev Med & Child Neurol.**

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- 9 children 21-61 months
  - Single-case design using children as their own controls
  - 4 week baseline with no hand treatment, controlling for maturation
  - 4 week treatment
  - 4 week no treatment-measure carry-over
  - Verbal instructions and gentle restraint of the unaffected arm were used (adult holding the arm during the activities)
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## Results: consistent with other studies showing improvement in upper limb function after CIMT

- Key difference-

Used only gentle restraint and verbal instructions versus other studies that used prolonged periods of physical restraint

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**Yasukawa, A. (1990) Case report-  
upper extremity casting: adjunct  
treatment for a child with cerebral  
palsy hemiplegia, AJOT.**

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IDELLA  
16 MOS.  
RT HEMI

22 DAYS  
CASTED  
3-11-87

18 MOS.  
LT CAST  
24 DAYS

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# Criteria for inclusion

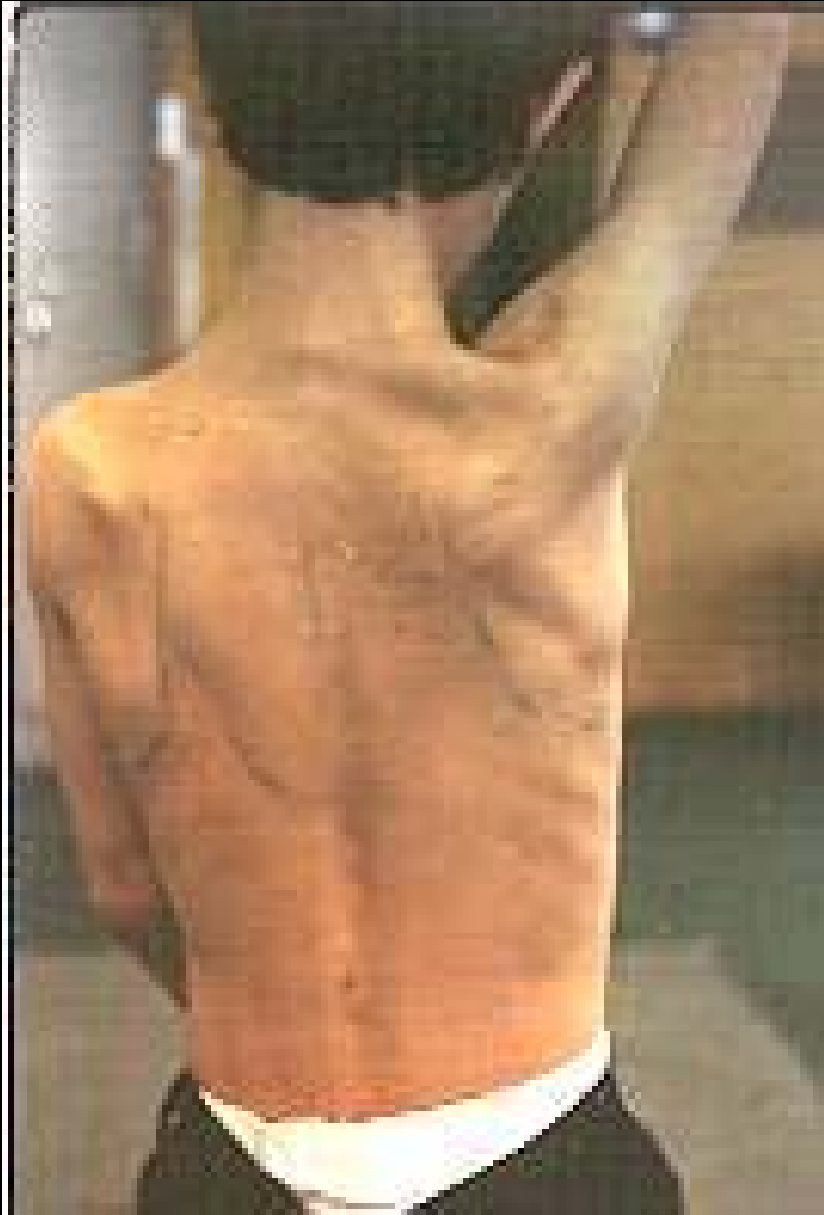
- Age: 5 months-5 yrs.
  - Voluntary control: gross functional assist for active reach, WB, bilateral task and grasp and release
  - Sensation: no major sensory deficits
  - Motivation: enjoys moving and exploring
  - Realistic parents: motivated to participate, realistic expectations
  - *Preparation of the involved limb-biomechanical alignment*
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# ***Preparation of the involved limb- biomechanical alignment***





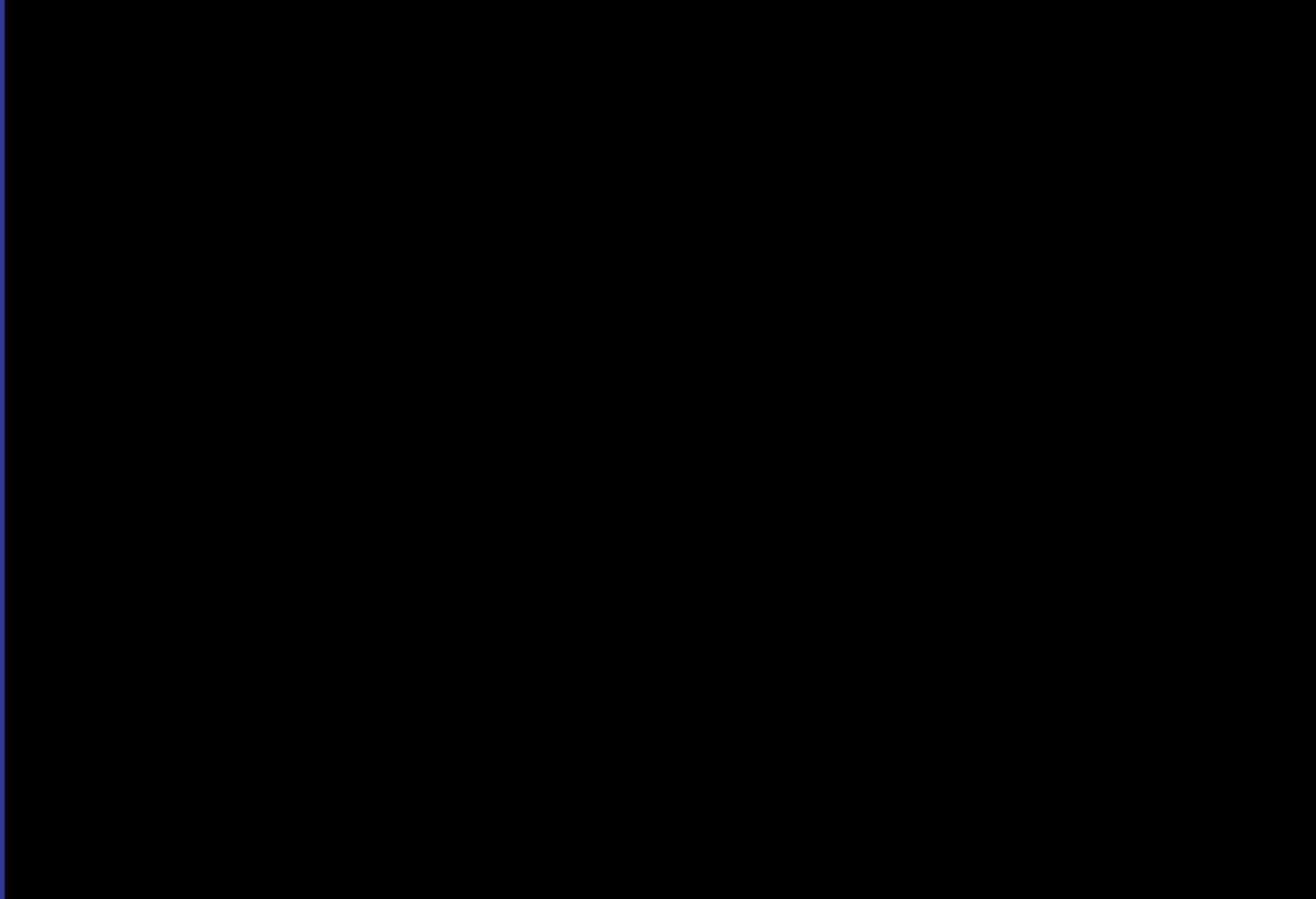


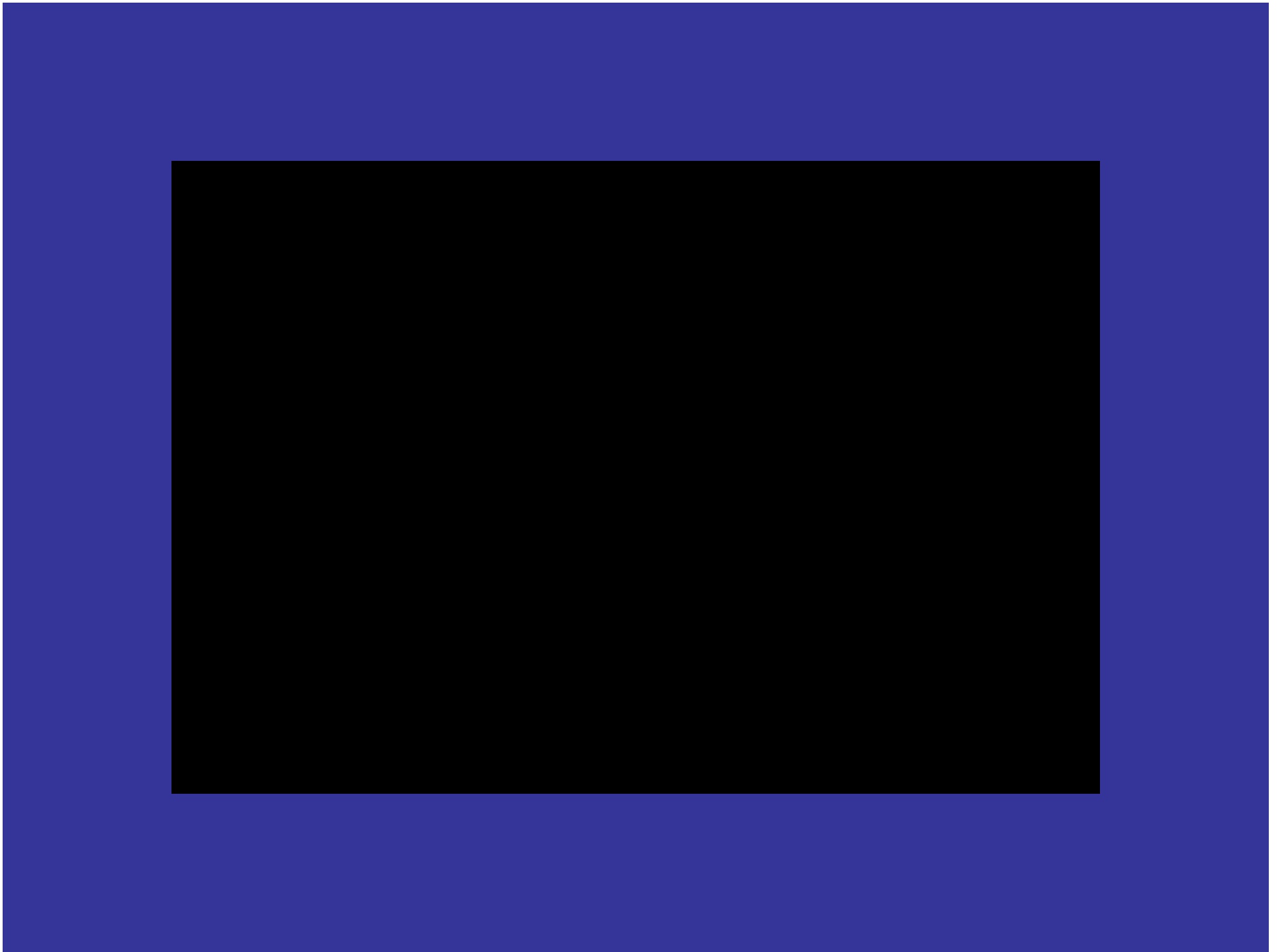






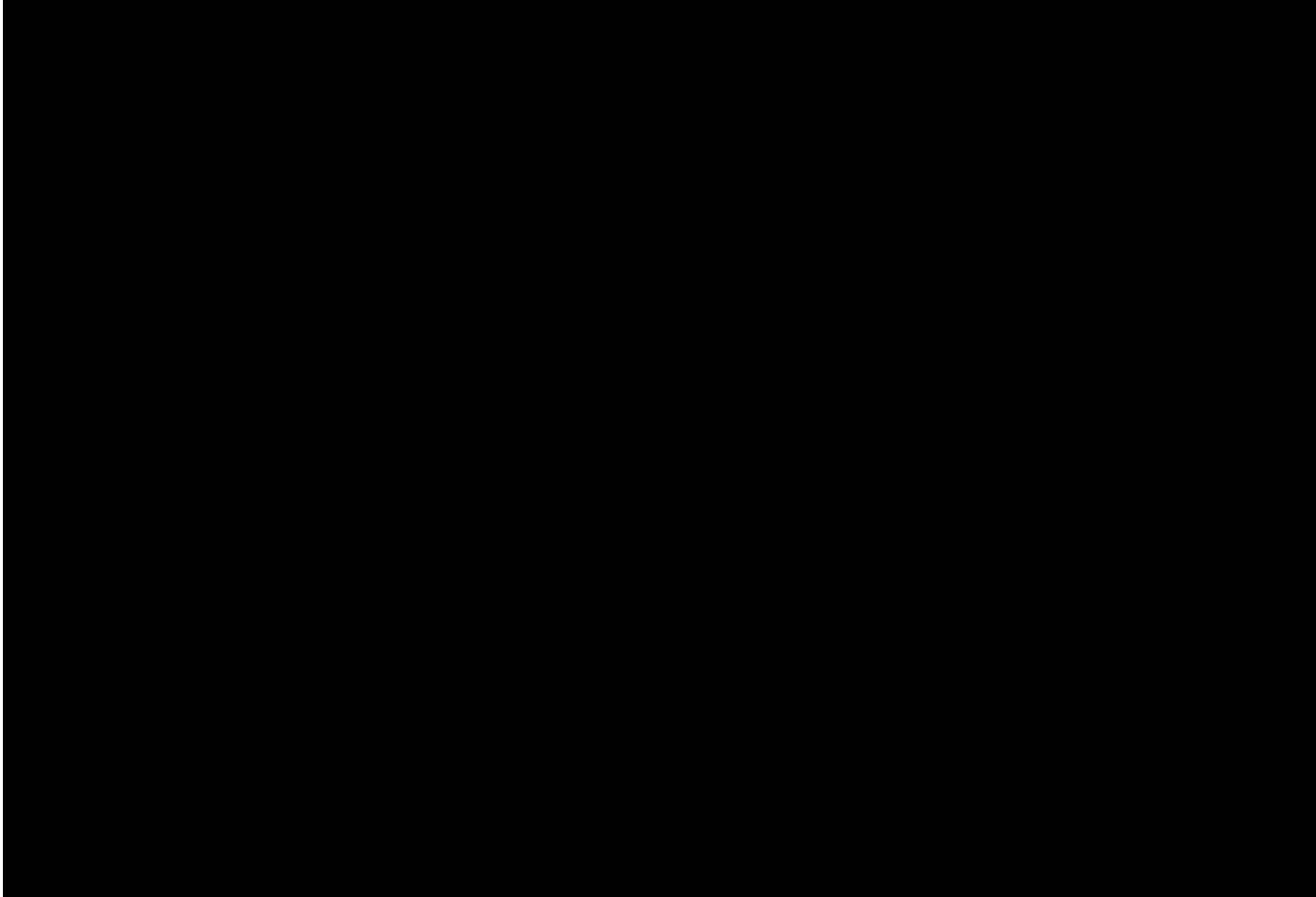
# Prepare the hand for fine motor skills



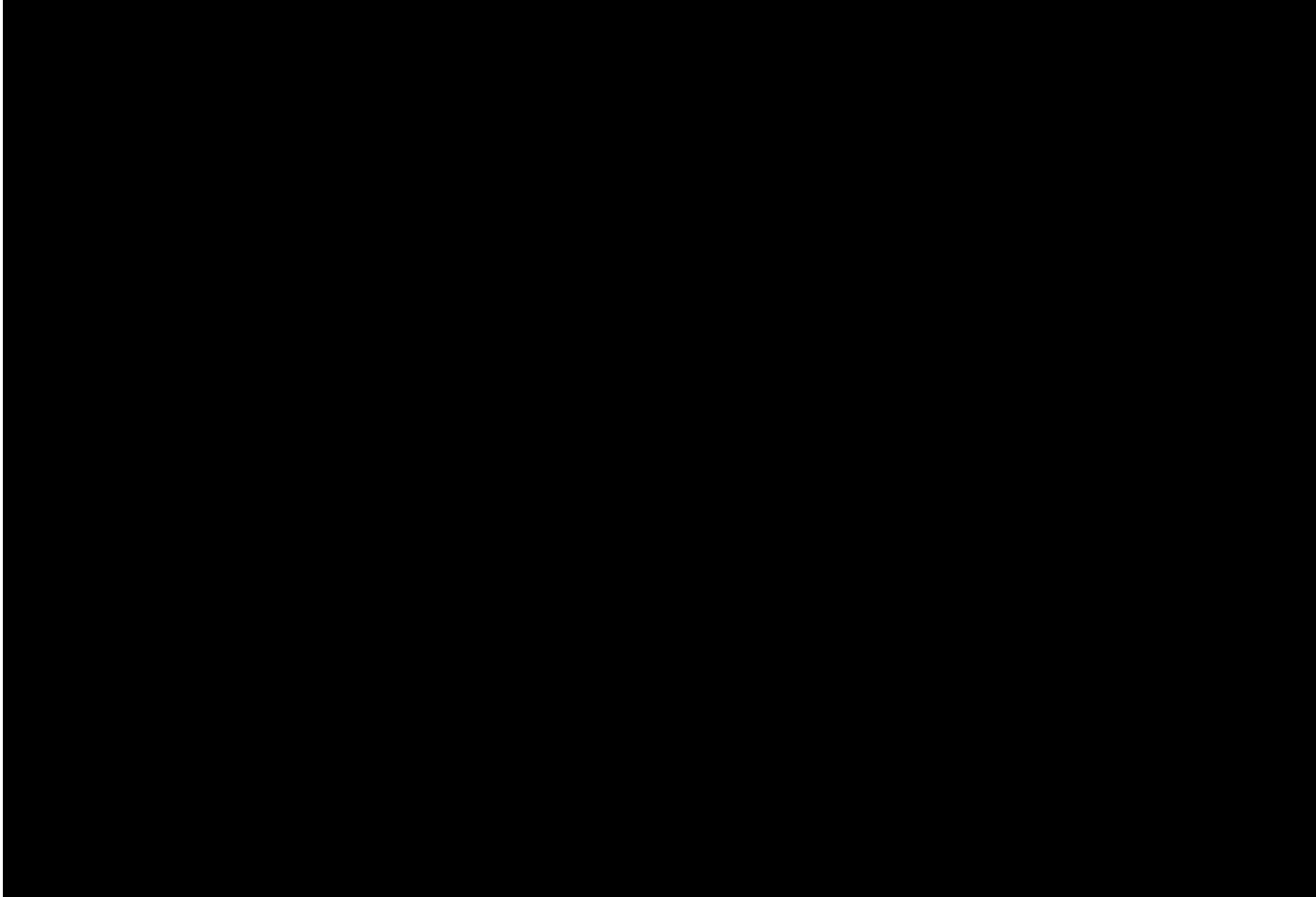




Alex



Alex









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**Can constraint therapy be  
developmentally appropriate and  
child-friendly?**

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**Editorial: Hilary Hart**

**June 2005 Dev Med & Child Neurol**

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**There are critical periods of heightened plasticity in early development when neural circuits can be shaped by experience which points to extreme caution in restraining children at too young an age.**

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- **Therapy needs to be developmentally appropriate**
  - **Structure activities at the child's developmental level**
  - **This form of therapy should be child friendly**
  - **What is the lowest level of hand function that a child can improve with CIMT**
  - **Can similar intense practice be elicited without restraint and produce better outcome?**
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**Charles J & Gordon AM. 2006. Development of hand-arm bimanual intensive training (HABIT) for improving bimanual coordination in children with hemiplegic cerebral palsy. Dev Med & Child Neurol. 48:931-936.**

- Modified constraint induced movement therapy-evidence suggest practice improves function
  - CP hemi have impairments in bimanual coordination
  - Aimed at improving coordination of the two hands using principles of motor learning
  - Introduced a newly developed bimanual treatment, Hand-Arm Bimanual Intensive Therapy (HABIT)
  - Intensive structured practice and child friendliness
  - CI & HABIT-intensive uni-manual and bimanual skills
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**One hand or two? Randomized trial of  
constraint induced movement therapy versus  
bimanual training for children with congenital  
hemiplegia- Boccthy LS, Boyd R, et al**

2008 Dev Med & Child Neurol. 50 (4), p15

Both groups made significant improvements in  
movement efficiency following intervention

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## **Little-Hayes P., et al. 2007. Embracing the Spirit of Inquiry- Creating and Evidence-Based Guideline for Using CIMT, OT Practice, 9-15.**

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Evidenced based clinical practice guidelines for children with CP- CIMT.

CIMT refers to restraining unaffected limb while training the affected limb for 3 or> hrs p/day for 2 or more weeks.

Mod CIMT unaffected limb is restrained < 3hrs each day

Forced use constraining unaffected limb without structured upper-limb training

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## Effectiveness of CIMT with children

- Methods of constraint and duration, varied
  - Positive gains noted in all studies
  - Areas measured and extent of gains varied
  - Increased spontaneous use of affected limb
  - Increase in ADL
  - Improved quality, speed and dexterity
  - Improved use of impaired hand as an assist in bilateral activities
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## CIMT being considered need to meet the needs and abilities of the child and family

- Discuss options with family on the best protocol
  - CIMT requires commitment of time and energy from the parents
  - What is realistic with the parent
  - Optimal frequency of therapeutic intervention during CI not clear from literature
  - Increase noted whether seen for 6 hrs. daily to 1-2 hrs. 2-3x/p/wk, to no therapy during constraint
  - Method of constraint: removable cast, soft mitt with splint inside, ace wrap around splint, bivalve.
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## Intervention

- Child interested and motivated to play
  - Activities are age appropriate, also challenging so the child can be successful in developing new skills
  - PRACTICE PRACTICE PRACTICE
  - REPETITION
  - Determine goals and develop home program
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**Studies suggests children with hemiplegic CP can improve motor performance if provided with sufficient practice**

intensive practice may improve function in the in the involved UE that could lead to increased use in ADL

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## Managing spasticity can be successful with an integrated treatment approach



- **Assessment of tone**
- **Biomechanical alignment**
- **Muscle imbalance**
- **Using a variety of treatment approaches**
- **Incorporating CI-developmentally appropriate task**