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# Stroke Rehabilitation: Maximizing Recovery in Acute and Chronic Cases

1. **The window for neuroplastic changes post stroke would be best cited as:**

   A. 7 days
   B. 30 days
   C. 1 year
   D. 5 years

2. **The most critical elements for stimulating neuroplasticity include:**

   A. Task intensity, specificity, difficulty, concentration
   B. Task specificity, difficulty, dual task, complexity
   C. Task difficulty, intensity, specificity, complexity
   D. Task difficulty, concentration, specificity, dual task

3. **Body weight supported treadmill training aids the rehabilitative process post stroke in that**

   A. Patients can be challenged sooner in the act of walking when densely hemiplegic
   B. Patients can be challenged safely with a greater intensity
   C. Patients will have a better long term outcome if they can be led to believe that they have less severe involvement post stroke
   D. A and B are both correct

4. **Patients post stroke can and should be trained to improve their dual-task capacity, so that:**

   A. Patients can gain greater automaticity in gait and other procedural memory tasks
   B. Patients can learn to do two ADLs at once – light hygiene and dressing
   C. Patients can improve their scores on the Trails B test
   D. None of the above

**5. Somatosensory reweighting (sensory neuroplasticity) can include which interventions?**

A. Remove or inhibit sensory strengths
B. Remove or inhibit sensory strengths
C. Inhibited somatosensation – compliant surfaces
D. All of the above

**6. When applying Opportunistic Use Therapy "OUT" for the upper extremity, therapists should create a task that:**

A. Gives the learner a bilateral task such as lifting a box overhead
B. Uses a mirror, fooling the patient to think that the impaired arm is now moving
C. Safely places the impaired arm in a position of protection for balance
D. Gives the patient financial incentives to use the impaired arm

**7. In an effort to maximize attention, therapists could use one of the following strategies:**

A. Self predictions of success
B. Interest (meaningful, end point, challenging)
C. Challenge (patient competition)/dual tasking
D. All of the above

**8. Strategies specifically built for awareness in stroke recovery include all but the following:**

A. Power of prediction
B. Systematic cueing strategy
C. Stories about others' impairments and a summary of how they have done
D. ICF model, using a patient's pre-stroke interests and roles

**9. Measuring divided attention, as suggested in this course, can be carried out with**

A. Functional attention cost – using an item with/without a distraction and measuring the difference in score
B. Duration of capacity to sustain one object
C. Patient predictions
D. Investigating eye motion timing with distractions

**10. When a patient recovering from stroke is engaged in functional activities in rotation from station to station, this is by description most likely an example of:**

A. Constraint Induced Movement Therapy
B. Sensory Reweighting
C. Task Specific Circuit Training
D. None of the above

# Stroke Rehabilitation: Maximizing Recovery in Acute and Chronic Cases

Mike Studer, PT, MHS, NCS, CEEAA, CWT, CSST

## TIMELINE

- Introduction, outline, goals
- Rethinking neuroplasticity in stroke
- Interventions in neurologic rehabilitation: MOTOR
- Interventions in neurologic rehabilitation: SENSORY

CONTINUED

# TIMELINE

- Beyond neuroplasticity: Untapped resources (body, psychology, cognitive)
- Videotape applications
- Summary and discussion, questions

CONTINUED

# Learning Outcomes

After this course, participants will be able to:

- List at least four critical elements necessary for neuroplasticity in stroke recovery.
- Identify at least three variables that can increase task intensity in clinical practice.
- Identify at least three critical measurement techniques in stroke rehabilitation to maximize outcome, attention, intensity, and participation

CONTINUED

# Neuroplasticity: The laws of demand and supply

- The rules have changed. We must consider the brain changeable under and condition and any time frame until proven otherwise. > 5 YEARS PROVEN
- The brain has potential to change at any stage in life. Attention to new information stimulates neuronal branching.
- YOU can change a patient's brain in 10 min!

CONTINUED

# Neuroplasticity: Mechanisms and Methods

| Mechanisms | Methods |
|---|---|
| Synaptogenesis | Repetitions |
| Dendritic arborization | Struggle/challenge/failure |
| Synaptic efficacy | Success |
| Angiogenesis | Salience |
| | Measurable change |
| | Observable change |
| | Vicarious experiences |
| | Overload principles |

6

CONTINUED

# Neuroplasticity Principles

1. Use it or lose it: failure to drive a specific brain function can lead to functional degradation
2. Use it and improve it: training that drives a specific brain function can lead to an enhancement of that function
3. Specificity: the nature of the training experience dictates the nature of the plasticity
4. Repetition matters: induction of plasticity requires repetition
5. Intensity matters: induction of plasticity requires sufficient training intensity

Kleim and Jones 2008

7

CONTINUED

# Neuroplasticity Principles

6. Time matters: different forms of plasticity occur at different times during training
7. Salience matters: the training experience must be sufficiently salient to produce plasticity
8. Age matters: training-induced plasticity occurs more readily in younger brains
9. Transference: plasticity in response to one training experience can enhance the acquisition of similar behaviors
10. Interference: plasticity in response to one experience can interfere with the acquisition of others

Kleim and Jones 2008

8

## The brain must see a pe… to…

Survive, protect, compete, in…

If there is pe…
If th…
If the…
If there…

There is … to continue to improve…

Patient engagement
Attention
Hope
Individualized error frequency
Relevance (not just functional)

## Neuroplasticity is but one road to functional change

- Neuroplasticity: motor control
- Neuroplasticity: sensation
- Neuroplasticity: integrative function (attention, balance)
- Muscular endurance
- Muscular strength
- Psychology
- Cognition (attention, awareness, reaction, etc)

## Destination Function: Road less- traveled

- Motivation
- Scheduling intensity for greater dosage
- Using measurements as an intervention
- Consider the “dosage of errors”
- Sensory neuroplasticity and reweighting
- Constraint-induced…procedural memory training?
- Using technology to convey expertise, change
- Maximizing patient attention: hyperexcitability
- Maximizing expectations and minimizing risk
- Pressure and distraction training for automaticity

## Resources: BEYOND the lesion

- Capacities that can be OVERtrained to improve recovery or compensate for lack of recovery
  - Strength
  - Endurance
  - Balance
  - Sensation
  - Motivation to succeed and overcome

CONTINUED

# Capacity vs. Capability

Motor learning seeks first to restore/recover connections

Therapeutic exercise compliments functional training – endurance, strength ***capacities***

Functional retraining then serves to improve ***capabilities***

Work simultaneously to build resources (capacities) in patients so that they can re-develop the capabilities

CONTINUED

# Recovery vs. compensation

**RECOVERY**

- Restore connections
- Therapeutic exercise : endurance, strength *capacities*
- Functional retraining then serves to improve *capabilities*
- Elevating baselines of daily activities, choices, perception

**COMPENSATION**

- Use of an adaptive device: cane, brace, communication device
- Reliance upon a caregiver
- Reliance on alternate transport w/c
- Word substitution
- Compensatory movement*
  - Swallow
  - Gait deviation
  - Changed dominant UE

CONTINUED

CONTINUED

# Motor learning: "Coaxing neuroplasticity"

- Feedback type
- Feedback frequency
- Feedback focus (internal/external)
- INTEREST….and task specificity
- Practice: blocked/random; part/whole; variability
- Induced Errors
- Competition
- Self preservation/protection

CONTINUED

# Motor learning: "Coaxing neuroplasticity"

| Motor Learning Variable | WHY |
|---|---|
| Feedback type | Individualize + "dependence" |
| Feedback frequency | Challenges active participation |
| Focus (internal/external) | Result not process |
| Task specificity | Facilitates transfer/retention |
| Practice structure | Adaptability, readiness for "real" |
| Errors + constraint | Stimulus for change |
| Intensity | Attention, accuracy, skill |
| Repetitions | Solidifies motor program |
| Distractions | Requires attention shift |
| Pressure | Reduce sympathetic interference |

## Forced Use: Principles

- High dosage by repetitions + difficulty
- Constrain compensations as able (motor +)
- Encourage neuroplasticity in a focused area

- Can these principles be applied elsewhere?
- Do these principles still stand?

- Motor, sensory, and communication applications

## Intervention – demonstration

- Examine patient tolerance and self efficacy
- Adjust treatment intensity
- Observe and “dose” for patient error -

- Error tolerance is different with each person
- Losses of balance, missed steps, failed sit to stand trials

## Sensory neuroplasticity

- Remove sensory strengths
- Vision
- Somatosensation
- Force the UE to be useful if not compulsory
- Daily +

## Maximize outcome with intensity: Capture attention through…

- Interest
- TEST
- Challenge and potentially inducing errors
- Patient predictions
- Error estimation

## Error Dosage: Gait Rehabilitation

| SOURCE OR MODE | EXAMPLE |
|---|---|
| Physical demand | Treadmill speed<br>Resistance against direction or posture<br>Obstacles to step over<br>Carry weight or ankle weight<br>Accuracy/agility, narrow pathway |
| Complexity | Without assistive device<br>Obstacles to step around<br>Carrying a backpack<br>Carrying a full cup of water or a plate<br>Head motion, scanning the world* |
| Distractions | Working memory : recall items<br>Find an item in a bag or purse<br>Listen to and comprehend a story<br>Watch a sporting event |
| Pressure | Hurry to the door, phone, or restroom<br>First time walking again with no help |

## OPTIMAL

**O**ptimizing
**P**erformance
**T**hrough
**I**ntrinsic
**M**otivation
**A**ttention
**L**earning

## ENHANCED EXPECTATIONS – PLUS...

- My brain can change
- I can effect improvement (self efficacy)
- I SEE my improvements: observed AND measured
- Challenge = opportunity to improve
- My effort makes a difference
- I see others improving + know of more that have

## AUTONOMOUS CONTROL…PLUS

- I can direct some of my recovery
- I can ask for help
- I have access to experts with experience
- I can choose how much is too much
- My health has some known variables
- My potential is not entirely time-dependent

## EXTERNAL FEEDBACK…

- I am accomplishing real and meaningful tasks
- I am gaining confidence as I see more movement
- I can give myself advice, when my therapist is away
- My improvements are not dependent on touch
- This can make sense, be fun, and be helpful!

## Untapped resources: Capacity

When we focus on resources OUTSIDE of the nervous system….does this necessarily mean compensation?

## Capacities: Beyond neuroplasticity

- Muscular strength
- Muscular endurance
- Cardiovascular endurance
- Psychological
- Cognition

- Are we INTENSE enough in these arenas?

## DOSAGE PRESCRIPTION FOR NEUROLOGIC REHAB?

And what is the purpose?

- Optimal dosage for our patients to make functional changes?
- Or to make neuroplastic changes?
- Or both?
- What are we measuring?

Define our DOSAGE terms in neurologic rehab, specifically the term INTENSITY

## The term intensity…

- "…the majority of evidence then indicates that functional improvement through the use of CIMT is attributable to the intensity of training..." (Wolf, 2007)
- "Repetitive task practice combines elements of both intensity of practice and functional relevance." (French, 2007)

## The term intensity…

- "In a study of outcomes at 70 skilled nursing facilities, an increased intensity of physical therapy and occupational therapy resulted in increased ADL ability and decreased length of stay."
- (Dromerick, 2006)

## Point by point… How You Intervene

- Muscular strength:
  - Resistance tolerated 8-12 reps
  - 3-4 days/week
  - 2-3 sets
  - “Expect soreness”

## Point by point… How You Intervene

- Muscular endurance
  - Resistance 15-20 repetitions
  - 3-4 days/week
  - Multiple sets

## Point by point… How You Intervene

- Cardiovascular endurance
  - Sustained activity, whole body as able
  - 30 minutes
  - 10 minutes, 3 +/day acceptable (cumulative)
  - 4-7 days/week

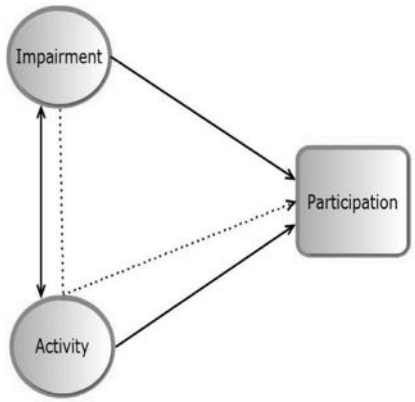
## Chronic Stroke: Beyond Neuroplasticity

- Reversing the secondary changes of:
  - Deconditioning (strength)
  - Deconditioning (endurance)
  - Sensory nonuse (visual dependence)
  - Imbalance from fear and deconditioning
  - Flexibility-led biomechanical impairments

## RESOURCES in and outside the nervous system:

CAPACITY

CAPABILITY




*Nudo & Dancause (2007)*

## Interventions in neurologic rehabilitation: MOTOR

- Are direct motor control improvements in the face of CNS lesion considered RESTORATIVE or COMPENSATORY?
- Are we actually restoring the same connections that were lost?

## Motor control neuroplasticity

- Motor control neuroplasticity

- As discussed – demand and supply
- Task specific
- Repetition-based
- Intense (Forced use, constraint, BWS, etc)

- MUST be challenged…and see progress
- Measurement IS an intervention!

## Lower Extremity Interventions:

- Massed practice: walking, sit to stand, bed mob, MRADLs
- SIRROWS: Reinforcement, shaping, function
- BWSTT: affording more repetitions (safety and fear*)
- High Intensity Interval Training (in BWS or land) speed
- Forced-use of the impaired LE:
  - Unstable surfaces
  - Reduced reliance on compensation (devices, assistance)
  - Advanced speeds (treadmill)
  - Advanced mobility tasks (low surfaces, stairs, etc.)
- Task-specific circuit training: Functional 60-90 sec cycles

CONTINUED

## Neurologic rehabilitation

- ANY patient can improve ANYTIME
- Measurement priority
- Requires consistency and intensity

CONTINUED

## Interventions in neurologic rehabilitation: SENSORY

- Does sensory neuroplasticity occur in response to CNS lesion?
- Are the mechanisms similar?

## Somatosensory reweighting: *WHY* to improve sensation

- Patients become dysfunctionally dependent on faster and more accurate stimuli
- Sensory "learned nonuse"
- Systematically removing strong/dependent sensory stimuli
- Force the brain to improve accuracy
- Improve timeliness and accuracy

## Point by point… How You Intervene

- Sensory neuroplasticity

- Remove sensory strengths
- Vision
- Somatosensation
- Daily +

## Brainstem/cerebellar + Parietal stroke rehabilitation: Sensory neuroplasticity

- Sensory reweighting
- Adaptive training with visual conflict and head motion

## Somatosensory reweighting: HOW to improve sensation

- Patients become dysfunctionally dependent on faster and more accurate stimuli
- Sensory “learned nonuse”
- Systematically removing strong/dependent sensory stimuli
- Force the brain to improve accuracy
- Improve timeliness and accuracy

## Opportunistic Use Therapy

- https://youtu.be/N4tUPlxarnM
- Opportunistic Use Therapy (OUT) video demonstration

## Characteristics of a Successful Clinician

- Scientist: neurophysiology, kinesiology
  - "What works? What does THIS system need?"
  - Changing the brain as you are able. Providing peripheral resources of strength, endurance, etc. as able
- Psychologist/counselor
  - Frequency of errors and intensity THIS PERSON can tolerate
- Motivational coach: Salesperson
  - Convince THIS PERSON that together you can maximize THEIR potential

## Psychological principles

- Psychology as a tool in recovery
  - Measurement (gamification)
  - Group therapy
  - Behavioral economics: Loss aversion, confirmation, bias, nudge, etc
- Vicarious experiences
- Protection Motivation Theory
- Self efficacy
- Enhanced Expectancies (success rates)
- Autonomy, purpose, mastery

## Measurement as an Intervention OPTIMAL “triple play”

## Psychological intervention

- Understand that the brain can change
- Understand that I can improve
- SEE that I have improved
- Know that challenge = opportunity to improve
- Use MEASUREMENTS to prove potential

## Measurement as a psychological principle to maximize intensity

- This professional believes that I can improve
- They are taking measures to see if I improve
- I want to see that I improved, not pretend
- I have to compete against myself!
- I need to work hard to show this person and myself, that I can do this!
- Both of us have some risk here (PT and patient)

## What's In It for Me?

- "I believe that therapy can help me" (efficacy)

- Predicts therapy outcomes through adherence +
- Protection Motivation Theory – compliance up with external motivators of physical, financial, stress avoidance
- PMT also assumes we can change how people think about their situation and their belief that doing certain behaviors will reduce problems or risks.

## Protection Motivation Theory

**Protection of self CAN mean…**

- Resources spent on caregivers
- Spouse's health
- Long term quality of life
- Time
- Avoiding the hospital
- Avoiding on the field injury
- Preventing pneumonia
- Maintaining privacy (ADLs)
- Keeping playing time
- Reducing recurrence back pain

## Protection Motivation Theory

- A tool for you to use in SNF, home care?
- Protection of self CAN equal…

- Resources spent on caregivers
- Spouse's health
- Long term quality of life
- Time
- Greater independence and privacy

## Intervention in neurologic rehabilitation: COGNITIVE

- PT, OT, SLP and psych can/should be involved and attempt to intervene to remediate cognitive impairments
- Billable for all?
- Functional context separate for each
- Qualifications and interventions are different
- Are the mechanisms for cognitive recovery similar to those in sensory and motor?

## Complication: Cognitive impairment in the stroke patient

- Pushing for more attention, challenging the brain
- If we can demand it, can the brain supply it?
- INTENSITY, SPECIFICITY, DIFFICULTY, COMPLEXITY = neuroplasticity
- When and how to challenge attention...

CONTINUED

# Learning DEMANDS attention!

How can we acquire and SUSTAIN a patient's attention?

1. Interest
2. Testing
3. Challenge (patient competition)/dual tasking
4. Self monitoring expectations
5. Patient predictions

CONTINUED

# Rehabilitating Attention: Interest

Consistent with the ICF model

- Know the PERSON you are working with -
Capture THEIR interest - tie to premorbid.

*"A person's attention is only as good as their interest."*

## Rehabilitating Attention: TEST

Nothing captures a person's attention like the word…

TEST

## Rehabilitating Attention: Challenge

Consider patient personality

Confidence

Self efficacy

Competing against themselves, you, another patient or an issued "challenge"

## Rehabilitating Attention: Patient Predictions

Patients estimate their abilities, become invested in the outcome: Ask them to predict:

"How much help will you need?"
"How much time will it take you?"
"How many times will you lose your balance?"

## Rehabilitating Attention: Patient Predictions

Reinforcing learning from previous efforts
Advancing patient awareness
Fewer cues or "logic" from therapists

Pre task delivery with post task review
"HOW will I do next time?"

## Error Estimation

| Underestimates | Overestimates | Accurate |
|---|---|---|
| Patient gains awareness of their impairment, is pleasantly surprised by their performance - benefits from this experience | Therapist obtains information about patient awareness. Patient gains insight about the amount of assistance needed. Sets a more realistic goal + strives to meet the previous goal | Therapist notes patient awareness is accurate for this trial. Patient is pleased with their performance |

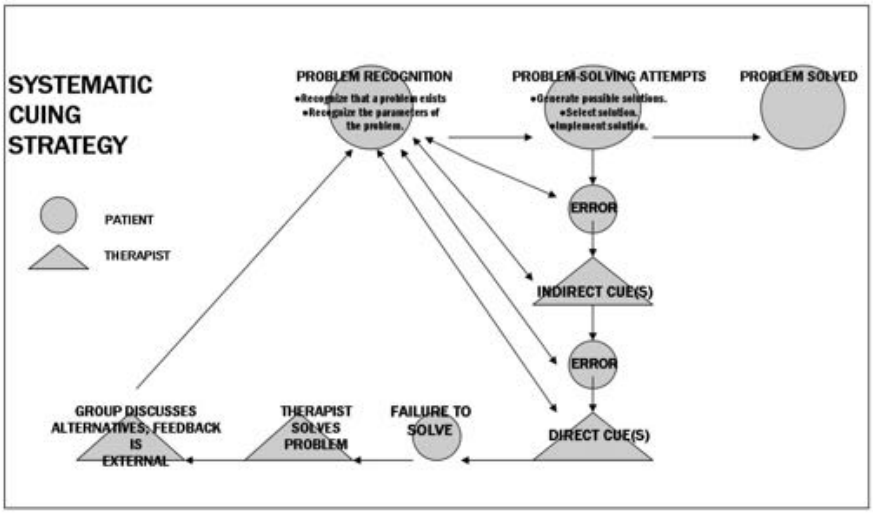
## Rehabilitating Attention: Goals

Recognize when safety is compromised: requires awareness

Accommodation/habituation: handle more complex and distracting environments

# Challenging the brain - allowing errors to promote self-awareness

- Systematic cueing strategy
- We allow patients to struggle in transfers, in ADLs, why not in problem solving?



## The Systematic Cueing Strategy

- Video example:
- https://youtu.be/9wYwrdSCGQQ

## Learning after stroke…

- Capture attention - meaningful tasks!
- Sufficient stimuli - recognizable goal/error
- STAY QUIET and HANDS OFF if possible
- Overt or subtle retention testing
- Follow the steps for awareness rehabilitation
- Value silence: “Say less, mean more”
- More active patient involvement – providing feedback
- Introduce dual tasking at the right time
- Measure your results!

## Dual task testing: An objective measure of attention?

Combine a standardized or objective measure with everyday distracters

Compare performance with/without distracter

Compare performance pre/post intervention

The result is your functional attention cost

## Dual tasking: Returning automaticity to gait

- Remember: DEMAND yields SUPPLY

- If you do not challenge dual-task attention, the brain will not supply it…

## Dosage: Dual task training

- ~70% success rate (pathway deviation, LOB, timed testing, etc.)
- Cognitive vs manual
- Random vs blocked
- Focus on primary vs secondary task
- Pre-cued for allocation of attention ?

## Intensity: Dual task training

- Focus on adding more demands to enable the learner to make the primary task (functional mobility, swallowing or ADLs) automatic

CONTINUED

# Dual task training

| Mobility | Manual | Cognitive |
|---|---|---|
| Walking | Carry water | Remember a fact/word during mobility |
| Standing w/ eyes closed | Pour water | Read from a magazine |
| Walking up stairs | Pull things out of a bag | Object recognition |
| Walking on uneven surfaces | Turn pages of a magazine | Alphabet backwards |
| Propel a w/c | Dial a phone | Recite a phone number |
| Get in/out of a chair rapidly | Write a note | Hold a conversation, keep eye contact |
| Walking backwards | Button a shirt | Count backwards by sevens |
| Avoiding obstacles | Thread a belt | Think of things you need to do this month |

CONTINUED

# Functional Dual Task Training

- https://youtu.be/pY98CmH_l6w
- Dual task walking in BWSTT: Patient engagement

# WARNING

- The following case studies are to be viewed at your own discretion. Some footage may be contrary to your current approach to practice and may involve patients being challenged – intensively.
- If you are averse to watching a patient struggle – please do not open your eyes.

# Video examples, applications

- https://youtu.be/S6G96xmz_cQ
- Pressure training
- https://youtu.be/0UwYb4-SZuc
- Method of Amplification of Error
- 
- https://youtu.be/lG9RKZSnIM8
- Agility training after stroke: Tone management habituation

## Task specific circuit training

- Sit to stand repetitions
- Standing without UE support or vision - compliant surface
- Ascending stairs with the affected LE
- Sit to supine repetitions
- High speed or weighted LE efforts BWSTT
- More…

## Misconceptions about the frail and very elderly stroke patient

- Memory decline is normal
- Endurance, strength decrease with age
- Falling is a part of aging
- People can maintain, but not GAIN strength
- Dizziness is a part of aging

## The frail and very elderly stroke patient

- Memory decline is a factor of attention – and limited stimulation in routine environments
- People can make endurance, strength improvements at any age
- Falling is often a “Use it or lose it” problem of balance or a person to task mismatch. This may be in the form of physical or cognitive.

## The frail and very elderly stroke patient

- Measurement is critical
- HOW do I measure the frail patient?
- Frail patient considerations…

## The frail and very elderly stroke patient: MEASUREMENT

Objective recordings that can be reproduced to prove real changes within a patient's case

- Bed mobility
- 5x sit to stand
- Unassisted sit to stand height
- 10' w/c propulsion
- Standing endurance

## Task Specificity: individualizing

- Tolerance of intensity
- Tolerance of errors
- Awareness
- Patient specific goals
- Considerations of lifestyle, activity, environment

## Frail patient considerations

- Psychology of rehabilitation
- Nutritional considerations
- Evidence and recommendations: ACSM
- Provide body weight support to allow for endurance improvements
- Build RESOURCES, then function

## Summarize the potential

- Enable a patient to improve through intensity
- Force the brain and body to improve
- Read a patient – know the person - to dose intensity
- Less from the therapist, more from THEIR brain
- Use measurements to motivate
- The more you cue, touch, help them…the more they need you

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