Stroke Rehabilitation: The Advanced Interventions Course

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

MEDBRIDGE

Disclosures

- Financial
  - None
- Nonfinancial
  - None

Course Outline

1. Beyond the basics: the advanced course content
2. Forced use of the upper extremity (UE): motor and sensory
3. Forced use of the lower extremity (LE): motor, sensory, and psychology (confidence)
4. Recreating automaticity
5. Adaptability: practical strategies to reduce tone and increase consistent function
6. The severely impaired and frail patient management approaches
7. Maximize your patient engagement
8. Summary
9. Questions

Course Description

- Be ready—this course is intended to deliver an advanced view of evidence-based stroke-rehabilitation-targeted interventions to promote greater functional recovery through central (neuroplastic) avenues, peripheral (fitness-based) resources, and psychological (patient engagement, attention, intensity) mechanisms
- Topics such as rebuilding automaticity, practical and task-specific dual task, promoting sensory return in UE/LE, adaptability, and more

Learning Goals

- Identify the evidence for and applications for introducing pressure and distractions in stroke rehabilitation
- Name the three guiding principles of dual-task (DT) training
- Identify neuroplastic opportunities to promote sensory recovery after stroke
- Identify the importance of and applications in promoting adaptability for the patient recovering from stroke
- Create an individualized program for severely impaired and frail patients recovering from stroke

Chapter 1

Beyond the Basics: The Advanced Course Content

Why Does the Brain Reorganize?

- Reinforced learning (success, food, feedback)
- Persistent error signals
  - Foot drop, loss of balance, missed target, pain, dizziness, blurred vision
- Danger/fear that is real or imagined
  - Perception of vertical, instability, paranoia, PTSD

How Does the Brain Reorganize?

Repetitions, stimulus, challenge

- Makes a statement, a need and context for change
- Demonstrates capacity, the possibility of change
- Improves processing, tolerance, or strategy
- Enhances awareness: shaping motivation or depression

Neuroplasticity: Stimuli

- **Constraints:** forcing or directing behavioral or motor choice to enhance recovery
- **Incentives:** tangible reward, praise, or accomplishment as a direct function of success
- **Avoidances:** shaping motor control through fear, pain, embarrassment, or error

Constraints

- **Hemianopsia:** food on left side of plate
- **Hemiparesis:** sit-to-stand with one foot in front, or constraint-induced movement therapy (CIMT)
- **Strength/motor control:** weights on ankles
- **Initiation:** timing choice reaction or motor performance

Incentives

- **Motor control:** typing or texting (word is correct if we are accurate)
- **IADL:** self-feeding a favorite food
- **Endurance:** finishing a race, arriving
- **Expression:** positive feedback after a public speech

Avoidances

- **Imbalance:** tightrope/tandem walk up on platform
- **Neglect:** getting lost in an obstacle course with choices to the left
- **Pain:** low-surface sit-to-stand with arthritis
- **Dysphagia:** coughing on a new/advancing texture

Where Does the Brain Reorganize?

- **Physiologically**
  - Synaptogenesis
  - Angiogenesis
  - Dendritic arborization
  - Synaptic efficacy
  - Collateral sprouting
- **Functionally**
  - Habituation
  - Adaptation
  - Compensation (substitution)

Habituation

- Habituation is a reduction in the magnitude of the response to repetitive sensory stimulation, and it is induced by repetitive exposures to a provoking movement
- Habituation is specific to the type, intensity, and direction of the eliciting stimuli. In most cases, the provoking movement is a less frequently executed movement during daily activities. Repetition of the originally abnormal signal will stimulate compensation.
- In **stroke** recovery, habituation pertains to balance responses, tone, choice for using a preferred UE, and more

Adaptation: Readjusting Expectations

- Changing the gain of the vestibuloocular reflex (VOR) or vestibulospinal reflexes
- Expectations of an extremity being available to assist
- Adjusting after a sensory signal is lost
- Adjusting the weight distributed to a limb
- Altered calibration of reaction speeds, angles in gait
- In **stroke** recovery, adaptation pertains to the reorganization of weight shift, balance reactions, or expectations for sensory input

Compensation (Substitution)

- Alternative strategies of movement that do not approximate pre-injury. Using help, device, or techniques of change.
- Specific to **stroke**
  - Visual compensation after vestibular lesion
  - Changing procedural patterns of hand dominance
  - Weight shifting
  - Choosing modes of communication (gestures over speech)
- “If I cannot dorsiflex (DF) as much, I might hip flex more”

The Advanced Concepts

- Forced use of the UE: motor **and** sensory
- Forced use of the LE: motor, sensory, and psychology (confidence)
- Recreating automaticity
- The adaptable patient: a practical strategy to reduce tone and increase consistent function
- Severely impaired and frail patient management
- Patient engagement: motivation, attention, **value**

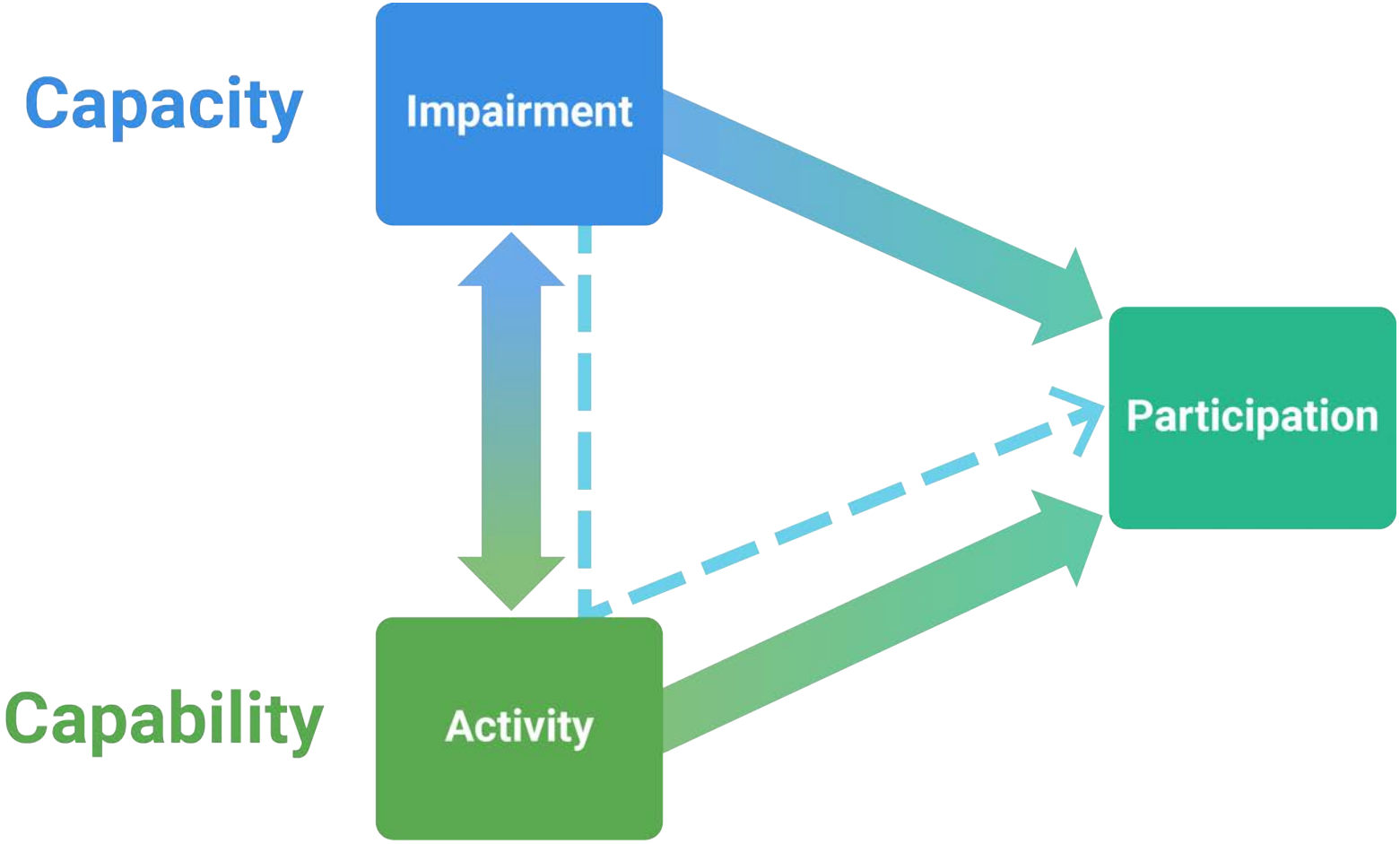
Putting It All Together in Neuroplasticity: Mechanisms and Methods

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

Analyzing Interventions

- Follows evidence in the literature
- Utilizes principles of neuroplasticity
- Fundamental science: motor learning, exercise
- **Directed** at central or peripheral structures
- Includes patient considerations/The International Classification of Functioning (ICF)
- **Results** that are measurable and meaningful for this person

Resources In and Outside the Nervous System Impact Participation



Nudo & Dancause (2007)

Poll Question:

Which of the following can be considered to be a viable neuroplasticity mechanism for recovery post-stroke?

a) Synaptogenesis, growing new connections
b) Synaptic efficacy, improving the use of existing connections
c) Angiogenesis, improved local blood supply
d) All of the above

Where Do Gains Come From?

- **Capabilities**
  - Neuroplasticity sensory
  - Neuroplasticity motor
  - Neuroplasticity integration
- **Capacities**
  - Strength
  - Muscular endurance
  - Cardiovascular endurance
  - Psychological (fear-based losses)
  - Cognitive (attention, reaction speed, decision-making)

Acute and Chronic Stroke: Resources

What remains that can be improved?

- Secondary changes of
  - Deconditioning (strength)
  - Deconditioning (endurance)
  - Visual dependence
  - Imbalance from fear and deconditioning
  - Flexibility-led biomechanical impairments
  - Learned nonuse: motor, sensory, cognitive

Chapter 1: Summary

- Mechanisms and methods of neuroplasticity
- The “sources” for improvement after stroke
- Capacity vs. capability
- An introduction to the advanced intervention techniques

Chapter 2

Forced Use of the UE: Motor and Sensory

Neuroplasticity of the Upper Extremity

- Creating a stimulus (demand) for the UE
- Inherent challenges
- UE recovery trends vs. LE: the controversy debunked
- Tasks that require (force) sensory information
- Tasks that encourage (force) motor contribution

Sensory Neuroplasticity of the Extremity

- **O**pportunistic
- **U**se
- **T**herapy
- **"OUT"**

Patient Video(s)

Point by Point, How You Intervene

- Sensory neuroplasticity for the UE
- Remove sensory strengths
- Vision
- Somatosensation
- Daily plus

Point by Point, How You Intervene (cont.)

- Motor control neuroplasticity for the UE
- As discussed, demand and supply
- Task specific
- Repetition based
- **Must** be challenged and see progress
- Rebuilding automaticity?

Neuroplasticity in the UE Post Stroke

- Constrained learning and **forced use** applications
- Applications in **overtraining**
  - **HIIT, error-enhanced learning, and amplifying error**

Point by Point, How You Intervene

- Motor control neuroplasticity for the UE
- Use **overlearned** procedural movements
- Do these **need** to be ADLs?
- Rebuilding automaticity through procedurals?
  - Brushing teeth
  - Throwing
  - Frisbee
  - Boxing
  - Push-ups

Error Dosage in ADLs

Source or mode	Example
Physical demand	Speed demands Cushioned surface Height of sitting surface
Complexity	Challenging buttons Particular look/appearance (hair, clothes) Layers Zippers
Distractions	Pain Conversation Shopping list Appointments
Pressure	Timing to appointments Availability of transport (bus, other) Continence

Intensity: Bilateral Challenges

Adding the unimpaired side will increase

- Mirror neuron benefit
- Intensity
- Gamification
- Accountability
- Procedural memory utilization
- Attention
- Functionality

Intensity: Dual-Task Challenges

Adding a dual-task element will increase intensity

- Manual task
- Auditory distraction
- Visual distraction
- Cognitive task

Attentional and Procedural Networks

Intensity: Gamification

Adding a measurement can increase intensity

- Scoring right arm vs. left
- Baseline scores of the same person improving
- Baseline scores level under increasing duress (resistance, time, accuracy %, etc.)
- Normative data

Chapter 2: Summary

- Practical and applicable techniques to force the UE to recover after stroke
  - Constrained
  - Forced
  - Bilateral (functional inclusion, mirroring, etc.)
  - Procedural (dual task stimulating procedural movements)
  - Gamified/challenged
- All invoke intensity and can be personalized

Chapter 3

Forced Use of the LE: Motor, Sensory, and Psychology (Confidence)

Point by Point, How You Intervene

Sensory neuroplasticity for the LE

- Remove sensory strengths
- Vision
- Somatosensation
- Daily plus

Point by Point, How You Intervene (cont.)

- Motor control neuroplasticity for the LE
  - As discussed, demand and supply
  - Task specific
  - Repetition based
  - **Must** be challenged and see progress
- Rebuilding automaticity?

Motor Control Neuroplasticity for the LE

- Optimizing the use of the impaired LE
- Force: favorable conditions **or** overload
  - Biomechanics
  - Surface stability
  - Speed
  - Accuracy
  - Weights

Encouraging Motor Neuroplasticity

- **Optimize impaired leg**
  - Favorable conditions
    - Biomechanics
    - Surface stability
    - Proximity
    - Functionality/choice
      - Balance, position, opportunity
- **Overload**
  - Speed (HIIT, other)
  - Weights
  - Accuracy
  - Total strength required
    - Surface height, power

Error Dosage in Mobility

Source or mode	Example
Physical demand	Speed demands Weights (ankles) Incline Duration
Complexity	Carry a tenuous object (water) Narrow pathway/accuracy
Distractions	Retrieve an item from a purse/wallet Hold a conversation Listen to walking directions
Pressure	Continence Safety for self/others Timing to cross a street/reach a door

“Flow” and Challenge Point Framework

- Patients must be challenged to stay attentive
- Challenge or intensity can/must be low with novices
- Difficulty increases with practice, experience, success
- Patients should “earn” more challenge and be aware
- Success in the face of challenge improves learning
- “Flow” is a state of performance, enhanced by a relative match in skill and difficulty

Guadagnoli and Lee: Challenge Point Framework, 2004

Chapter 3: Summary

- Practical and applicable techniques to force LE to recovery
  - Forced use
  - Task-specific circuit training
  - Procedural (dual task stimulating procedural movements)
  - Overload (physical, dual, pressure, or complexity)
  - Gamified/challenged
- All invoke intensity and can be personalized

Chapter 4

Recreating Automaticity

What Is Dual Tasking

- "Dual tasking is widely recognized as a functional mobility concern among older adults and is an important public health problem due to its association with the risk of falls"
- Dual tasking requires (or forces) the use of automatic operations in the brain by **constraining** the attentional resources

Plummer P, et. al., Gerontology 2016

Dual Task in Stroke Rehabilitation

- Being **dependent on attention** is dangerous
- The acts of walking, swallowing, and dressing **were** all procedural pre-stroke
- Tasks become automatic when function demands
- Retraining tasks to be conscious and “frontal” will **not** allow the function to be re-automatized
- DT affords an opportunity to re-automatize function

Patient Video

Function and Physiology Of Dual-Task Tolerance

- Building habituation/capacity
- Awareness for self, task
- Problem-solving: prioritizing, filtering
- Utilizing other cerebral resources
  - Memory
  - Autonomics
  - Procedural shift
- Rebuilding motor automaticity/ procedural memory

Dual-Task Considerations: Stroke

- Asymmetry is persistent in static and dynamic function
- Persistently displaced center of mass due to asymmetry
- Learned nonuse in balance strategies
- Learned nonuse leads to more impairment
- Sensory and motor control impairment **with** visual, cognitive, and resting muscle tone changes
- Balance activities must be lifelong and challenging
  - **Rehabilitation potential:** neuroplasticity and learning
  - **Reverse nonuse:** strength, balance, sensory

Dual-Task Training in BWS: Manual

- Zipping, buttoning, and unbuttoning a shirt or jacket
- Pouring water from a pitcher into a cup
- Handling a newspaper
- Reading the time on a watch or fastening the clasp/band
- Texting or dialing a phone
- Retrieving an item from a purse or wallet
- Pulling a tissue from a pocket and feigning or using it
- Retrieving, unfolding, and donning a pair of sunglasses
- Brushing teeth

Dual-Task Training in BWS: Cognitive

- Relaying directions “from here to my home”
- Explaining the intricacies of a favorite hobby, sport, or avocation
- Generating a list of known birthdates
- Generating a list from a favorite topic
  - Sports teams
  - Historical events
  - World leaders
  - Wonders of the world
  - Mountain ranges/rivers
- Reading, comprehending
- Explaining activities of the previous day in chronological order

Dual Task Training in BWS: Auditory

- Encoding/recalling a “grocery list” for later recall
- Remembering a novel phone number or street address
- Encoding and recalling the left to right directions and upcoming streets
- Hearing/remembering about a new restaurant and menu item
- Listening to a full conversation about a friend/relative, engaging

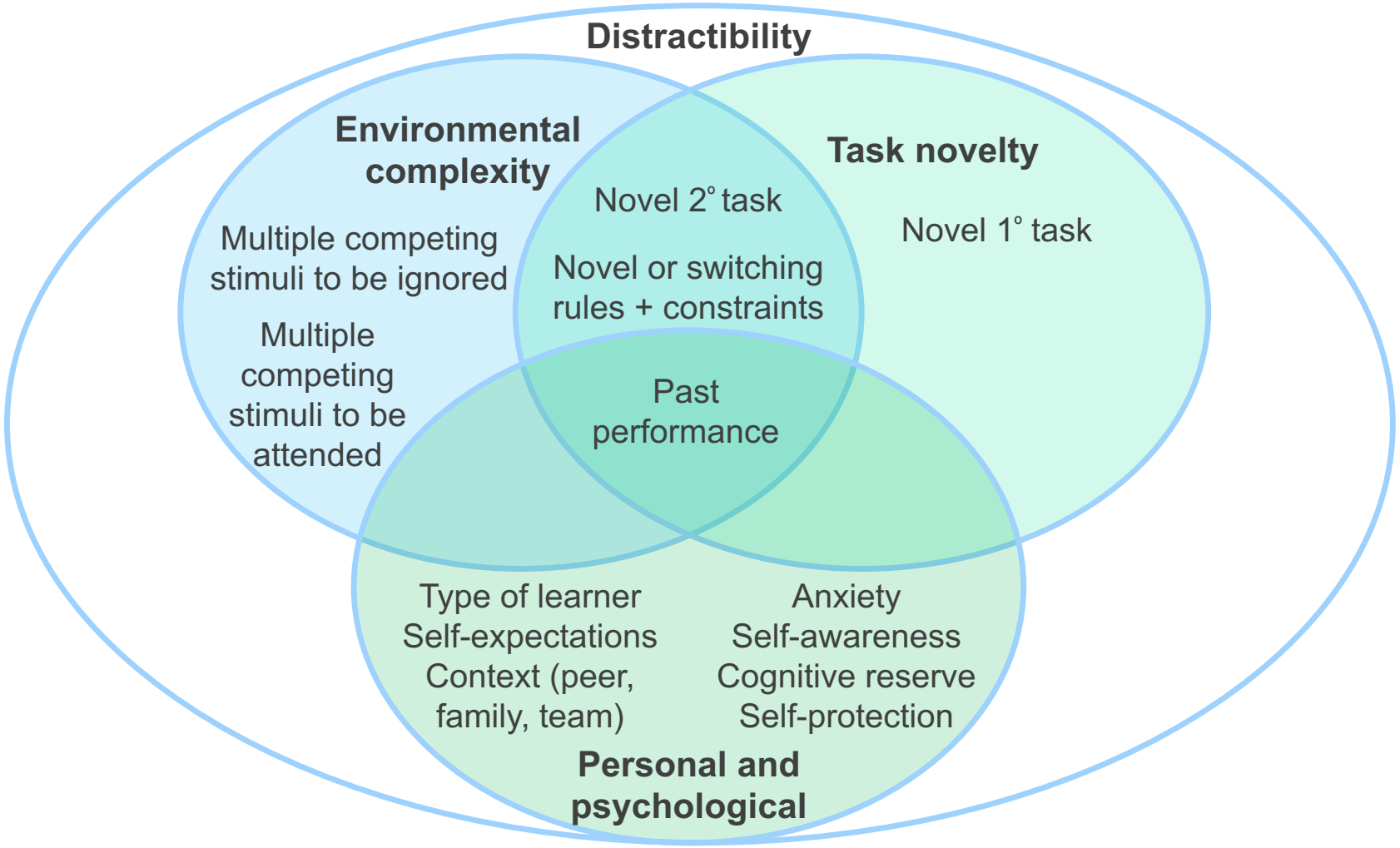
Dual Task Training in BWS: Visual

- Flashcard-based identification of world icons, landmarks
- Adding coins presented to a total
- Viewing a video or slide show for recall/testing (no audio)
- Face to name matches (novel)
- Object recognition by flashcard or electronic
- Concentration game with tablet basis
- Two or three-dimensional shape rotation

Dual Task Training in BWS: Dosage

- Provide a safety net: protecting primary task risk
- Provide body weight support (BWS): allowing gait to be challenged
- BWS on treadmill keeps the gait task “honest” at a set speed
- Treadmill training allows for greater number of repetitions
- Adaptable challenges quickly on the treadmill (see video)

Studer Distraction Venn



Hierarchy of Modalities

- Cognitive
- Visual
- Auditory
- Manual
- Which one is highest or most demanding?
- Do any of the “others” **not** include cognitive?

ADL Independence, Efficiency

Independence and efficiency in basic ADLs are dependent on a wide array of skills to be accomplished well

- Motor control
- Awareness (self-monitoring)
- Sequencing/planning
- Attention
- Sensation
- Motivation
- Visual recognition

Hygiene Completion

Hygiene, as compared to basic ADLs, requires more

- Fine attention to detail
- Full visual fields, scanning
- Higher levels of awareness

ADLs and Procedural Memories

- Some insight into the walking/hygiene combination
- Two procedural memories
  - Walking
  - Brushing your teeth

IADL: Accuracy and Safety

In comparison to basic ADLs, IADLs require more

- Attention to detail
- Calculations
- Multi-tasking
- Sequencing

Cognition, Working Memory, and Procedural Memories

Some insight into the walking/reading comprehension and visual recall combination

Patient Video

Functional Relevance of DT

- The lack of automaticity equals distractibility/dual task intolerance
- This impairment predicts
  - Fall risk
  - Dependence on assistive device
  - Dependence on caregivers for mobility
  - Relative activity levels
  - Dependence on caregivers for ADLs
  - Inefficiency (time and energy) in ADLs

Poll Question:

The four main modalities of distractions in clinical and real-world DT applications include:

a) Manual
b) Visual
c) Auditory
d) Cognitive
e) All of the above

Patient Video

Patient Video

Dual Task Improves Learning? How?

- Constraint induced reduction of cognitive resources
- Forced use of implicit/procedural memory centers
- Improved primary resource of attention
- Compensatory re-prioritization through awareness

Dual Task: Procedural Memory Considerations

- Patient's relative experience
- Transfer of training: replicating tasks
- Lesion location/type
- Patient tolerance of error: consider personality
- Specificity: exposure to conditions/environments
- Intensity: sufficient challenge to create a dosage
- Awareness
  - Recognize dual task conflict
  - Recognize as they are being distracted?
  - Independently re-prioritize attention

Physiology and Function of Improving Dual Task Tolerance

- Neuroplastic changes in structures, neurotransmitters, connections and dynamics (automaticity)
- Awareness: recognizing functional importance of attention
- Learning and creating new tolerance: rehabilitation
- Adaptability: environment, task, modes of distraction
- Prioritization and compensation

Retraining Procedural Memories

- Neuroplasticity of motor control
- Intensity, specificity, difficulty, complexity
- **Constraint-induced** procedural processing
- **Forcing** the re-integration and automaticity

Intervention Across Four Modalities of Concurrent Tasks: Progression

- Increasing complexity of primary and/or secondary tasks
- Increasing novelty of primary and/or secondary tasks
- Functional demands of the person's environment
  - Home, work, avocation, sport
- Psychological response to error/need for success
- Multi-task: tolerance, expectations, functional demand

Common Procedural Activities in Everyday Life: Pick Three of "Yours"

- Walking
- Brushing your teeth
- Putting on a t-shirt
- Tying your shoes
- Shifting your car gear
- Riding a bicycle
- Buttoning a shirt
- Zipping a jacket or pants
- Entering a code or phone number
- Driving a route to work

Identify One Thing that You Normally Do While Doing Each of the Chosen Three

- Talk to someone in person
- Talk on the phone
- Watch the television
- Listen to a podcast/ radio
- Perform another on the list
- Rehearse a speech for work
- Identify grocery items
- Review your driving route
- Consider what to wear
- Fold clothes/household chores

Prioritization Strategies

- Stop participating in a primary motor function
- Ignore the distraction
- Avoid likely distracting environments
- Caregivers manage distractions
- Reduce life complexity
- Slow the performance/response and dual task

Comprehensive Assessment: Considerations

Dual task capacity is a function, dependent on many cognitive, motor, and psychological considerations

Motor	Cognitive	Personality/ psychological
Novelty	Attention	Relevance
Task complexity	Working memory	Interest
Resources (strength, endurance)	Awareness	Grit/thrive/ perseverance
		Competitiveness

Measurement in Dual Task

Evidence-based DT treatment is based on

- Establishing intolerance through examination
- Using tests and measures of function, impairment, and participation
- Re-examining patients to ensure that they are improving
- Challenging functional distraction in a task-specific manner that is consistent with tested impairments

Cognitive Timed Up and Go (C-TUG)

- **When should I use this test?**
  - Functional gait in combination with cognition
  - Creates a comparative “dual-task cost” to TUG
- **What can I do with these results?**
  - Understand conditions that can increase fall risk
  - Build a more individualized balance program
  - Screen for early cognitive signs

C-TUG

- **TUGO:** stand, walk 3 meters, return and sit
- **Secondary task:** subtract by 3 from a random number between 66 and 100
- **Measurements:** times for walking in single and dual task
- **Cutoff:** 15 seconds discriminate subjects with a history of falls
- **Limitation:** cognitive task difficulty varies based on education, math ability
- Expose and test **each** as **single**, prior to **dual**

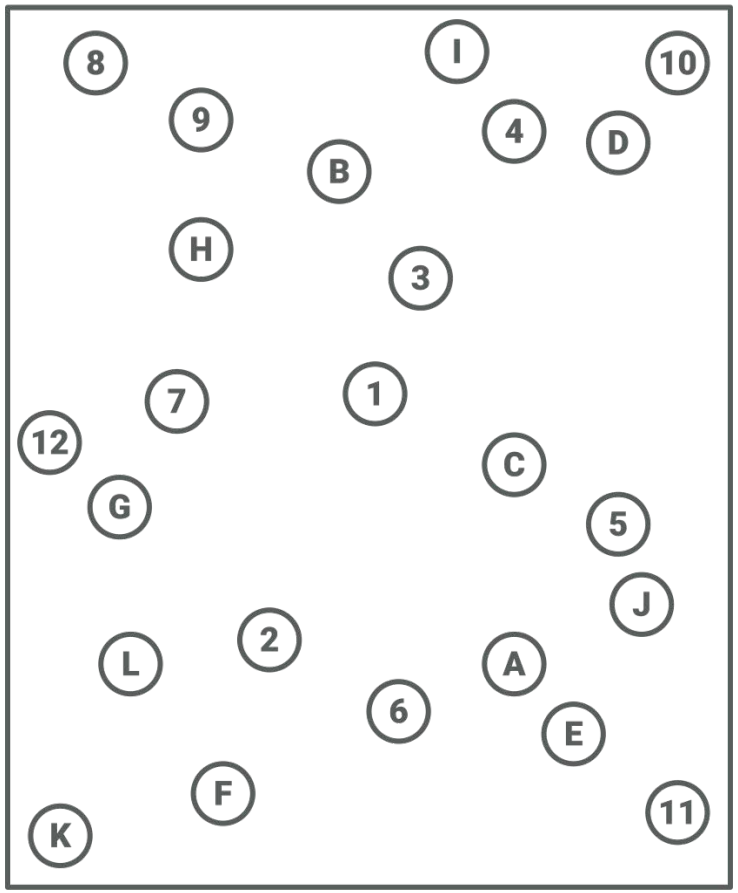
Manual TUG (TUG-M)

- TUGO baseline
- **Secondary task:** carry a cup of water
- **Measure:** times for walking in single and dual task
- **Cutoff value:** 4.5 seconds or more in dual-task condition associated with greater fall risk for frail older adults in next six months
- **Limitations:** must be able to ambulate with at least one hand free, have sufficient motor control to carry a cup
- Is this a **secondary** task or a **complex primary**?

Trails A and B

Trail Making Test Part B

Patient's Name: _____ Date: _____



Modified Ambulatory Trail Making Test

- Measures the ability to alternate attention as a dual-task experience combined with dynamic balance/agility
- Combines response speed in function (upright standing and agility) with visual scanning

Patient Video

Cognitive Four-Square Step Test: CFSST

- Six words presented. One minute to memorize. Recheck words. Say words aloud as moving through the FSART, relying on working memory. The pattern of movement is described and then completed during the test, requiring memory of the required directional pattern.
- DT with the simultaneous recall and reiteration (aloud) of the words, during the FSST=FSART
- Percentage of words recalled
- Remembered sequence with direction change
- DT cost in terms of percentage, a function of time loss

Stroop Test

Look at the list below and say the *color* not the word

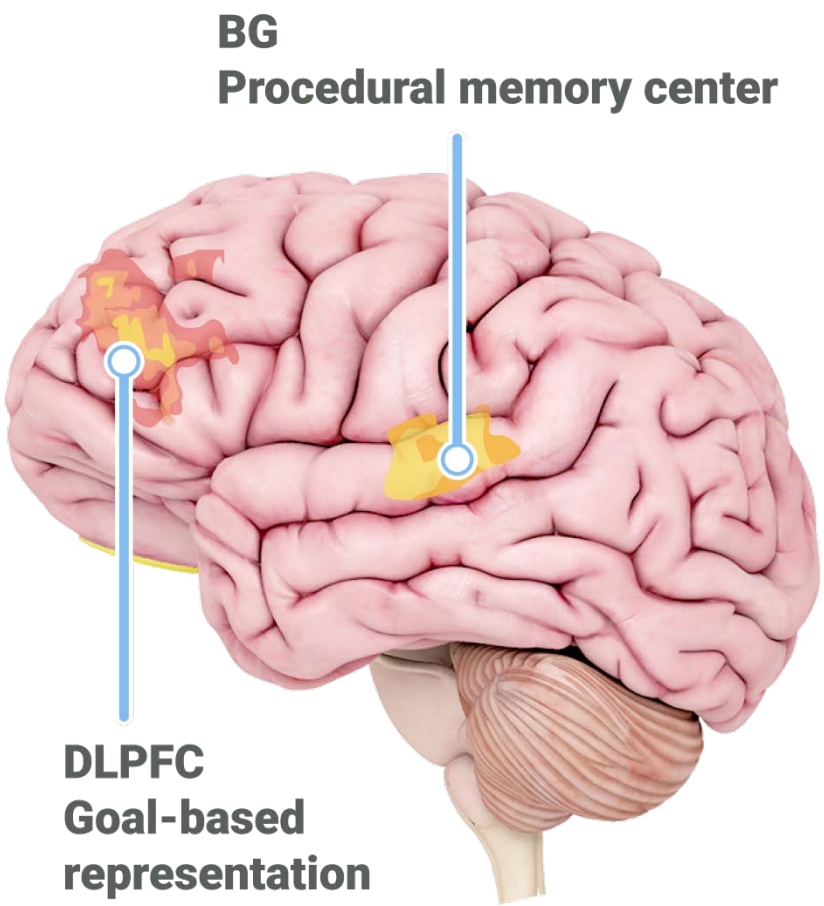
YELLOW	BLUE	ORANGE
BLACK	RED	GREEN
PURPLE	YELLOW	RED
ORANGE	GREEN	BLACK
BLUE	RED	PURPLE
GREEN	BLUE	ORANGE

Left – Right Conflict

Your right brain tries to say the color
Your left brain insists on reading the word

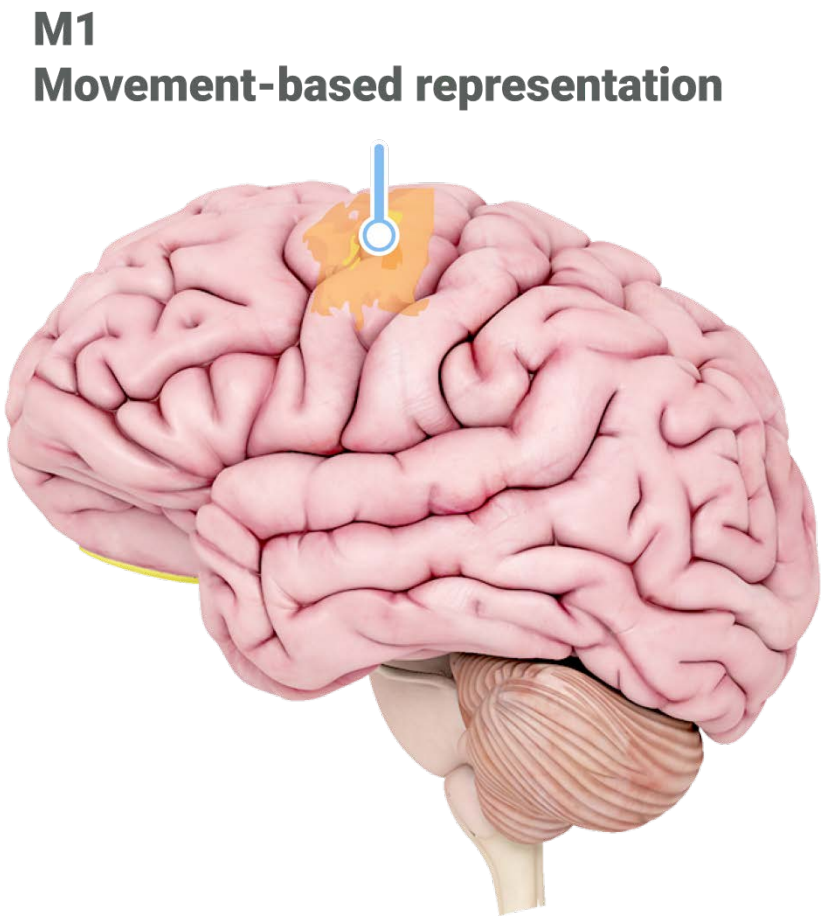
Where Is Walking Processed Pre-Stroke?

Procedural memories with attentional supervision to task and environmental constraints



Where Does Walking Re-emerge After Traditional Stroke Rehab?

Therapists direct cues internally; patients focus on body parts



Robertson, 2009

Dual-Task Training: Overarching Themes

- Attend to relevant stimuli given environment and task
- Extinguish, ignore, or filter extraneous stimuli (selective attention)
- Self-monitor function (safety, communication) and prioritize
- Tolerate more distractions with less primary task loss
- Avoid environments that are too much to manage
- Improved motor skill automaticity with dual-task training

How Is Dual-Task Tolerance Improved?

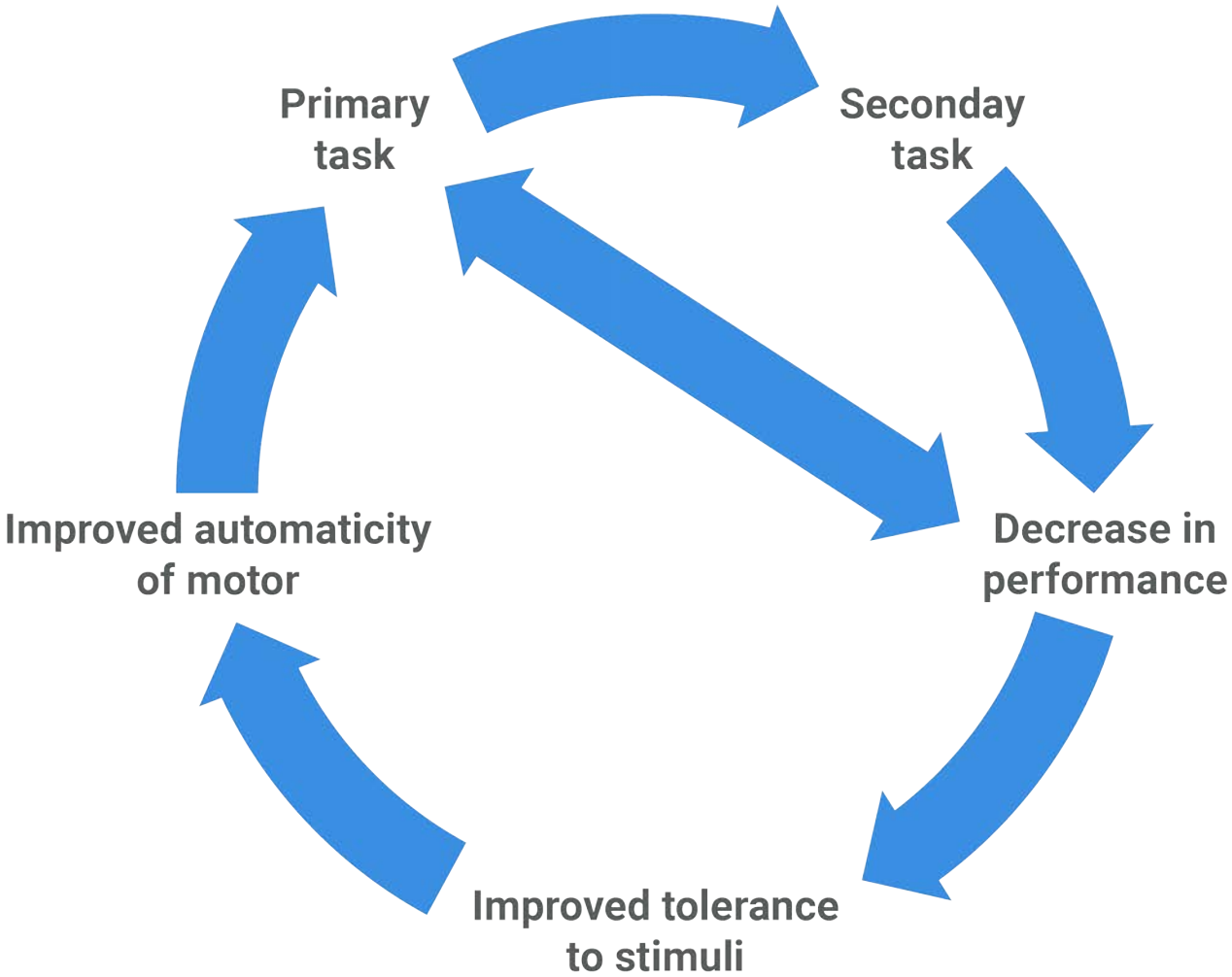
Principles/Tenets of Dual-Task Rehabilitation

- Task specificity to the type of distraction (mode)
- Intensity matters
- Timing of learning/relearning motor skill matters
- Cognitive capacity matters
- Novelty matters
- Complexity matters
- Prior experience/procedural learning matters

Dual-Task Considerations: Stroke

- Asymmetry is persistent in static and dynamic function
- Persistently displaced center of mass due to asymmetry
- Learned nonuse in balance strategies
- Learned nonuse leads to more impairment
- Sensory and motor control impairment **with** visual, cognitive, and resting muscle tone changes
- Balance activities must be lifelong and challenging
  - **Rehabilitation potential:** neuroplasticity and learning
  - **Reverse nonuse:** strength, balance, sensory

Attentional and Procedural Networks



Individualizing Effects of Distractions

Tasks are not equal in cognitive/attention load

- Novel tasks
- Calculations
- Mental rotation
- Sequencing
- Visuospatial
- Personal preference and experience basis

Dual-Task Testing

- Measurement of interference of one task due to concurrent performance of a second, yielding a pattern of performance deterioration of one or both tasks

- Dual-task cost: $\frac{\text{DUAL} - \text{SINGLE}}{\text{SINGLE}} \times 100$

Dual-Task Cost (DTC) (cont.)

$$DTC = \frac{(DT - ST)}{ST} \times 100$$

- ST: time to dress a button-down shirt: 78 seconds
- DT: recall your five-item grocery list while dressing
- DT: time = 115 seconds
- (115 − 78)/78 = 37 sec 37/78 x 100 = 49%

Screening DT Tolerance Across Four Modalities of Concurrent Tasks

Tenets of **screening**

- Overlapping of modalities will happen
- Testing is **not** intended to be task-specific or functional
- Test **each** primary and distracter alone
- Dual task **can** enhance primary motor
- To cue or not to cue?
  - Prioritization must be consistent

Intervention Across Four Modalities of Concurrent Tasks

Tenets of **intervention**

- Overlapping of modalities will happen
- Intervention **must** be task-specific/functional
- Interventions consider patient preference
- Underestimate patient expectations in DT
- Follow DT with single task
- Either vary or choose **not** to cue prioritization

Intervention Across Four Modalities of Concurrent Tasks: Timing

Primary tasks should

- Be safe to perform with the available assistance: PT, BWS, harness/tracking, etc.
- Be improving in performance through practice

Intervention Across Four Modalities of Concurrent Tasks: Content

- Review “tenets of intervention”
- Consider modality of DT based on
  - Functional reality of this patient
  - Screened tolerances **and** intolerances
  - Psychological response to error/need for success

Intervention Across Four Modalities of Concurrent Tasks: Progression

- Increasing complexity of primary and/or secondary tasks
- Increasing novelty of primary and/or secondary tasks
- Functional demands of the person's environment
  - Home, work, avocation, sport
- Psychological response to error/need for success
- Multi-task: tolerance, expectations, functional demand

Automaticity

- Automaticity is the relative ease with which something is processed
  - This considers consistency, adaptability, fatigability, and the degree of concentration or attention required
- Automaticity is related to the experience of a performer, their relative ease, and degree of habit vs. skill

Patient Video

Automaticity in Walking?

Automaticity in ADLs

Automaticity in Avocation

Dual Task Improves Learning? How?

- Introducing a distraction during the act of relearning an overlearned task can aid in reforming procedural memories
- Devoting full attention to a motor task creates a dependence on attention that can be dangerous to depend on in time

Studer M, Winningham R: Recovering the Procedural Memory After Stroke. 2017

Poll Question:

The best applications of dual task facilitate the transfer of experiences into:

a) Procedural memories
b) Consciously controlled actions
c) Selective attention
d) None of the above

Synthesizing Concepts in Stroke

- Procedural memories/movements are **stored**
- **Most** strokes do not damage procedural memories
- Restore movement through procedural memories
- Use DT to pull cognition away and **shift** to procedural

Chapter 4: Summary

Recovering automaticity in function after stroke

- Dual-task challenges constrain attention, force procedural
- Dual-task testing and training in four modes of distraction
- Neurophysiology of dual task is functional and real world
- The cost of dual-task performance is measurable

Chapter 5

The Adaptable Patient: A Practical Strategy to Reduce Tone and Increase Consistent Function

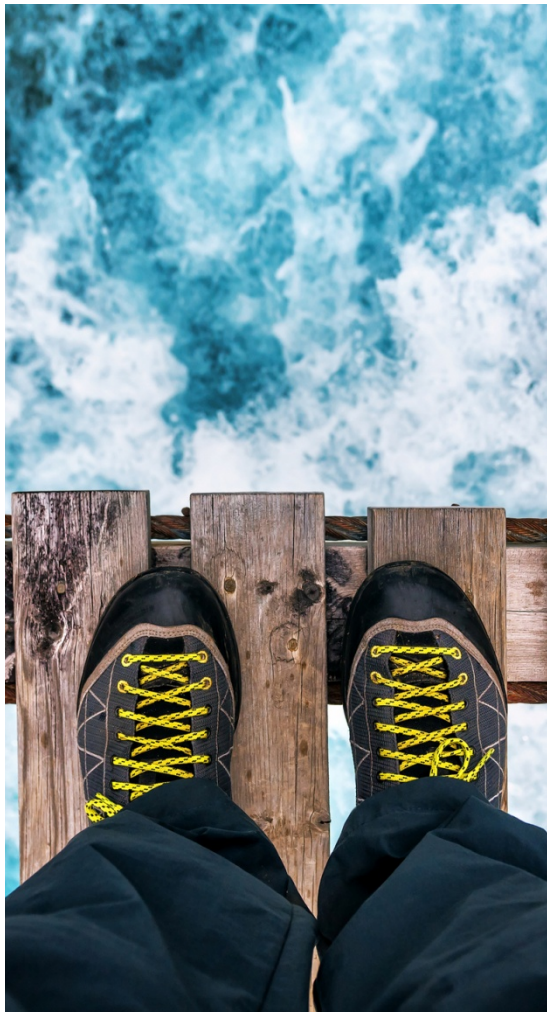
Adaptability

- The importance of errors, and success, in exploration
- Variety of conditions in training (3)
  - Overtraining by physical demand
  - Error enhancement
  - Complexity and distractions
- Enhancing errors: the method of amplification of error
- “Reducing tone” with handling, bracing, re-education
- Changing and increasing levels of accuracy
- Introducing **pressure** and creating habituation

The Importance of Errors, and Success, in Exploration

Patient Video

Habituation

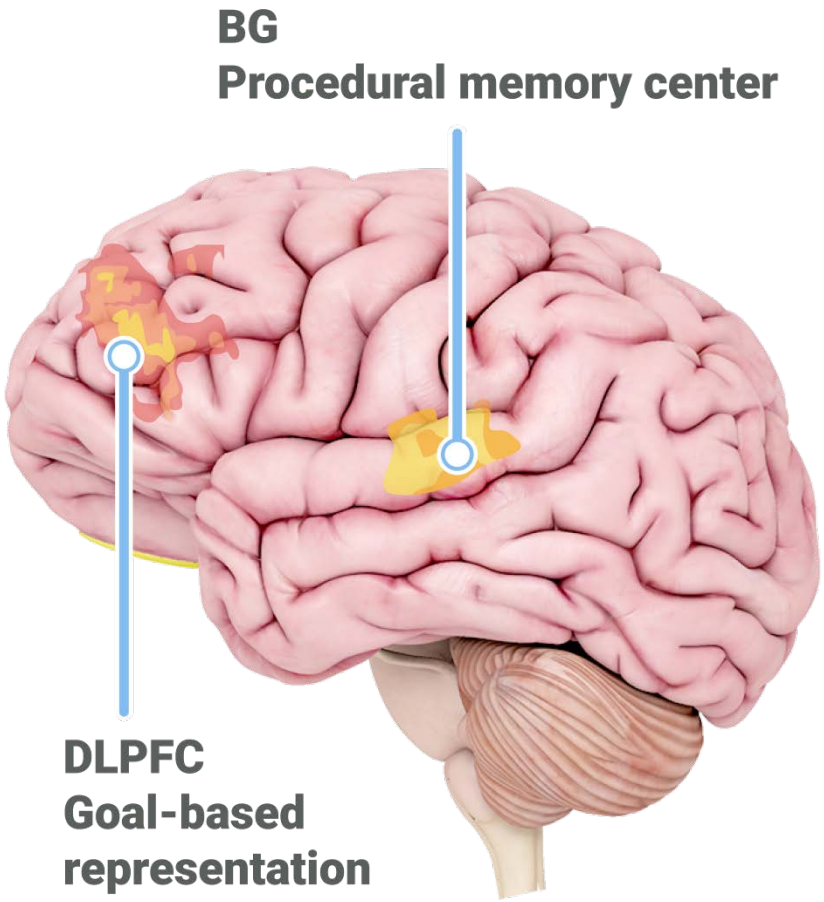


Patient Video

High-Intensity Dynamic Balance, Gait

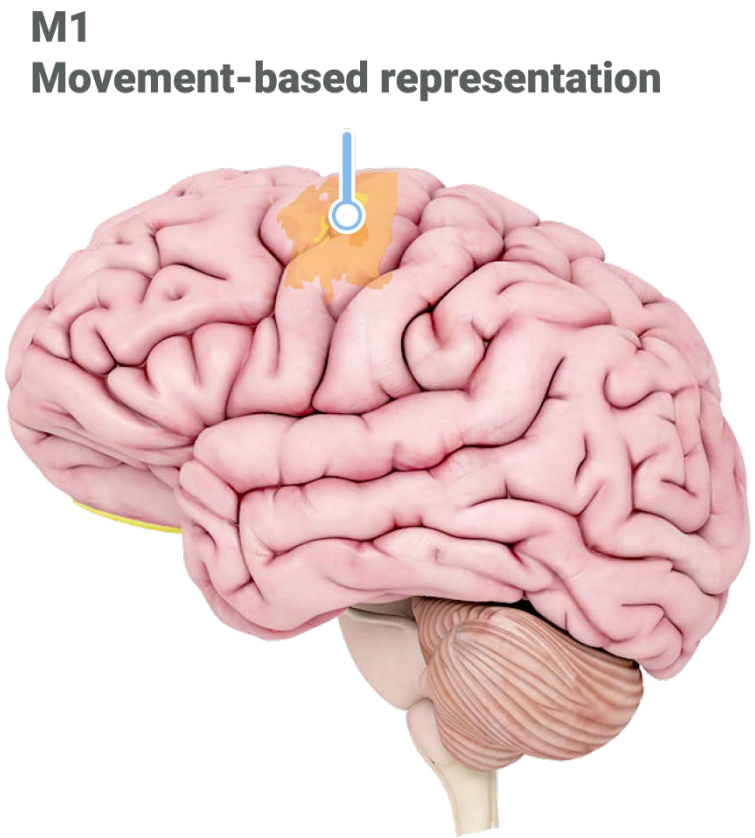
Where Is Swallowing Processed Pre-Stroke?

Procedural memories with attentional supervision to task and environmental constraints



Where Do These Tasks Re-emerge After Traditional Stroke Rehab? (Cues, Attention Based)

Therapists direct cues internally; patients focus on body parts

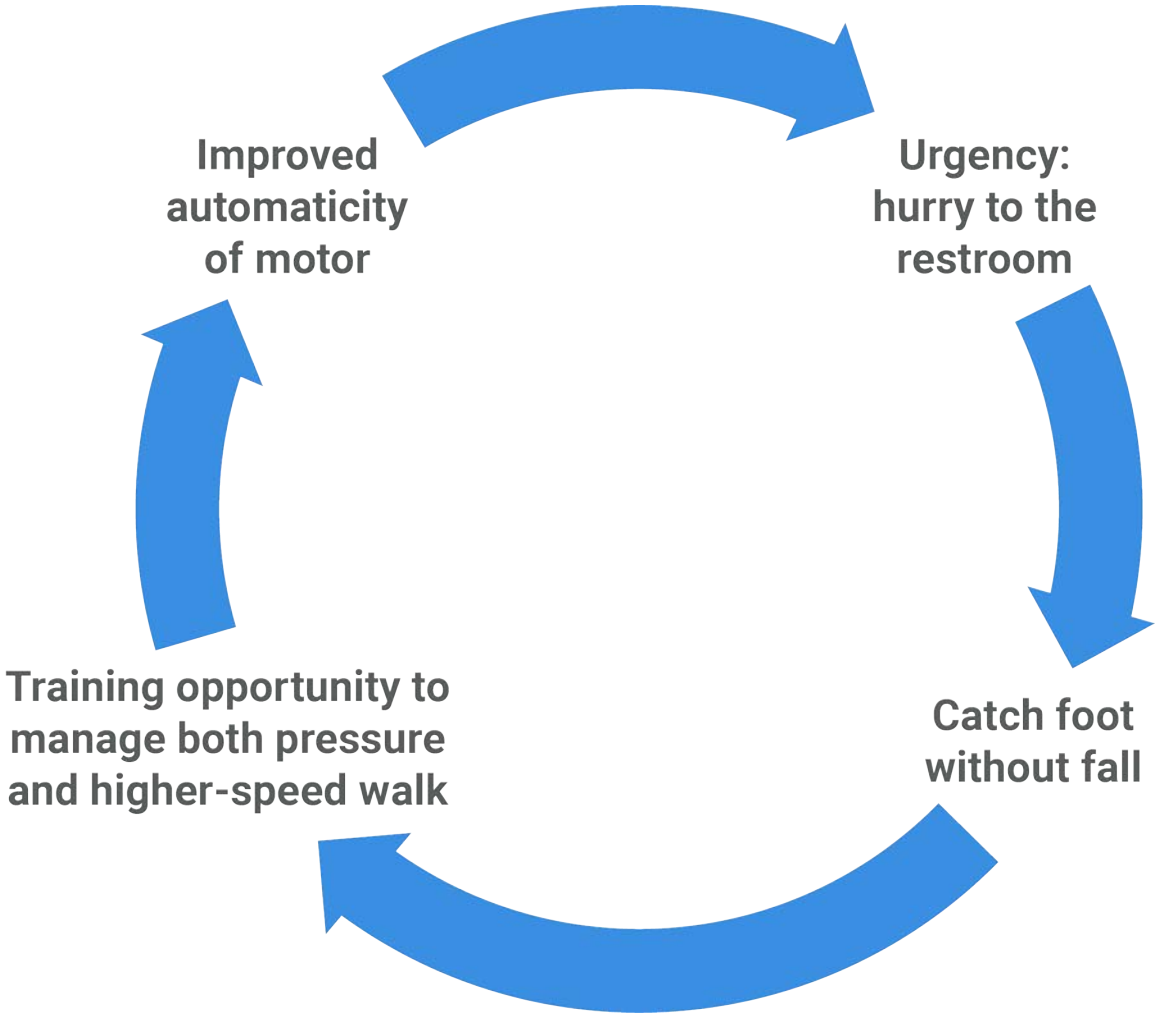


Robertson, 2009

Automaticity, Skill, Procedural: Rehab

- **Direct focus to**
  - Body parts
  - Sequencing assistive device
  - Act of dynamic balance
  - Verbal cues from therapist
- **Direct focus to**
  - A secondary task
  - An end goal/ destination

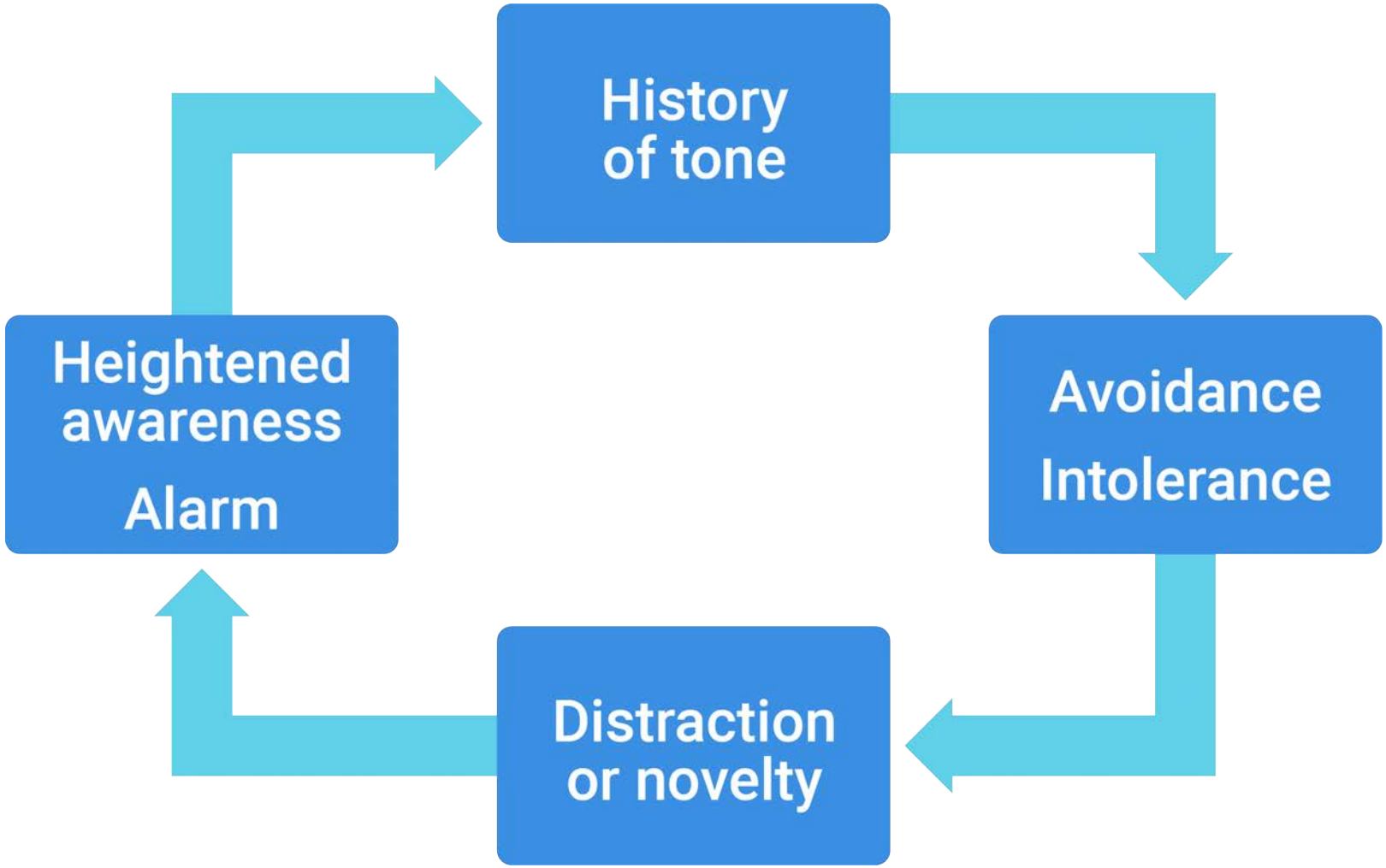
Walking and Urgency: Outcome 1



Patient Video

Patient Video

Psychological Aspects



Chapter 5: Summary

Adaptability enhances function after stroke

- Adaptability increases functional consistency, safety
- Adaptability includes across environments, contexts
- Fear emerges from novelty and gives rise to tone
- Tone restricts the expression of motor control gains

Chapter 6

The Severely Impaired and Frail Patient: Management Approaches

Chronic Stroke

Reverse the secondary changes of

- Deconditioning (strength)
- Deconditioning (endurance)
- Visual dependence
- Imbalance from fear and deconditioning
- Flexibility-led biomechanical impairments
- Maladaptive sensory strategies

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

- Timed bed mobility
- Timed 5-Times Sit-to-Stand
- MCHST: unassisted sit-to-stand height
- 10′ w/c propulsion
- Timed standing endurance

Frail Patient Considerations

- Psychology of rehabilitation
- Nutritional considerations
- Evidence and recommendations: ACSM
- Providing body weight support to allow for endurance improvements
- Building **resources**, then function

Chapter 5: Summary

Adaptability enhances function after stroke

- Adaptability increases functional consistency, safety
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Chapter 7

Maximize Your Patient Engagement

OPTIMAL

Optimizing
Performance
Through
Intrinsic
Motivation
Attention
Learning

Lewthwaite, Wulf, 2016

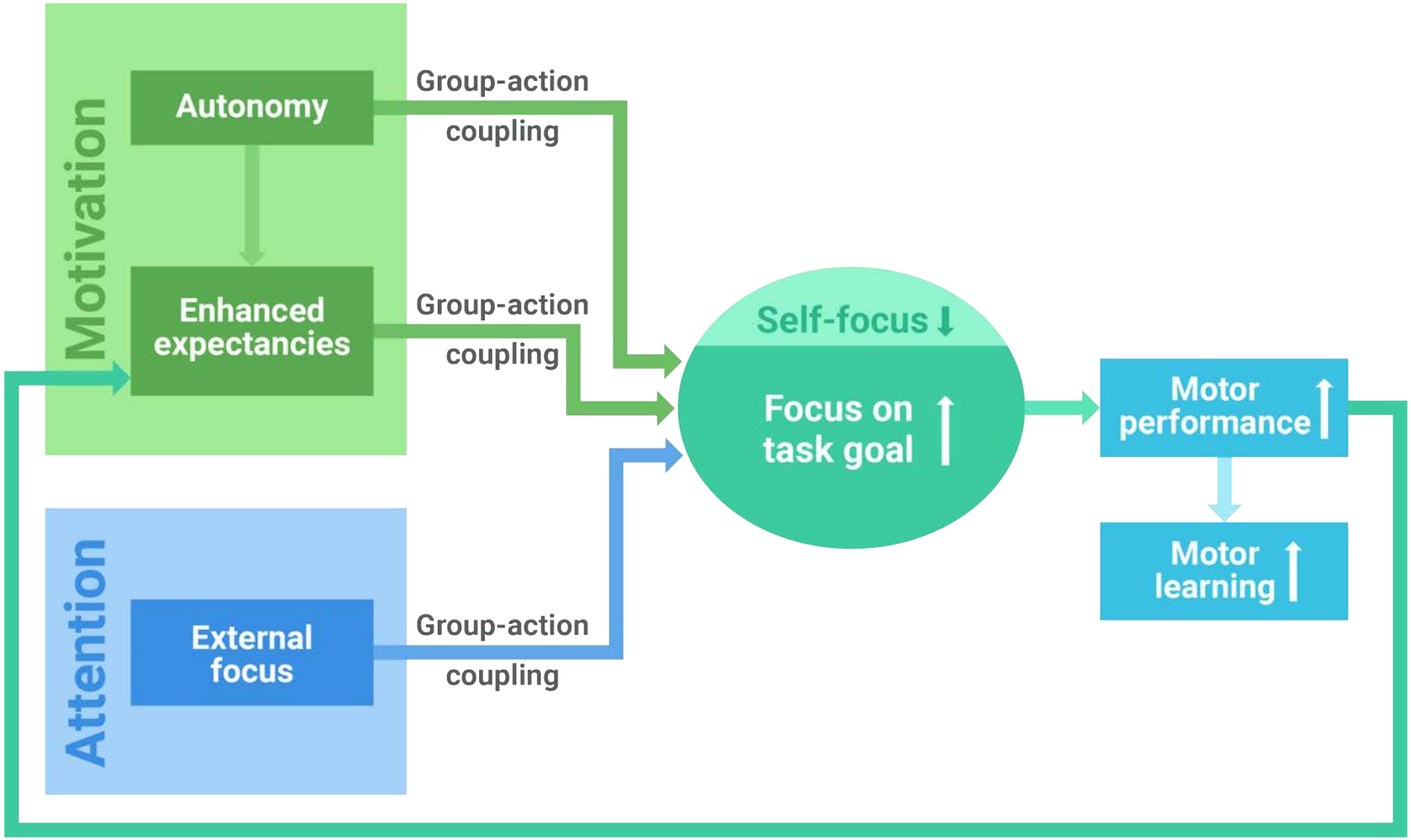
Enhanced Expectancies: Applications

- Brief periods with higher demands
  - Consider nearly any task made harder: speed, reaction time, balance requirements, forces, complexity of environment
- Exceeding self-predictions
- Exceeding therapist-stated expectations
- Holding task performance in constraint
  - Constraint-induced practice to be discussed
- Setting new PR in objective measures
- Enduring longer than expected
- Struggling **and** persevering

Neurophysiologic Benefits of Enhanced Expectancies

- "You have to force your patients to succeed"
- When they expect to succeed, they
  - Try harder and pay more/full attention
  - Try to beat their own expectations
  - Try to exceed **your** expectations
  - Receive dopamine, reinforce learning

Optimal Theory of Motor Learning



Autonomy

- Choice in task type, difficulty, setting, or order can improve investment and attention in practice or function
- Pathways of motivation, attention, and intensity allow autonomy to influence learning and neuroplasticity
- Excessive options of autonomy can agitate some patients and discount the authority of therapists

Autonomous Support: Applications

- Choosing a constraint or aspect of practice for their input
- Choosing the order of practice
- Providing first-order feedback (respected opinion)
- Choosing a level of difficulty
  - Perceived exertion becomes a measure for dosage
- Setting new PR in objective measures
- Enduring longer than expected
- Struggling **and** persevering

Neurophysiologic Benefits of Autonomous Support

- Neurotransmitter and neuromodulators
  - Dopamine
  - Serotonin
  - Endorphins
- Growth factors
  - BDNF/IGF/GDNF
- Feel success
- **Reduce** cortisol
- Continue learning

Perceived Exertion Drives Dosage: "Autonomy Meets the Borg Scale"

- History of Borg Scale
- Applications cardiovascular workload
- Strength workload
- Cognitive challenge (ADL, speech, IADL)
- Balance[1]
- **Future applications**
  - Gait speed, sit-to-stand height
  - Difficulty of reading, naming, or swallowing (texture)
  - ADLs in complexity, time, memory, or surface

1. Espy, et al

The Borg Scale

Completely stable Standing/sitting undisturbed on soild ground	1
Steady Balance does not feel challenged, but may have some body movements	2
	3
Unsteady Feels like work to keep balanced, but still do not need to step	4
	5
Mildly unbalanced Feels like I might/could have to take a step **or** reach for support to maintain balance	6
Moderately unbalanced	7
Unbalanced Feels that even the smallest or sudden movements will cause a fall	8
Very unbalanced	9
About to fall Extremely challenged; and have to step or grab support to keep balance	10

Espy, D. Used with personal permission

External Focus: Applications

- Therapist cues to goal and inanimate > body
- Educating patients for self-application
- Analogies of sport
- Seeing success through visualization of goal completion
- Creating opportunities in the clinic
- Compensatory applications with external focus (EF)

Neurophysiology and Neurophysiologic Benefits of EF

- Applications in sport (goalpost vs. foot; rim vs. fingertips; hole vs. wrist)
- Applications in ADL (self-feeding, dressing)
- Applications in swallow
- Effectively interrupting the procedural memory pathway through the basal ganglia for a more part-task-focused program through M1

Example: Gait Training

- **Pre-OPTIMAL**
  - “Spend less time on your right”
  - “Take steps more frequently”
  - “Try to make sure that your left foot goes past your right”
  - “Take bigger steps and don’t lean over so much…”
- **OPTIMAL-enhanced**
  - “Can you get there in fewer steps?” (EF)
  - “Do you believe you can make it in 17 strides?” (EF/AS)
  - “That’s impressive! When we started, this took 22 steps. What is a reasonable goal for you now?” (EE/EF/AS)

Area of Focus: Sit-to-Stand and Reverse

- **Pre-OPTIMAL**
  - “Lean forward more”
  - “Put equal weight on both legs”
  - “Don’t lean back as you stand up”
  - “Push from your hips first”
  - “Don’t straighten your knees first”
- **OPTIMAL-enhanced**
  - “Imagine there is a band holding you back into the chair” (EF)
  - “Are you able to sit down like you are trying to be very quiet?” (EF)
  - “Wow! Great job! Do you want to try to get up from a lower surface now?” (AS/EE/EF)

Area of Focus: Curb Ascent

- **Pre-OPTIMAL**
  - “You have to go up with your left leg first”
  - “Put the cane up on the step with you before you push up”
  - “You need to really lean on the left and lift the right foot up high”
- **OPTIMAL-enhanced**
  - “Which leg do you feel can best lift your body up there today?” (AS)
  - “The last time we tried this, you did very well. Can you recall what worked for you?” (AS/EE/EF)

Example: Gait Speed and Symmetry

- **Pre-OPTIMAL**
  - "Make sure you place your heel down first"
  - "Don't let your left knee snap back"
- **OPTIMAL-enhanced**
  - "Can you get there in fewer steps?" (EF)
  - "Do you believe you can make it in 17 strides? "(EF/AS)
  - "That's impressive! When we started, this took 22 steps. What is a reasonable goal for you now?" (EE/EF/AS)
  - "Show me how tall you can walk. Scrape your head up against an imaginary ceiling as you walk." (EF)

Example: MRADL/Dressing

- **Pre-OPTIMAL**
  - "Don't lift it by hiking up your shoulder"
  - "You are losing your balance as you are thinking about putting on the shirt"
  - "Put your left arm in first"

- **OPTIMAL-enhanced**
  - "Can you show me a few ways to lift your arm and tell me what feels best?" (AS)
  - "Do you believe you can keep pressure on both legs of the chair while you put the shirt on?" (EF/AS)
  - "How many seconds do you believe that you can balance without needing help?" (EE)
  - "May I offer some advice?" (AS)
  - "Can we try this with a few techniques, after which you can tell me what feels best?" (AS, EF)

Chapter 7: Summary

- Patient engagement is key to accessing intensity
- The OPTIMAL motor learning theory guides patient engagement by maximizing motor control variables of
  - Autonomy
  - Expectations to succeed (enhanced expectancies)
  - Goal-directed movement (external focus)

Chapter 8

Summary

The Definition of Dual Tasking

- Dual task is the concurrent performance of two tasks that can be performed independently and measured separately, and have distinct goals
- Dual tasking is **not** a complex single task, such as
  - Carrying a cup of water, backpack, or suitcase

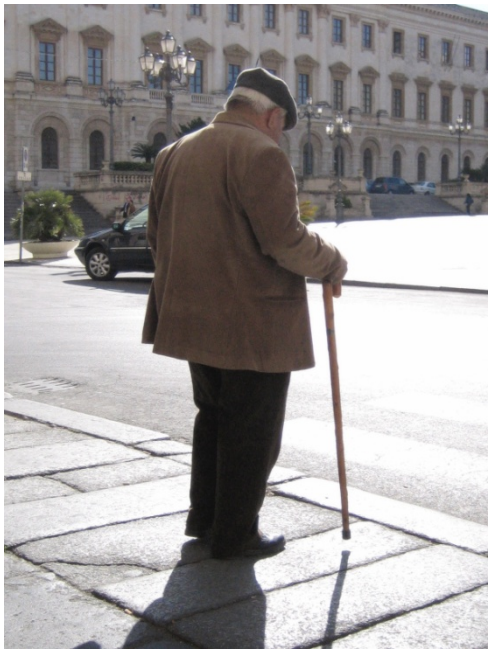
Patient Video

Dual Tasking: Mobility

Considerations: history, complexity, confidence, fatigue, fragility of items, prioritization, importance of phone call (emergency), etc.

Dual Tasking: Mobility (cont.)

Considerations: history, complexity, confidence, fatigue, fragility of items, prioritization, importance of phone call (emergency), etc.



Dual Tasking: ADL

Considerations: pain, complexity, injury, fatigue, awareness, vision, etc.

The Common Thread: Procedural Memories

Why Is this Important After a Stroke?

- Being **dependent on attention** is dangerous
- The acts of walking, swallowing, and dressing were **all** procedural pre-stroke
- Retraining tasks to be conscious and “frontal” will **not** allow the function to be re-automatized
- DT affords an opportunity to re-automatize function

The Physiology of Dual Tasking

- When attention (DLPFC) is loaded, motor tasks are pushed to procedural memory centers (PMC)
- Attention: dorsolateral prefrontal cortex (DLPFC)
- PMC: basal ganglia (BG), supplementary motor area (SMA), cerebellum, premotor cortex (PMC)
- Simplified vantage without consideration of emotion, psychology, autonomics
- **Recall that most strokes do not involve the basal ganglia**: intact procedural memories

Repetitions

- Provide the brain with repeated exposure in an attempt to reinforce neuroplastic changes of synaptogenesis and synaptic efficacy
- Repetitions alone are often insufficient due to matters of intensity and reduced attention if delivered in blocked practice

Intensity

- Providing sufficient stimulus for change. Intensity does not need to be directly correlated to exertion as it can come from skill, difficulty, accuracy, or consequence (fall, embarrassment, etc.).
- Intensity without success can inhibit learning

Goal Direction

- Goal direction enables a learner to channel efforts around what is to be accomplished, rather than how
- Promotes movement organization around procedural memory consolidation and reduces the role of attention on specific body parts mid-task
- Early emphasis on goal direction at the complete exclusion of movement specifics can inhibit the benefit of advice, observation, and kinesthesia

Motivation

- Greater motivation often leads to improved neuroplastic stimulus through intensity, attention, and (after successful trial) dopaminergic rewards
- Motivation can dysfunctionally lead to addiction

Expectations of Success (Enhanced Expectancies)

- Learners who expect success are primed to repeat past successful strategies and repetitions, leading to consolidation of learning and neuroplastic change
- Dopaminergic reward systems are fulfilled with enhanced expectancies toward a common goal
- When practice or competition includes expectations of success, yet the resultant outcome includes too many repetitions (personality dependent), learning can be blunted, and systems depressed

Personality/Tolerance

- Individual attributes influence response to challenge, tolerance of intensity, tolerance of error, and reward systems
- Practice without sufficient incorporation of individual personality traits may not provide optimal dosage and may cause either boredom or agitation

Bibliography

MedBridge

Stroke Rehabilitation: The Advanced Interventions Course

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

1. McIsaac T, Lamberg E, Muratori L. Building a framework for a dual task taxonomy. *BioMed Research International*. vol. 2015, Article ID 591475, 10 pages, 2015.

2. Brustio PR, Magistro D, Zecca M, Rabaglietti E, Liubicich ME. Age-related decrements in dual-task performance: comparison of different mobility and cognitive tasks. A cross sectional study. *PLoS ONE*. 2017;12(7):e0181698.

3. Dørum ES, Alnæs D, Kaufmann T, Richard G, et al. Age-related differences in brain network activation and co-activation during multiple object tracking. *Brain Behav*. 2016;7;6(11):e00533. eCollection 2016 Nov. doi:10.1002/brb3.533

4. Plummer P, Zukowski LA, Giuliani C, Hall AM, Zurakowski D. Effects of physical exercise interventions on gait-related dual-task interference in older adults: a systematic review and meta-analysis. *Gerontology*. 2015;62(1):94-117. doi:10.1159/00037 1577. Epub 2015 Feb 19.

5. Plummer P, Eskes G. Measuring treatment effects on dual-task performance: A framework for research and clinical practice. Frontiers in Human Neuroscience. *Front Hum Neurosci.* 2015; 9:225. Published online 2015 Apr 28.

6. Yang L, He C, Pang MY. Reliability and validity of dual-task mobility assessments in people with chronic stroke. *PLoS One*. 2016;11(1): e0147833. doi:10.1371/journal.pone.0147833

7. Schinkel-Ivy A, Huntley AH, Inness EL, Mansfield A. Timing of reactive stepping among individuals with sub-acute stroke: effects of "single-task" and "dual-task" conditions. *Heliyon*. 2016;2(10):e00186. Published online 2016 Oct 31.

8. Kal E, Winters M, van der Kamp J, et al. Is implicit motor learning preserved after stroke? A systematic review with meta-analysis. Baron J-C, ed. *PLoS ONE*. 2016;11(12):e0166376

9. Wiener J, McIntyre A, Janssen S, et al. Effectiveness of High-Intensity Interval Training for Fitness and Mobility Post Stroke: A Systematic Review.PM R. 2019 Aug;11(8):868-878. doi: 1002/pmrj.12154. Epub 2019 May 30.

10. Crozier J, Roig M, Eng JJ, MacKay-Lyons M, et al. High-Intensity Interval Training After **Stroke**: An Opportunity to Promote Functional Recovery, Cardiovascular Health, and Neuroplasticity. .Neurorehabil Neural Repair. 2018 Jun;32(6-7):543-556. doi: 10.1177/1545968318766663. Epub 2018 Apr 20. Review.

11. Carl DL, Boyne P, Rockwell B, et al. Preliminary safety analysis of high-intensity interval training (HIIT) in persons with chronic stroke. Appl Physiol Nutr Metab. 2017 Mar;42(3):311-318. doi: 10.1139/apnm-2016-0369. Epub 2016 Nov 21.