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Applications in Dual Task Rehabilitation From High Tech to Low: Covering the Range for All Treatment Settings

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

- Presenter Disclosure: Financial: Mike Studer has received an honorarium for presenting this course. Non-financial: Mike Studer has no relevant non-financial relationships to disclose.
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Learning Outcomes

As a result of this course, participants will be able to:

- Identify the comprehensive responsibilities in testing dual task tolerance: cognitive, auditory, visual, and manual distraction tolerance.
- Identify and actualize the application of dual task training to achieve automaticity, procedural memories, and function without commanding all attentional resources.
- Identify the health-related consequences of dual task intolerance in function.

Along the way…watch for test questions…

Who is Mike Studer?

- 30 years as a PT
- Neuro, geriatrics, athletics
- Clinician, author, scientist
- Innovator (tests, interventions)
- Marathoner, triathlete
- Fellow of the American PT Association
- mike@northwestrehab.com

Course "Objections"

This…is what we are very intentionally NOT covering today, in an effort to stay focused on applications across the continuum:

- The comprehensive neurophysiology of DT
- The skill-acquisition/sport applications of DT
- DT research (present and future directions)

BRIEF theory, underpinnings, and **then treatment**

Dual tasking defined:

"Dual tasking is the concurrent performance of two tasks performed independently, measured separately and have distinct goals." McIsaac, Plummer, 2016

- BOTH are measurable, separately
- BOTH are DONE, separately
- EACH has it's own distinct goal

Dual tasking is not a complex single task, such as: carrying a cup of water, backpack, or suitcase; not walking with head rotation

Attention is not the same as DT…

The recognized **parameters of attention** extend beyond DT:

- Selective Attention – “I can filter and focus.”
- Divided attention – “I can divide, split, and tolerate.”
- Alternating Attention – “I can prioritize and shift.”
- Sustained attention – “I can endure.”

Chapter one

Consequences of DT intolerance in your patients

Why is Dual Tasking Important?

- "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

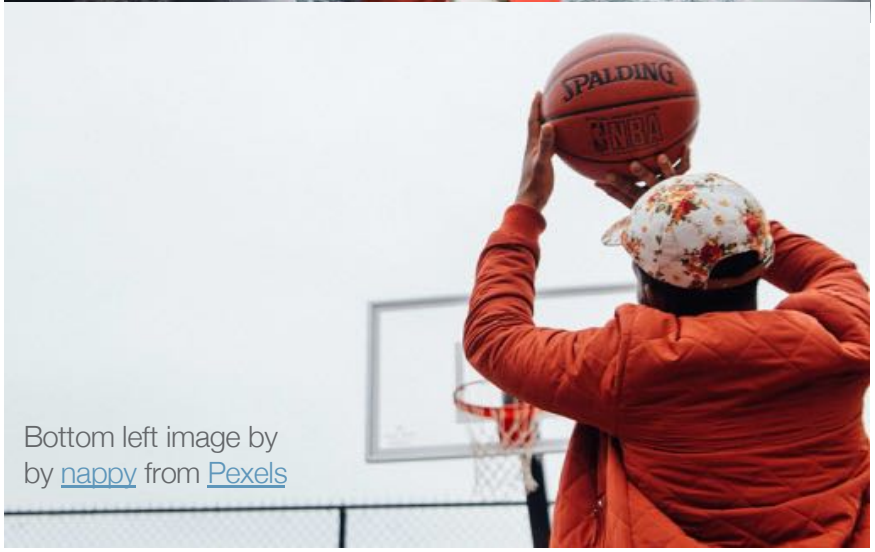
Dual Tasking: Mobility

- Considerations: history, complexity, confidence, fatigue, fragility of items, prioritization, urgency or emergency, etc.

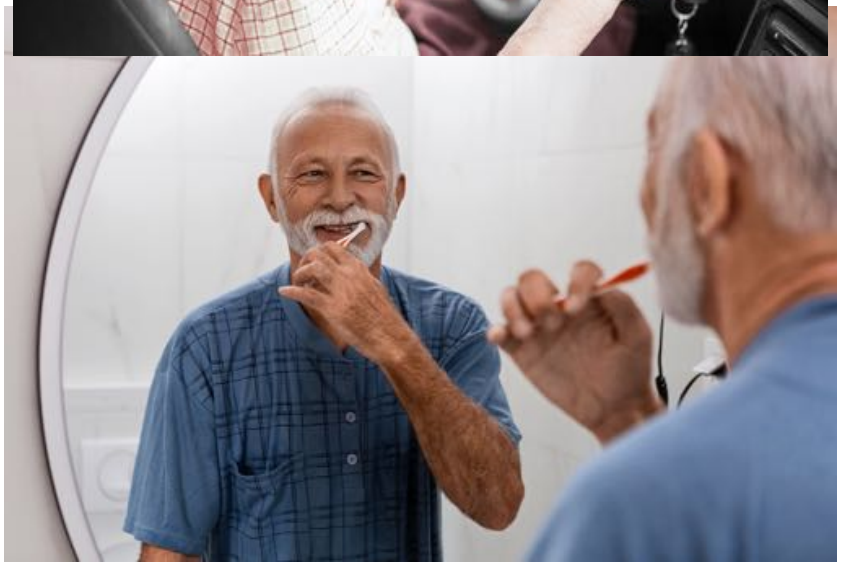
Dual Tasking: ADL

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

The Common Thread: Procedural Memories

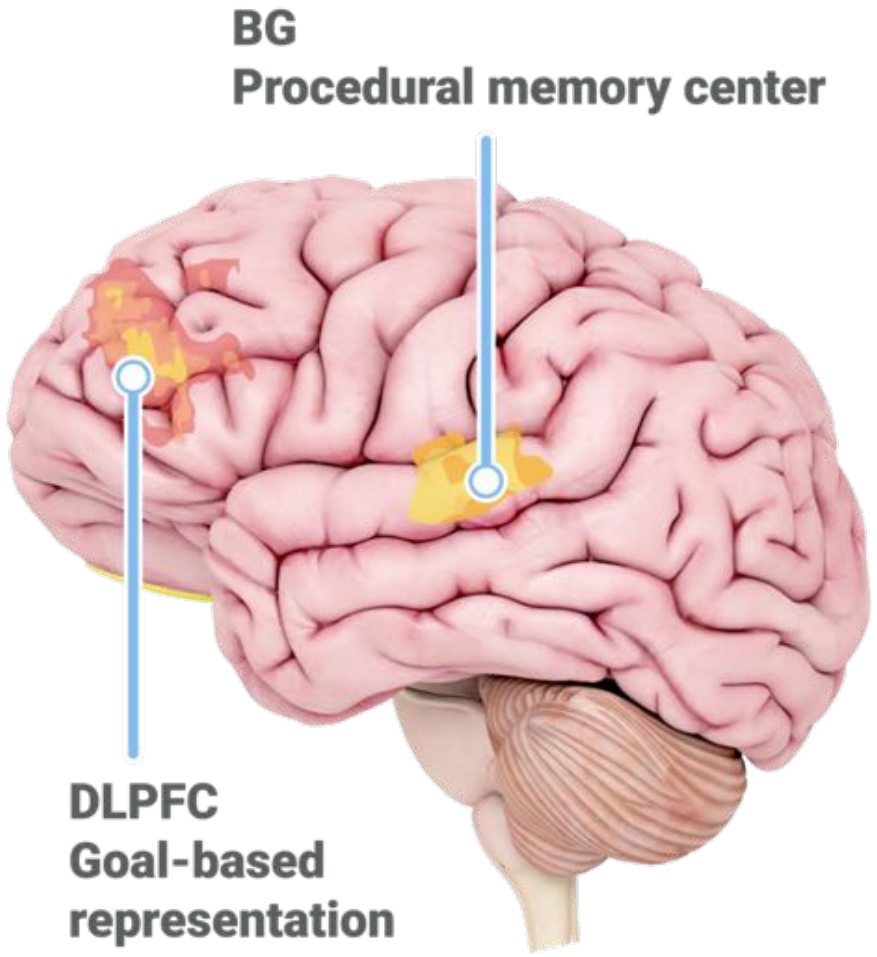


Bottom left image by by nappy from Pexels



Where is walking processed pre-stroke?

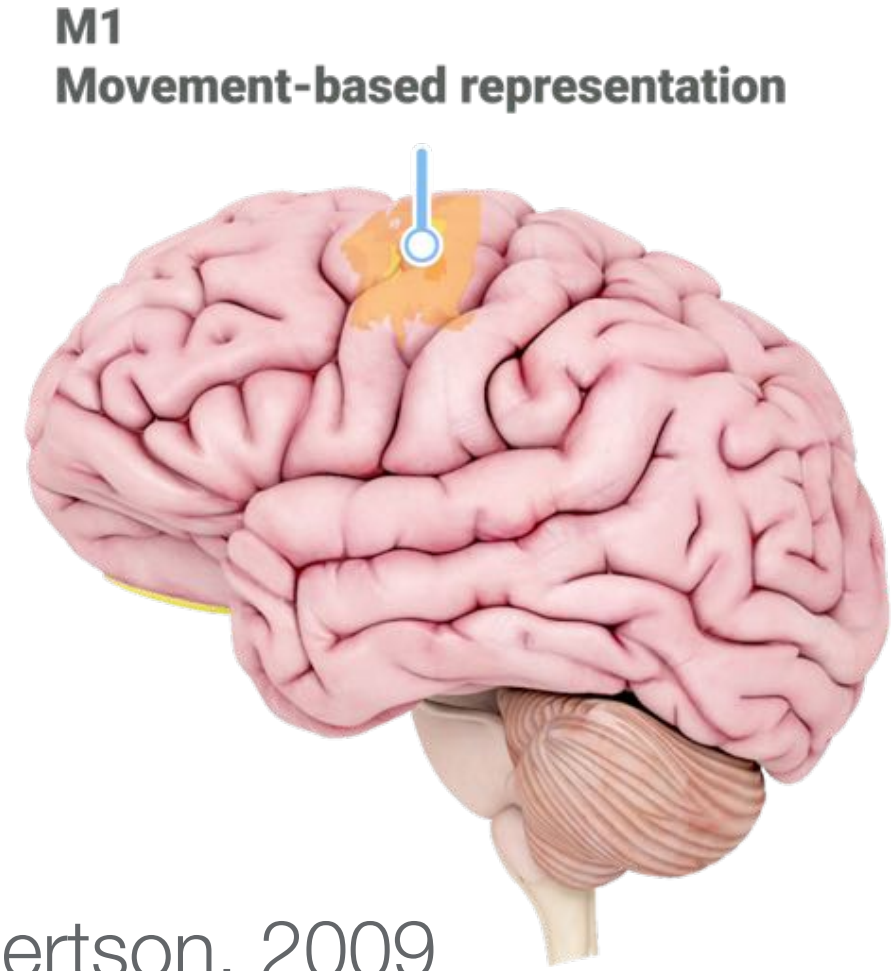
- Procedural memories with attentional supervision to task and environmental constraints



Dorsolateral prefrontal cortex

Where does walking re-emerge if we cue the patient's body parts?

- Therapists direct cues internally, patients focus on body parts



Robertson, 2009

Synthesizing Concepts: DT 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

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
- Most strokes DO NOT involve procedural structures: BG, cerebellum, premotor, SMA
- Retraining tasks to be conscious/“frontal”, does not facilitate automaticity
- DT asks for restoration, not compensation

Why is This Important in PD?

- Being dependent on attention, is dangerous
- The acts of walking, swallowing, and dressing were all stored in primary PD locations (Basal Ganglia)
- Retraining tasks to be conscious and “frontal”, will not allow the function to be re-automatized and can be additionally impaired in PD (attention centers)
- The DLPFC is largely dopaminergic
- DT training affords an opportunity to re-automatize function as compared to learned non-use

Why is This Important in MS?

- Being dependent on attention, is dangerous
- Attention is a distributed capacity and is often impaired in those with multiple lesions throughout the brain
- Fear of falling consumes a lot of attention
- Goals: “reserve” of attention, reducing fear, and improving distraction tolerance

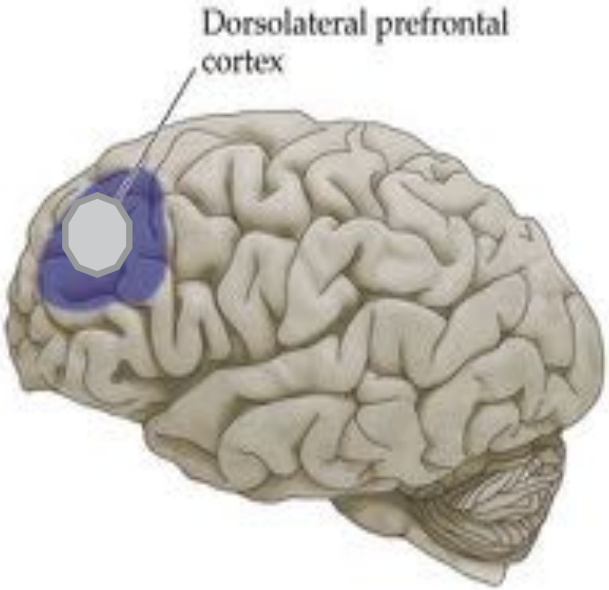
Why is This Important in Concussion

- Being dependent on attention, is dangerous
- Attention is VERY frequently impaired in concussion
- After concussion, higher sensitivities to sound, light, and motion can lead to cognitive distraction/fatigue
- Cognitive skill must be challenged to be restored, as do: balance, dizziness, exertion
- DT is ESSENTIAL for return to work, life, driving and sports
- People to not spontaneously restore DT tolerance

Chapter TWO
Education is AN intervention:

Can you explain how + why DT rehabilitation works

The primary attention center: Dorsolateral prefrontal cortex (DLPFC)



DLPFC receives Dopaminergic SN projections* to the frontal lobe

Dual tasking with allocating attention

Task-specific motor plan selection

Reinforcement of procedural memory

Learning during practice

Critical in managing the environment – allowing the BG to operate automaticity

(Rowe et al, 2000; Cross et al, 2007)

(Shadmehr and Holcomb, 1997)

The Physiology of Dual Tasking*

- When attention (DLPFC) is loaded, motor tasks are pushed to procedural memory centers (PMC)
- Attention = DLPFC = dorsolateral prefrontal cortex
- PMC: basal ganglia (BG), supplementary motor area (SMA), cerebellum, premotor cortex (PMC)
- Most (not PD) conditions spare all or part of the basal ganglia (one or both sides) = Intact procedural memories!

- *emotion, psychology, autonomics play a role…

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 through selective attention

Dual Task Improves Learning? How?

- Introducing a distraction during the act of re-learning 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

Retraining Procedural Memories

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

Function and physiology of improved dual task tolerance

- EXPECT IMPROVEMENTS IN:
  - Building habituation/capacity
  - Awareness for self, task
  - Problem solving = prioritizing, filtering
  - Capacities for other cerebral resources: memory, autonomics, procedural shift
  - Re-building motor automaticity/ procedural memory

Dual Task: Procedural Memory Considerations

- Patient's relative experience and
- 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

Automaticity: The outcome of DT

- Automaticity is the relative ease at 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

Automaticity in Walking?

Image: Patricia H on flickr

Automaticity in ADLs

Automaticity in Avocation

Photo by charan sai from Pexels

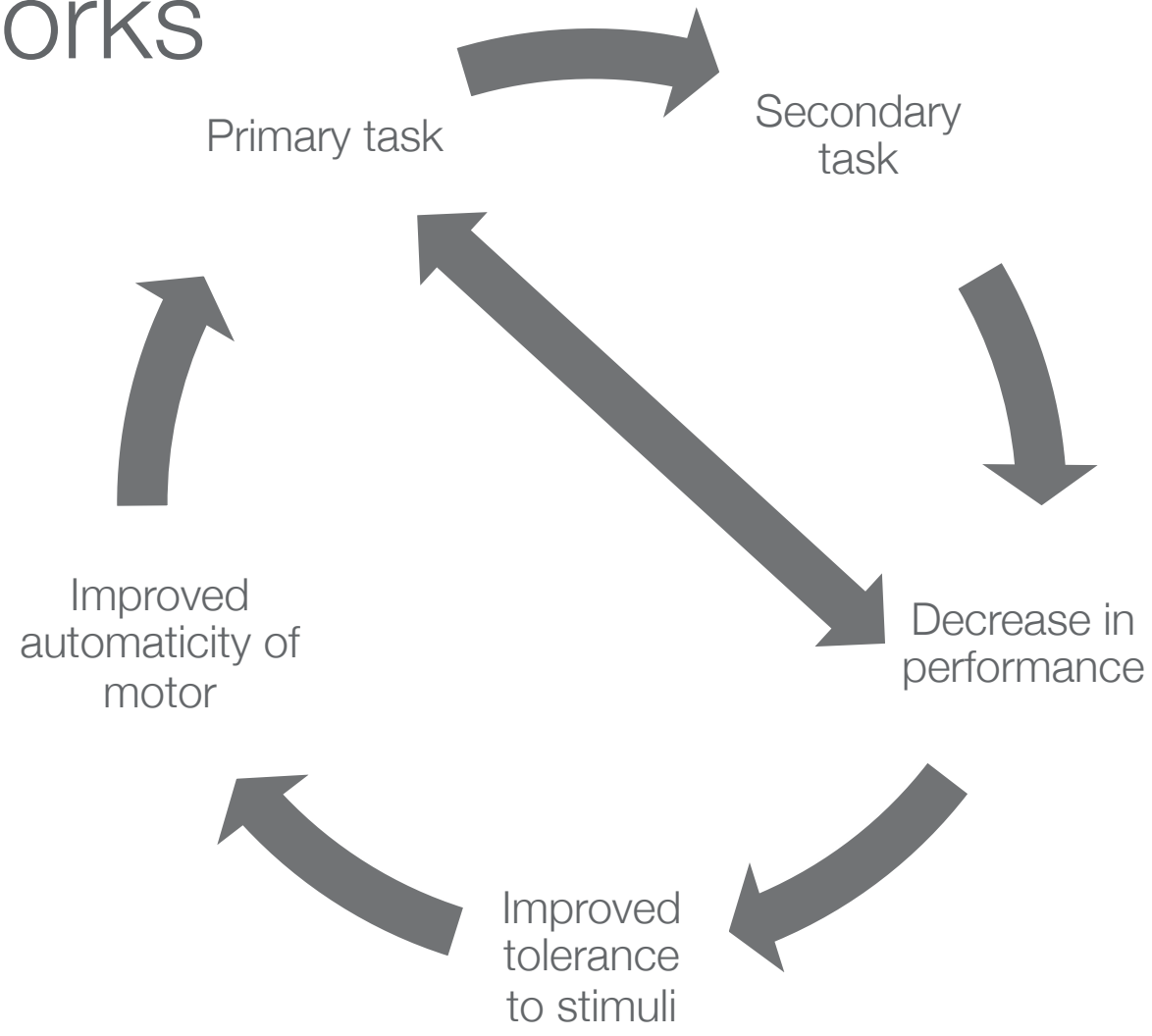
Principles/Tenets of Dual Task Rehabilitation

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

Hierarchy of Modalities

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

Attentional and Procedural Networks



How is Dual Task Tolerance Improved?

Yes…that's NEUROPLASTICITY…

Summary to this point

- DT is impacted by focal and global lesions
- DT challenges constrain attention, force procedural
- DT testing + training has 4 modes/modalities
- Dual task is obligatory, functional, and real world
- The cost of DT performance is measurable
- DT can be responsive to neuroplasticity

Chapter THREE

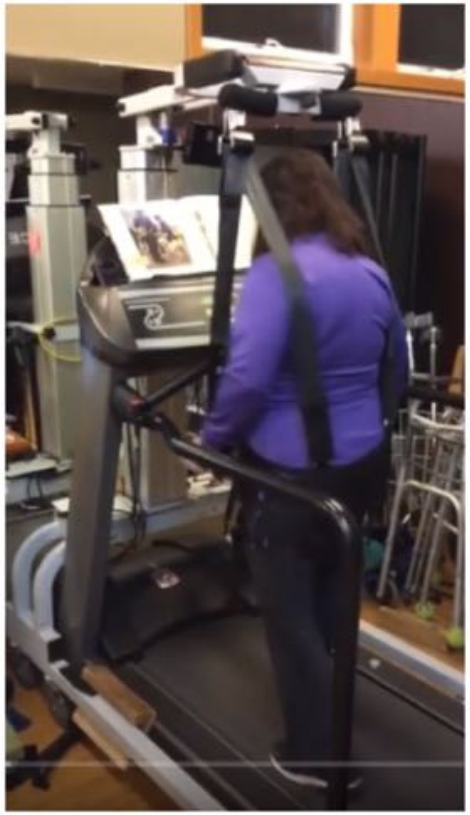
Interventions for DT – the applications in gait

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

Cognition, Working Memory, and Procedural Memories

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



- Metronome
- Eyes closed
- Manual (manipulation)
- Reading forward/backward

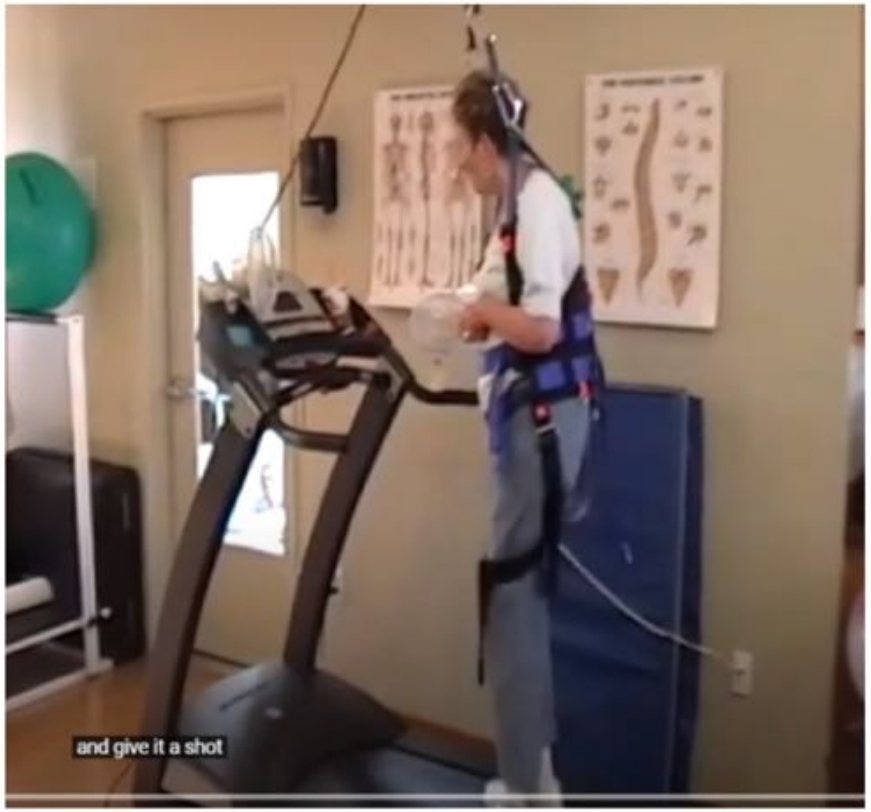
Dual Task Reading/Walking

Patient walking and attempting to read newspaper

1. Has awareness
2. Improving in single task
3. Has personality tolerance
4. Desires to achieve this…
5. Real world practical

Dual Task Walking/Drinking

Patient walking in BWS attempting to drink from a cup



1. Has awareness
2. Improving in single task
3. Has personality tolerance
4. Desires to achieve this…
5. Real world practical

Dual Task on Treadmill: Walk the Dog

Patient walking facing backwards, pulling therapy cord “her dog” in body weight support on the treadmill

Again:

1. Awareness
2. Improving single task
3. Personality tolerance
4. Desires/motivation
5. Real world practical

Dual Task Training in Gait: Manual

- Zipping, buttoning and unbuttoning a shirt, jacket
- Pouring water from a pitcher to 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 your teeth

Dual Task Training in Gait: Manual

Dual Task Training in Gait: 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 Gait: 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 Gait: 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 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, visual, auditory
- 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
- Patients should feel *successful and challenged*
- Neuroplasticity depends on the reward cycle of dopamine

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 7s
Avoiding obstacles	Thread a belt	Think of things you need to do this month

Chapter FOUR

Interventions for DT – the applications in balance, function, and fitness

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

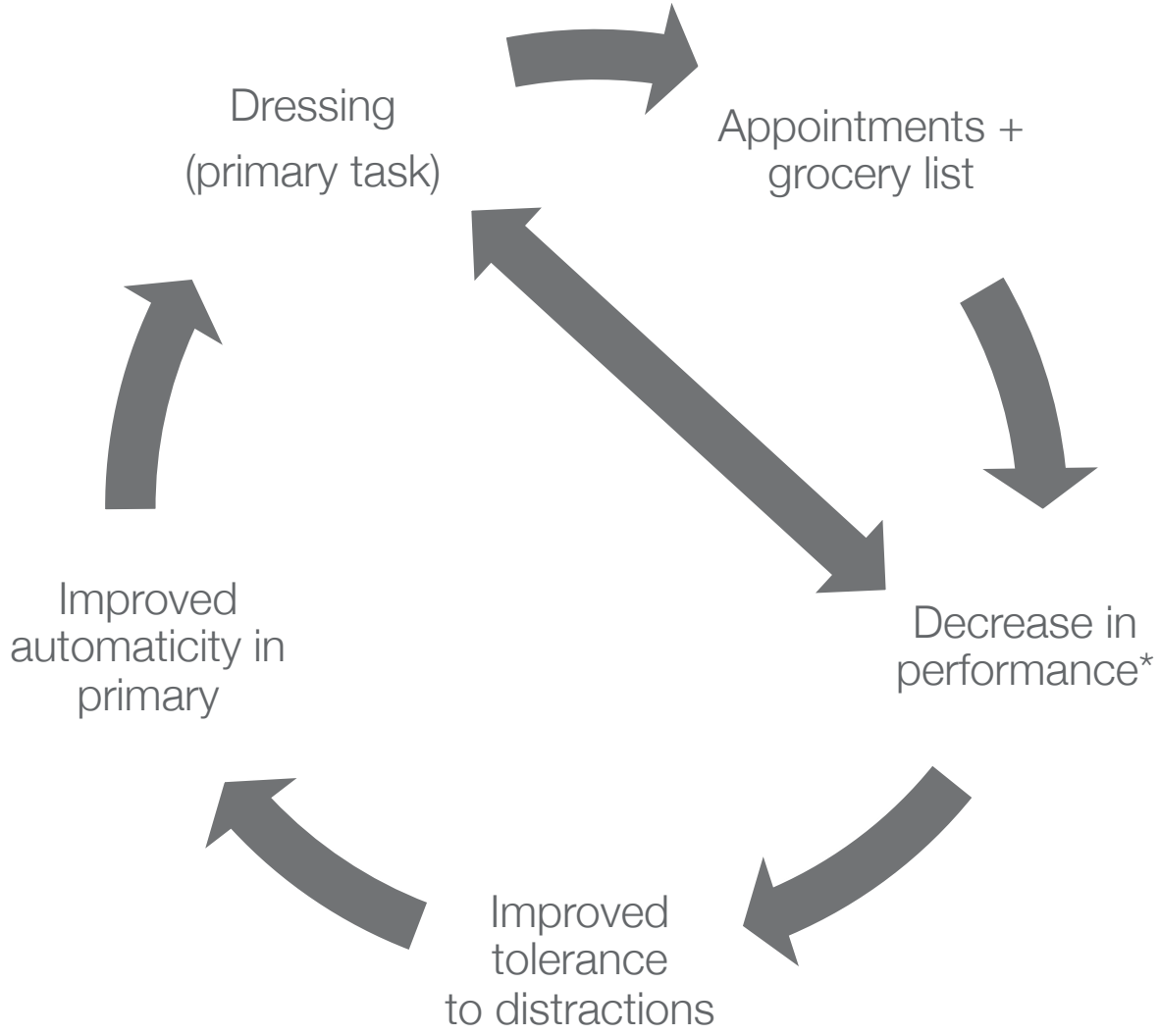
ADLs, IADLs and Procedural Memories

- Combining IADL and procedural memories
  - Walking
  - Retrieving: payment, keys, kleenex, glasses
  - Getting dressed (multiple combinations)
  - Light hygiene – hair, ears, brushing teeth

IADL: Accuracy and Safety

- In comparison to basic ADLs, IADLs require more
  - Attention to detail
  - Calculations
  - Multi-tasking
  - Sequencing

Adding DT constraint to ADL/IADLs:



* Is your patient AWARE that they should expect a reduction in performance?

Dual task training

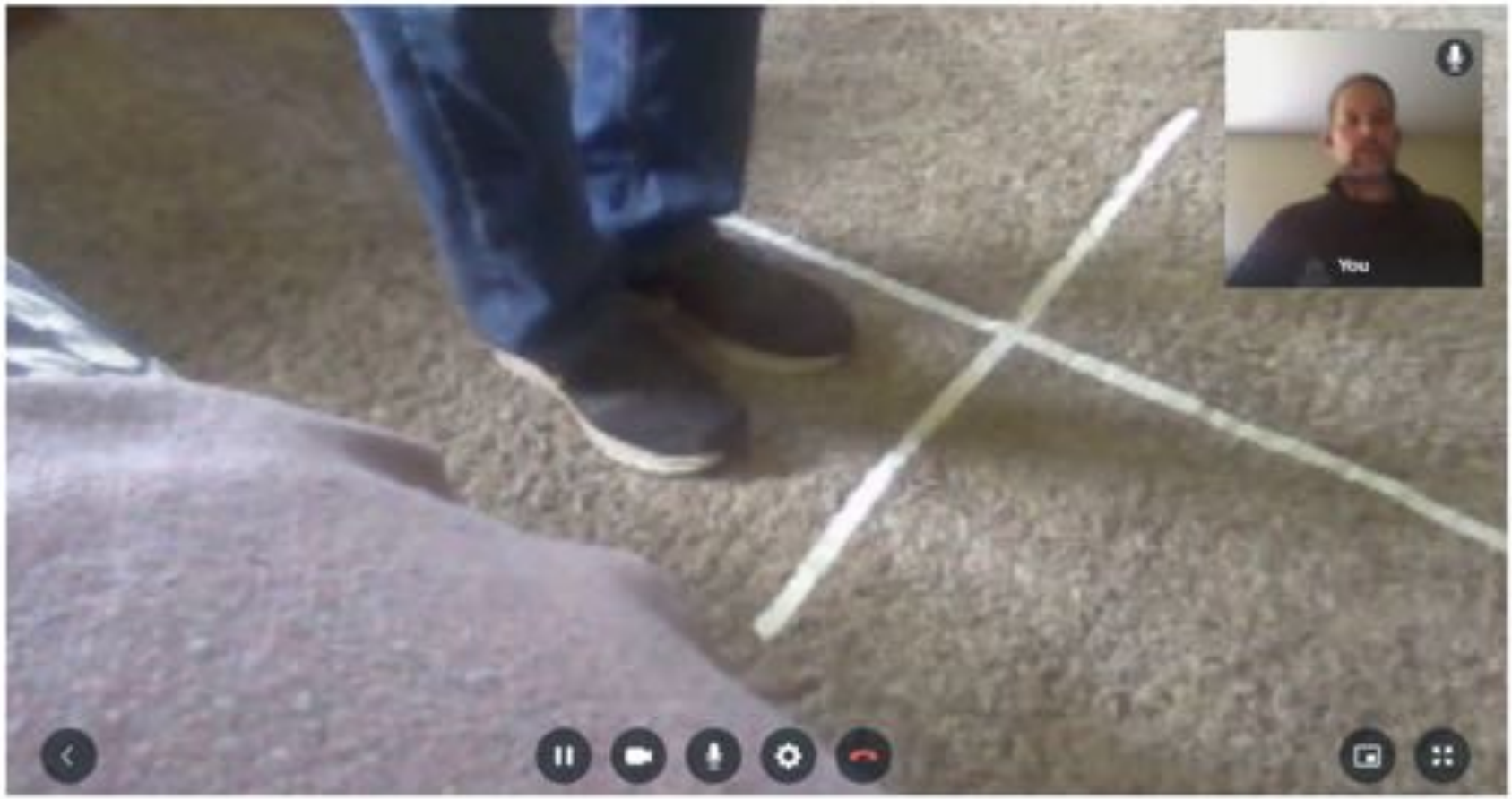
ADL/IADL/MRADL – choose one	Distractor – choose one
Button a shirt	Remember a fact/word or list
Pull things out of a purse or bag	Comprehend TV, radio, podcast
Thread a belt	Object recognition
Loading dishwasher/clear table	Alphabet backwards consecutive or forward every-other letter
Dial a phone	Hold a conversation, keep eye contact
Get in/out of a chair rapidly	Recite a phone number
Write a note	Count backwards by 7s
Folding, ironing, sorting	Name grandchildren in order
Meal preparation/set table	Recite poem from past or new
Donning shoes or socks	Think of errands/tasks to do list
Balance checkbook or count $	Recite work or school history self/others

Common 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

Does this sound like what happened when you first learned to drive???

Dual Tasking in Telehealth



Intervention Across Four Modalities of Concurrent Tasks: Timing

- Primary tasks should:
  - Be safe to perform with the available assistance: PT, BWS, harness/tracking, caregiver, etc.
  - Be improving in performance through practice
  - Be improving in single task
  - Represent a skill to be automatized
  - Be familiar to the learner
  - Have pre-formed structure for self-feedback
  - Be IMPORTANT TO THIS PERSON

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
- Assess psychological response to error/need for success
- Multi-task: tolerance, expectations, functional demand

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

Chapter FIVE

Case studies in DT – each video is worth a million words

The Timed Up and Phone??

Movement in the Background…

Movement in the Background…

Error Enhanced DT Training

Error Enhanced DT Training

Bimanual DT (stroke)

Chapter Six

Measurement and documentation

The Essence of DT: Cost, Risk, Danger

- Can we measure the impact of dual task?

  Yes

- Does DT predict risk and danger in gait?

  Yes

- Does DT predict risk in other areas of function?

  Yes

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

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

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

Dual Task Cost (DTC)

DTC: the additional "expense" in task performance that can be attributed to the addition of a secondary task

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

This can be represented in extra time, more steps required, more losses of balance…etc.

Dual Task Cost (DTC) (cont.)

DTC = (DT- ST) x 100

ST

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

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

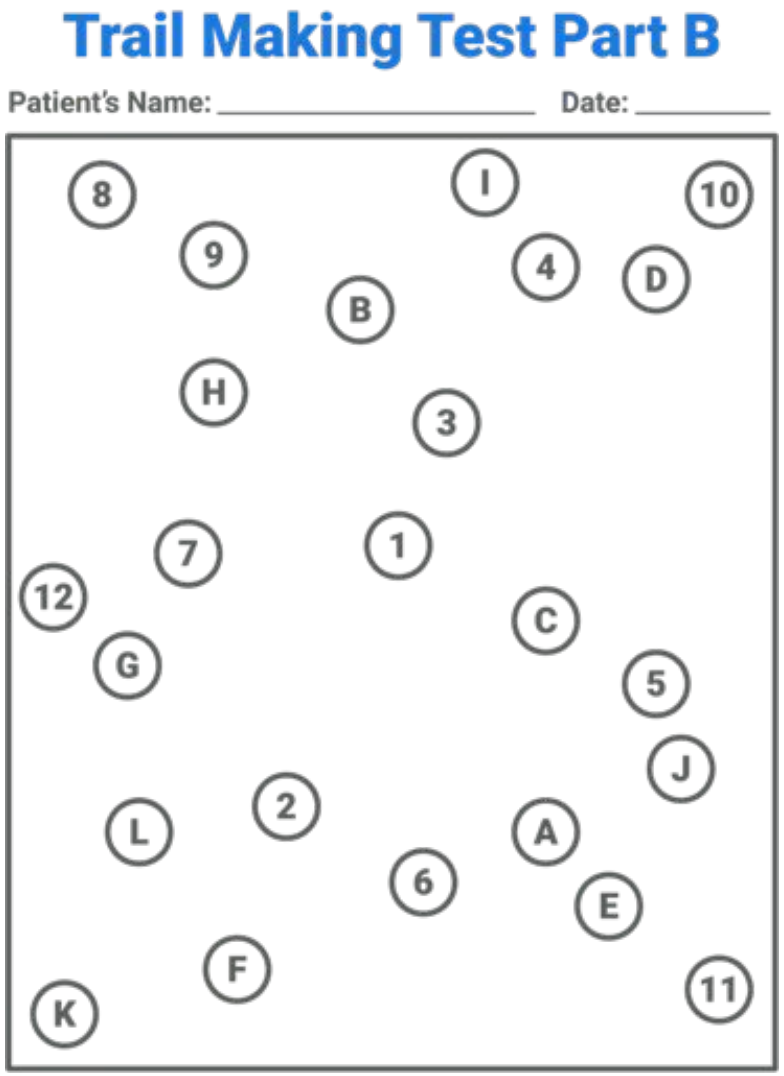
C-TUG

- TUGO: stand, walk three meters, return and sit
- Secondary task: subtract by three from a random number between 66 and 100
- Measurements: times for walking in single and dual task
- Cut-off: 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
- Cut-off value: 4.5 seconds or more in dual task condition associated c 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



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

Modified Ambulatory Trail Making Test

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. Since 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

Video 4SST applications screening

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

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

Summary, Q & A

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
- Fear of falling consumes attention
- 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 non-use: strength, balance, sensory

Dual Task Considerations: PD

- Patients with PD often have dopamine losses to the Basal Ganglia AND the DLPFC
- Dopamine losses and Lewy Bodies leave PwPD patients without strategy: “automate or focus”
- Degenerative dz considerations: Preventative?
- Can we create a “reserve” of function?
- Fear of falling consumes attention

Dual Task Considerations: MS

- Attention is a distributed capacity
- Patients with MS often multiple lesions throughout the brain
- Fear of falling consumes attention
- Degenerative dz considerations – timing of care
- Can we create a “reserve” of function?

Dual Task Considerations: Concussion

- Attention is a distributed capacity – injured easily
- Heightened sensitivities + slowed processing speed + vision disrupted yields higher levels of concentration and a demand on resources = fatigue
- Cognitive skill must be challenged just like all other impairments in concussion
- DT is ESSENTIAL for return to work, life, driving and sports

What did we learn?

Recovering automaticity in function requires DT:

- Each condition has a unique DT relationship
- Each person has unique DT tolerance/needs
- Implementing DT requires an understanding of
  Where (specific aspects of the brain)
    Why (condition and patient goal-specific)
    How (modes, timing, type)
    When (timing in recovery, timing in session)

What did we learn?

Recovering automaticity in function requires DT:

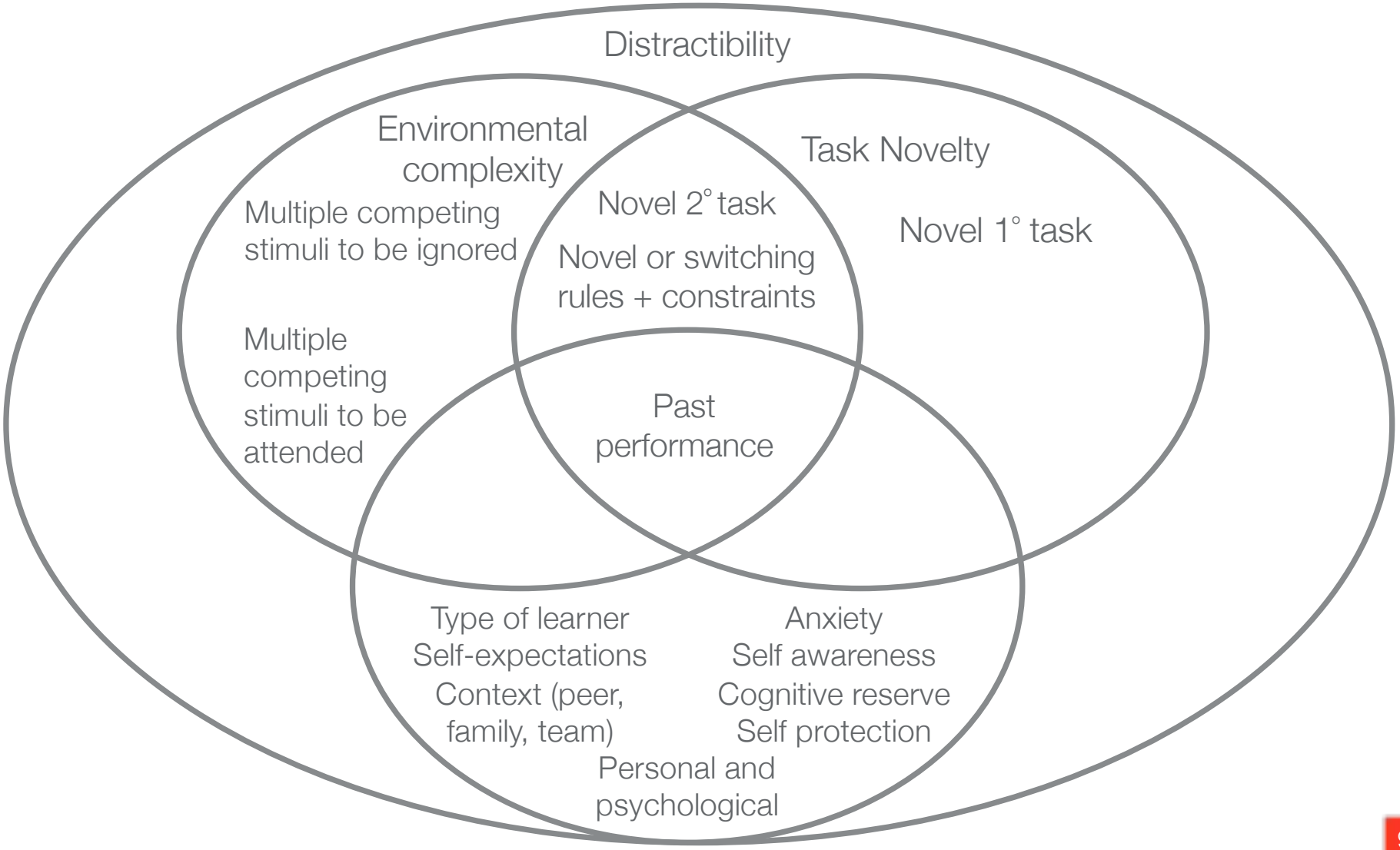
- Dual task is functional and real world
- DT challenges constrain attention and force* procedural memory development/automaticity
- Dual task testing and training should be represented across all 4 modes of distraction
- The cost of dual task performance is measurable

*Patients should feel ***successful and challenged***

Dual Task in Rehabilitation

1. Being dependent on attention, is dangerous
2. The acts of walking, swallowing, dressing….were ALL procedural pre-stroke
3. Tasks become automatic when function demands
4. Retraining tasks to be conscious and “frontal”, will NOT allow the function to be re-automatized
5. DT affords an opportunity to re-automatize function

Studer Distraction Venn



continued

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YouTube: Rehabilitation NWRA

www.mikestuder.com

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Bonus Slides!!

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

Dual task: Future research trends

1. Virtual reality
2. Gamification
3. Explorations in distractions: functional and laboratory
4. Concussion and uninjured athletic applications
5. Science of compensation
6. Healthy aging applications
7. Relearning procedural memories in recovery: stroke, brain injury, vestibular impairment, and more

Retraining procedural memories

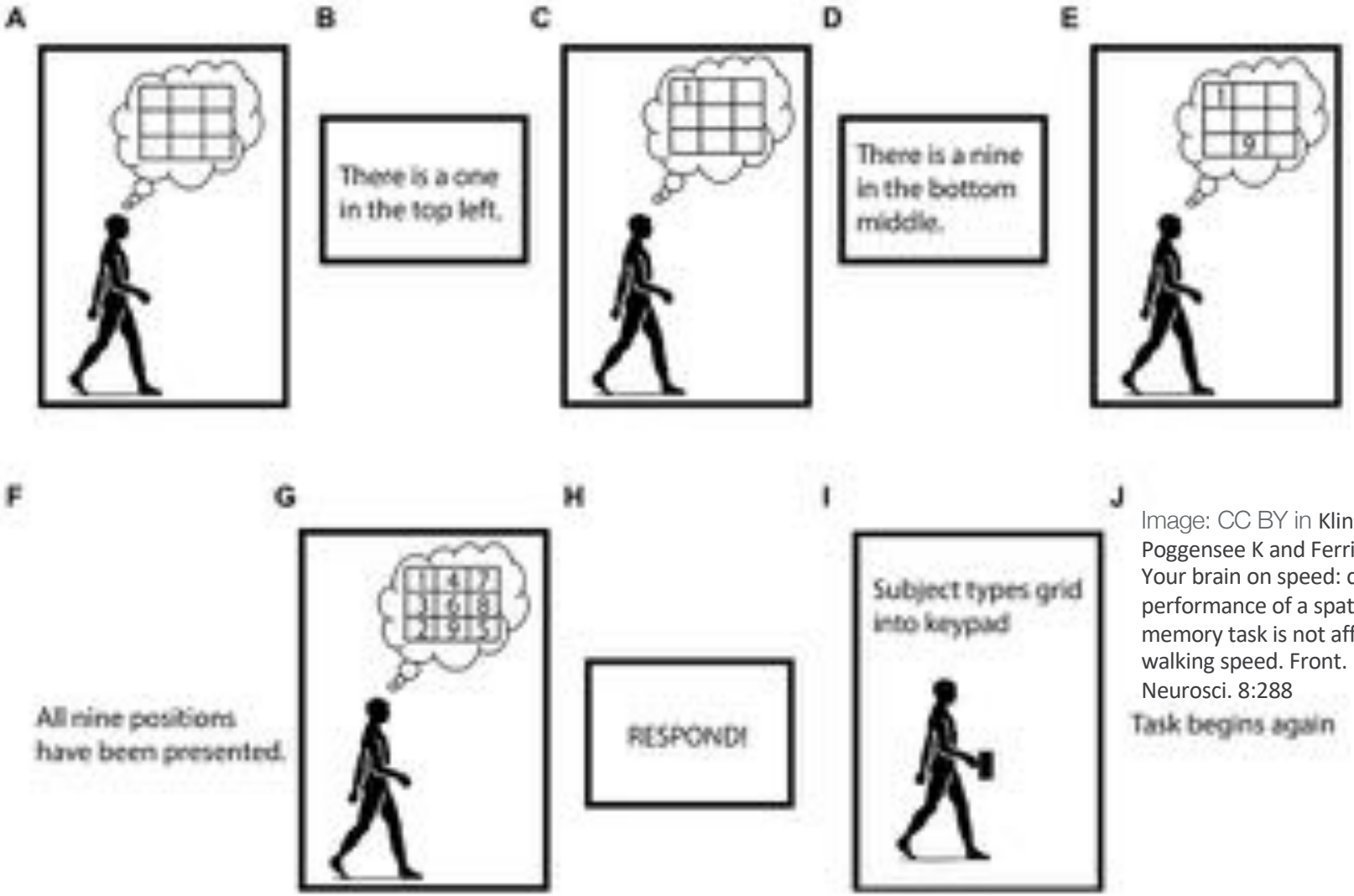

Image: CC BY in Kline JE, Poggensee K and Ferris DP (2014) Your brain on speed: cognitive performance of a spatial working memory task is not affected by walking speed. Front. Hum. Neurosci. 8:288

Dual task effects on gait speed: Comfortable

Task	Cut-off (s)	Sn (%)	Sp (%)	+LR	-LR
Single Task	11.3	70	45.6	1.29	0.66
Verbal Fluency	14.7	60	48.5	1.17	0.82
Subtraction of 3	16.8	55	64.7	1.56	0.70
Manual Task	14.9	65	52,9	1.38	0.66

Dual task effects on gait speed: Maximal

Task	Cut-off (s)	Sn (%)	Sp (%)	+LR	-LR
Single Task	8.5	75	33.8	1.13	0.74
Verbal Fluency	12.7	70	52.9	1.49	0.57
Subtraction of 3	14.0	65	61.8	1.70	0.57
Manual Task	11.5	70	44.1	1.25	0.68

Dual task effects on (backward) gait speed

Task	Cut-off (s)	Sn (%)	Sp (%)	+LR	-LR
Single Task	28.8	70	53.9	1.49	0.57
Verbal Fluency	35	65	48.5	1.26	0.72
Subtraction of 3	37.0	70	44.1	1.25	0.68
Manual Task	11.5	70	44.1	1.25	0.68

Dual task effects on gait speed: TUG

Task	Cut-off (s)	Sn (%)	Sp (%)	+LR	-LR
TUG	12	41	73	1.57	0.8
TUG-cog	14.7	76.5	73.7	2.9	0.32
TUG-manual	13.2	29.55	68.4	0.9	1.1