Implementing Dual Task Training to Improve Balance and Functional Mobility in Individuals with Neurologic Insult

Laura Martel PT, DPT
Jennifer Hladun PT, DPT
Learning Objectives

• Describe the evidence in support of dual task training for individuals with neurologic insult
• Identify outcome measures to evaluate the effectiveness of dual task training
• Understand the importance of a patient centered framework of task selection for dual task activities
• Explain the importance of an interdisciplinary approach to dual task training.
Course Outline

1. What is Dual Task Training (DTT)
2. Review the evidence to support DTT
3. Evaluating the efficacy of DTT using outcome measures
4. Implementation of Dual Task Taxonomy
5. Case Studies of DTT
6. Interdisciplinary Collaboration
What is Dual Tasking?

• Dual Tasking is defined as the performance of two individual tasks that can be performed simultaneously and have identifiable and separate goals.
• Each task is measurable independently as an individual task
• Motor-Motor Dual Task
• Cognitive-Motor Dual Task
The Potential Costs Associated with Dual Task Activities
The Potential Costs Associated with Dual Task Activities

Pedestrians admit to dangerous crossing behavior despite knowing risk

- Talk on the phone while crossing the street: 51% engage in activity, 26% find the activity dangerous
- Text or email while crossing the street: 26% engage in activity, 55% find the activity dangerous
- Listen to music while crossing the street: 34% engage in activity, 25% find the activity dangerous
- 60% of pedestrians use smartphones when crossing the street

Drivers admit to behavior endangering pedestrians despite knowing risk

- Talk on a cell phone while driving: 70% engage in activity, 59% find the activity dangerous
- Read or send text messages while driving: 38% engage in activity, 90% find the activity dangerous
- Listen to music at high volumes while driving: 64% engage in activity, 33% find the activity dangerous

For more information, visit www.LibertyMutual.com

Pedestrian deaths in traffic crashes rose 4% from the previous year to 4,280 in 2010 according to the latest data from the National Highway Traffic Safety Administration.
Dual Task Effect/Interference

- Attention is a limited resource
- Neurologic insult increases the demand of attention
- Correlation between community ambulation and quality of life
- Psychological Refractory Period (PRP)
- Cognitive-Motor Interference (CMI)
- Theories on the mechanism of dual task interference
  - Serial bottleneck model
  - Capacity sharing model
Serial Bottleneck Model

• Suggests only one information processing operation can occur at a given time
• Results in postponement of second task
• First proposed due to dual-task interference observed with serial tasks.
• Has been challenged by several studies

Pashler 1994
Yildiz, 2014
Capacity Sharing Model

• Processing of multiple task can occur but the capacity to perform is limited.
• Attention allocation may be voluntary or influenced by the task
• Results in a decision making process to determine the magnitude and direction of dual task interference for each task

Tombu and Jolicoeur, 2003, 2005
Yogev-Seligmann 2012
Brain Behavior During Dual Tasks

- Lateral prefrontal cortical structures recruited for serial response selection
- Striatal structures of the basal ganglia recruited for parallel/habitual response selection
  - Implication in individuals with Parkinson’s Disease
- Networks of two single tasks are likely made more efficient for dual tasking and integrated into a single network by linkage of distinct brain areas
- Brain interactions and outcomes may be influenced by task selection and/or physical/psychologic factors

Plummer 2015; Wu, 2013
Yogev-Seligmann 2012
Yildiz, 2014
Factors Influencing Dual Task Interference

- Postural Reserve
- Hazard Estimation/Self-Awareness
- Complexity of task/Previous experience with task
- Personality/Mood/Age
- System impairment and/or function
  - Neurological, vestibular, cognitive, musculoskeletal, etc.
- Clear instruction, distractions

Yogev-Seligmann 2012
Factors Influencing Dual Task Interference

Yogev-Seligmann 2012
Why use Dual Task Training?

- To assess every day physical mobility
- To evaluate cognitive and executive function
- To determine safety risk
- To evaluate gait and functional progression

McFadyen, 2015
Menant, 2014
Literature on Dual Task Performance-Patient Population

• Largest number of studies available are for the aging population
• Various studies regarding dual task performance are available for healthy, young adults
• Publications for neurologic conditions are variable depending on the condition.
• Limited heterogeneity of studies provide variable results for the effectiveness of dual tasking interventions and outcomes
Literature on Dual Task Performance - Activity

• Most of the literature evaluates walking, balance and postural control
• Limited research available on seated locomotion
  • Driving
  • Cycling
  • Wheelchair propulsion
• Research is further limited for manual tasks including dexterity, reaching, and grasping
Dual Task activities can be a predictor of falls in the elderly, PD, and stroke

Lundin-Olsson, 1997
Predicting falls in PD

• Walking speeds were assessed with subjects while motor-motor dual tasking: walking and checking boxes, and motor-cognitive DT: walking and subtracting serial 7s

• Higher DTC for walking while box checking (motor-motor DT)
  • Those with 20.4% higher DTC indicated those individuals were 2.6 times more likely to be a future faller
  • 71.4% sensitivity
  • 77.3% specificity

• Reason for this is hypothesized to be related to the nature of PD and dual motor-motor processing overloads the capacities in basal ganglia networks

Heinzel 2016
Predicting falls in stroke- SWWT

• Has only been used in a handful of studies
  • Populations included older adults, stroke, and PD

• Researcher begins a conversation about 30 seconds into walking down a straight hallway. Test considered positive if the individual stops walking when engaging in conversation

• Early research was promising with a positive predictive value of 83%, not repeated in more recent studies as well as in different populations.

• SWWT test is not a reliable single indicator for predicting falls

Lundin-Olsson, 1997
Hyndman, 2004
DTT in Parkinson’s Disease

• Effects on gait:
  • demonstrated increased gait speed and stride length, endurance and cadence

• Effects on balance:
  • Increase in SOT items 5 and 6
  • Four square step test

• Effects on ability to dual task:
  • Increase DT gait speed and stride length

Fritz 2015
DTT in Alzheimer’s Disease

• Effects on gait:
  • Increase in stride length
• Effects on Balance:
  • Berg Balance Scale
  • COP: decrease in postural sway
• Effects on ability to DT:
  • Decrease in DTE for velocity and stride length

Fritz 2015
DTT in Brain Injury

- Effects on balance:
  - CBAM improvements
- Effects on ability to DT:
  - Increase in DT gait speed

Fritz 2015
DT training in stroke

- DT interference due to limited central processing capacity - primary impairments increase the amount of attention needed for walking, leaving fewer resources for a secondary task.
- Plummer et al. found that individuals post stroke experience mutual interference, gait interference without cognitive interference, or gait interference with reciprocal cognitive benefit - see conceptual framework.
- Systematic review by Plummer found that endurance and gait training interventions including DT practice may improve DT gait speed after stroke.
- Baseline:
  - Single task gait speeds: 0.45-1.0 m/s
  - DT gait speeds: 0.31-0.71 m/s
- Interventions included motor-cognitive and motor-motor DT gait training.
- Post intervention gait speeds
  - DT gait speed increased by 0.03-0.06 m/s.

Plummer 2018
DT in Concussions

- Single Task Simple Gait
  - No change in gait speed, stride time, movement of the COM, and trunk stability

- Dual Task Simple Gait
  - Decrease in gait speed during acute phase
  - No change in stride width
  - Increase in movement of COM in ML plane
  - Trunk stability impairments during acute and subacute phases

Fino, 2018
DT in Concussions cont.

• Single Task Complex Gait
  • Slower speed for step over tasks and tandem gait during acute phase
  • More effects on COM seen with gait initiation/termination tasks

• Dual Task Complex Gait
  • No affect during obstacle step over task
  • Decreased gait speed and cadence during tandem gait

Fino, 2018
DT in Multiple Sclerosis

• DTE of walking velocity is significantly greater when performing dual task walking (decreased gait velocity)
• Decreased stride length and increased DTE is associated with increased fall risk for individuals with MS
• Association between frequency of falls and impaired cognitive function
• Improvements in visuospatial memory and cognitive processing speed was observed
• More research is needed

Wajda, 2013
Sosnoff, 2017
DT in the Elderly

- Dual-Interventions automate task and free processing capacity
- Association between a decline in gait performance and future fall risk.
- Decreased step length is a predictor of fall risk
- DTT can improve dual task performance and can be transferred to other dual tasks to some degree.
- Single task training does not transfer to improvement in dual task performance.

Pichierri, 2011; Muir-Hunter, 2016; Ayers, 2014; Agmon, 2014
Examples of dual task interventions

- Motor-motor DT
  - Walking while:
    - Texting
    - Eating popcorn,
    - Stepping over moving obstacles
    - Drinking a cup of water
    - Bouncing a ball
  - Tapping foot while drawing an object
  - Balance with external perturbations, dynamic weight shifting, etc.
Examples continued

• Motor-Cognitive DT
  • Counting to 10
  • Calculating a tip
  • Saying the alphabet backwards
  • Counting backwards
  • Matching
  • Reciting items needed for grilling, animals, vegetables
  • Going through alphabet naming girls’ names, animals, etc.
Cases - Harry

- 18 y/o
- TBI in a work-related motor vehicle accident
- Admission testing
  - Berg: 42/56
  - FGA: 17/30
- Discharge testing
  - Berg:
  - FGA: 29/30
  - Gait speed: 1.08 m/s
  - BESS: 29
DTT with Harry
If only caught on camera...

• Harry: “That was hard.”
• PT: “Why?”
• Harry: “Because you made me do two things at once”
DTT with Makoto towers
Outcome measures

- Stops Walking While Talking (SWWT), Walking While Talking (WWT)
- 4 Step Square Test
- TUG
- Gait Speed
- Gait parameters: Stride Length/Width/Cadence/etc.
- Balance tests: BESS, BBS, FGA, DGI, Mini-BEST
- Postural Stability/Sway
- Self Report: ABC, Falls Efficacy Scale
Walking While Talking (WWT)

- Individuals walk along a 20 foot corridor, turn around, and return 20 feet.
  - WWT simple: walking and reciting the alphabet
  - WWT complex: walking and reciting alternating letters of the alphabet
- WWT simple: high specificity for identifying fallers: 89.4%, positive predictive value of 54.5%
- WWT complex: high specificity for identifying fallers: 95.6%, positive predictive value of 71.4%
- Many variations of this test have since been used in research
- In general, research has shown that changes in performance while dual tasking are significantly associated with increased risk for falling

Vergheese, 2002
Beauchet, 2009
Four Step Square Test

- A test of dynamic balance that assesses and individual’s ability to step over objects forward, sideways, and backwards
- Equipment: Stopwatch and 4 canes
- Validated in Vestibular Disorders, Stroke, PD, and Older Adults
Four Step Square Test
BESS

• Includes 6 conditions all with eyes closed and barefoot for 20 second intervals on firm and foam surfaces

• Possible score of 0-60 (low score=less errors)
  • Maximum # of errors for each condition is 10

• Errors include:
  • Hands off iliac crest
  • Step, stumble, or fall
  • Hip abduction or flexion >30 degrees
  • Forefoot or heel come off surface
  • Out of testing position for >5 seconds

Iverson, 2008
BESS

- Insert video
Taxonomy

• Defined as the practice and science of classification of things or concepts.
• Often have a degree of order however, moving from a lower or higher degree of order is not always linear.
• Allows clinicians to frame evaluation an intervention using a common language
Dual Task Taxonomy

- Provides a framework for selection of single and dual tasks and task analysis
- Identify overall task characteristics by discriminating between activities
  - Single Goal
    - Walking and counting steps to facilitate walking (motor and cognitive components in a single complex task)
  - Two goals
    - Serial-three subtraction while walking (motor and cognitive goals)
- Flexibility allows all possible dual task pairings

McIsaac, 2015
## Dual Task Taxonomy

<table>
<thead>
<tr>
<th>Task Novelty</th>
<th>Task Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
</tr>
<tr>
<td>HIGH</td>
<td></td>
</tr>
</tbody>
</table>
Dual Task Taxonomy: Single Task Components

<table>
<thead>
<tr>
<th>Task Novelty</th>
<th>Task Complexity</th>
<th>Task Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>Walking on Level Surface</td>
<td>Walking on Level Surface While Carrying a Glass of Water</td>
</tr>
<tr>
<td>HIGH</td>
<td>Walking on an Icy Surface</td>
<td>Walking on an Icy Surface While Carrying a Glass of Water</td>
</tr>
</tbody>
</table>

McIsaac, 2015
## Dual Task Taxonomy: Dual Task Components

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Task Novelty</th>
<th>Task Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Single Motor</strong></td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td></td>
</tr>
<tr>
<td><strong>Single Cognitive</strong></td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td></td>
</tr>
<tr>
<td><strong>Dual Motor-Motor</strong></td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td></td>
</tr>
<tr>
<td><strong>Dual Cognitive-Motor</strong></td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

McIsaac, 2015
<table>
<thead>
<tr>
<th>Task Type</th>
<th>Task Novelty</th>
<th>Task Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Single Motor</strong></td>
<td>Low</td>
<td>Drinking a cup of water</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Propelling a wheelchair</td>
</tr>
<tr>
<td><strong>Single Cognitive</strong></td>
<td>Low</td>
<td>Reciting the alphabet</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Reciting alternative letters of the alphabet</td>
</tr>
<tr>
<td><strong>Dual Motor-Motor</strong></td>
<td>Low</td>
<td>Drinking a cup of water while writing a note with the other hand</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Tapping foot as fast as possible while drawing a 6 pointed star</td>
</tr>
<tr>
<td><strong>Dual Cognitive-Motor</strong></td>
<td>Low</td>
<td>Standing on one foot while saying the alphabet</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>Standing on one foot while performing word generation task</td>
</tr>
</tbody>
</table>

McIsaac, 2015
Utilizing Dual Task Taxonomy

• Identify target areas for your patient and select tasks that are relevant.
• Recognize the goals and constraints of movement.
• Measure motor and/or cognitive task performance both for single and dual task conditions.
• Determine the relationship between clinical deficits and outcomes for interventions.
• Assess changes in one task in relation to the other.
Why Measure Dual Tasks?

• To determine limitations throughout systems
• To distinguish the modality related to the pattern of dual task interference/effect
• To identify treatment goals
• To prioritize attentional focus or determine attentional biases
• To evaluate the effect of intervention
Measuring Dual Task Effect

- Measure each task alone (single task)
  - Motor Task
  - Cognitive Task (while sitting)
- Measure tasks when performed simultaneously (dual task)
- Use same tasks for pre and post assessment
- Provide clear and concise instructions
- Determine if more than one type of dual task combination should be tested

Wadja & Sosnoff, 2015
Measuring Dual Task Effect

• Absolute measures
  • Single task and dual task parameters
  • Example: Gait speed, stride length, naming tasks, etc

• Relative Measure
  • Dual Task cost/benefit

\[
DTE \, (\%) = \frac{\pm (\text{dual task} - \text{single task})}{\text{single task}} \times 100
\]

Mclsaac, 2015
Dual Task Interference

- Mutual interference
  - Inadequate attentional resources
- Motor interference
  - Prioritization of cognitive task
- Cognitive interference
  - Prioritization of motor task

Plummer & Eskes, 2015
Plotting Dual Task Effect

Plummer & Eskes, 2015
Plotting Dual Task Effect

Plummer & Eskes, 2015
How do you perform with Dual Tasks??

- 4 step square test
- BESS
- With and without cognitive task
Cases - Tom

- 21 year old male
- Suffered TBI in motorbike accident

- Admission testing
  - Berg: 51/56
  - FGA: 21/30
  - BESS: 18
  - Gait speed: 0.89 m/s

- Discharge testing
  - Berg: 56/56
  - FGA: 30/30
  - BESS: 11
4 step square test
Tom’s DTE

\[ DTE\% = \pm \frac{(\text{dual task} - \text{single task})}{\text{single task}} \times 100 \]

- 4 Step Square Test (single task): 4.9 seconds
- Naming task (single task): 6 colors
- Motor-Cognitive Dual Task: 5.65 seconds and 6 colors
- DTE motor: 15%
- DTE cognitive: 0%
Plotting Tom’s DTE

- 4SST

- Cog Task

+ 4SST

+ Cog Task
Your Turn
Joe’s DTE

\[ DTE(\%) = \frac{\pm (\text{dual task} - \text{single task})}{\text{single task}} \times 100 \]

- 4 Step Square Test (single task):
- Naming task (single task):
- Motor-Cognitive Dual Task:
- DTE motor:
- DTE cognitive:
Joe’s DTE

\[
DTE \, (\%) = \frac{\pm(dual \, task - single \, task)}{single \, task} \times 100
\]

- 4 Step Square Test (single task): 4.45 seconds
- Naming task (single task): 5 names
- Motor-Cognitive Dual Task: 9.26 seconds and 4 names
- DTE motor: 108%
- DTE cognitive: -20%
Plotting Joe’s DTE

- 4SST

- Cog Task + 4SST

+ Cog Task
One more example- TUG
Larry’s DTE

\[
\text{DTE} (\%) = \frac{\pm (\text{dual task} - \text{single task})}{\text{single task}} \times 100
\]

- TUG(single task):
- Naming task (single task):
- Motor-Cognitive Dual Task:
- DTE motor:
- DTE cognitive:
Larry’s DTE

\[ \text{DTE} \ (\%) = \frac{\pm (\text{dual task} - \text{single task})}{\text{single task}} \times 100 \]

- TUG(single task): 6.42 seconds
- Naming task (single task): 3 motorcycles
- Motor-Cognitive Dual Task: 9.03 seconds and 6 motorcycles
- DTE motor: 40%
- DTE cognitive: 100%
Plotting Joe’s DTE

- TUG

- Cog Task  + TUG  + Cog Task
Plotting Joe’s DTE

- TUG

- Cog Task

+ TUG

+ Cog Task
Interdisciplinary collaboration
Barriers to Using DTT in Clinical Practice

- Cognitive fatigue
  - Time of day, medications, consecutive therapies, sundowning, etc
- Physical fatigue, pain
- Language, cultural difference
- Aphasia, speech deficits
- Behavioral variability
- Previous level of cognition, physical abilities, education
Using DTT in Clinical Practice

• Determine whether your patient is appropriate for DTT
• Select appropriate interventions for their specific diagnosis
• Utilize outcome measures that are most suitable for your patient’s diagnosis.
Slap-tap

\[ p \quad q \quad b \quad d \quad q \quad p \quad b \quad d \quad q \quad p \\
q \quad b \quad p \quad d \quad p \quad d \quad q \quad q \quad d \quad p \\
b \quad q \quad p \quad d \quad b \quad q \quad p \quad d \quad q \quad d \\
b \quad p \quad b \quad q \quad p \quad d \quad b \quad q \quad p \quad b \\
q \quad b \quad q \quad p \quad q \quad d \quad b \quad d \quad d \quad b \\
d \quad p \quad d \quad b \quad q \quad p \quad b \quad d \quad q \quad p \\
d \quad q \quad b \quad d \quad q \quad p \quad p \quad b \quad d \quad q \]
Slap-tap with cognitive task
2 weeks later…
Questions?
References

References

Thank You

Jennifer Hladun PT, DPT
jhladun@craighospital.org

Laura Martel PT, DPT
lmartel@craighospital.org

CRAIG
UNYIELDING DETERMINATION. EMPOWERING LIVES.

3425 S. Clarkson Street, Englewood, CO 80113
craighospital.org