Advancing the clinical application of dual-tasking: addressing systems impairments in the dual task taxonomy

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Disclosures

• Dr. McIsaac reports no disclosures
• Dr. Muratori reports no disclosures
• Dr. Fritz reports no disclosures
• Mike Studer reports no disclosures
• Brady Whetten reports no disclosures

Learning Objectives

• Define dual-task in operational terms
• Describe the measurement of dual-task interference.
• Understand the importance of task selection and instruction, and the impact on dual-task performance.
• Discuss the interference resulting from simultaneous task performance in healthy individuals and people with neurologic dysfunction, and the implementation of dual-task training in patient populations.

Overview

• Dual-task operationally defined
• Review current evidence of neural networks underlying dual-task processing
• Measurement and factors influencing dual task performance
• Role of a dual-task taxonomy and application in the clinic
• Dual-task interference related to system/modality impairments: cognitive, auditory, visual, manual
• Case studies and Q&A with audience members

Dual-task interference effects: clinical considerations in measurement, assessment and intervention

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Dual Task Defined

...the concurrent performance of two tasks that can be performed independently and have distinct and separate goals.

Each task performance can be measured independently as a single task

McIsaac, Lamberg & Muratori 2015 Biomed Res Int

Why Use Dual Task Paradigms?

- Ecological validity – assess everyday function
- To assess cognitive and executive function  
  – Ability to process information and attend
- To assess gait and safety risk
- To assess functional progression

Neural networks of dual tasking

- Dual task interference may occur due to use of similar systems or brain regions
- Increase processing capacity or efficiency?
- 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 (Wu et al 2013 NeuroImage)

Classic dual-task paradigm

1. Measure performance of each task in isolation (single-task)
   - Gait alone
   - Cognitive task alone (sitting)
2. Measure performance of each task while performed concurrently (dual-task)

Patterns of cognitive-motor interference

Plot gait DTE against cognition DTE to understand the nature of the interference

Measuring dual-task performance

Purpose of measurement

- To quantify limitations across systems
  - Develop treatment goals
- To characterize the pattern of dual-task interference related to modality
- To infer attentional prioritization
  - Attentional biases, implications for safety
- To evaluate treatment effects

How to measure

- **Absolute measures**: single-task and dual-task parameters (e.g., gait speed)
- **Relative measures**: dual-task effect (cost/benefit)
  
  \[
  \text{DTE (\%)} = \frac{\pm (\text{dual task} - \text{single task})}{\text{single task}} \times 100
  \]

Motor-Cognitive Dual Task

- Pre = mutual interference
- Post = improved cognitive interference at a cost to gait interference (worsened)

Motor-Motor Dual Task

- Pre = mutual interference
- Post = Slightly improved buttoning interference, no change in gait interference

Implications for assessment

- Use the same two tasks for pre and post assessment
- Use consistent instructions
- Consider testing more than one type of cognitive-motor or motor-motor dual-task combination
  - Effects of task on dual-task interference
  - To evaluate transfer to untrained tasks
  - To assess capability of different systems with impairment

Factors influencing dual-task interference

- **Task Factors**
  - Complexity of task
  - Goal of task
- **Individual Factors**
  - Capability, reserve, autonomy & expectancies
  - Systems integrity (impairment) & function
    - Vestibular, visual, somatosensory, cognitive, cardiopulmonary, autonomic, musculoskeletal
  - Prior experience (novelty of task)
- **Contextual Factors**
  - Instructions
  - Hazards
  - Distractions, complexity
Implied vs instructed prioritization

Limitations:
• Selected strategy may be influenced by numerous factors
• Task structure, context and self-efficacy may implicitly drive prioritization
• Person may change the way they perform the two tasks together on a different day
  – Reliability of dual-task assessment

Considerations of conditions

• Vestibular impairment
• Peripheral neuropathy
• Mild cognitive impairment
• Stroke
• Parkinson disease
• Multiple Sclerosis

Measuring effects of task difficulty on prioritization of simulated driving tasks

Recommendations for assessment
1. Establish a standardized assessment protocol
2. Measure key aspects of performance of both tasks in single and dual-task conditions
3. Examine changes in absolute and relative measures
4. Evaluate changes in one task in relation to the other; consider attentional strategy/trade offs and specific system impairments
5. Assess treatment-related changes in absolute measures to clinically significant thresholds (MCID)
6. Evaluate treatment-related changes in relative measures in terms of pattern-strategy change

Learning Objectives
• Define dual-task relative to a dual-task taxonomy
• Describe how a taxonomy offers broad categories for task analysis
• Demonstrate how a dual-task taxonomy can be applied for clinical care of individuals with neurologic diagnoses.

The Dual Task Taxonomy:
Applicability in the Clinic

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Advancing the Clinical Application of Dual Tasking

Dual Task Defined

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What is a Taxonomy?

- Taxonomies are organizational systems that allow for the grouping of a specific topic or concept.
- Taxonomies usually have some inherent degree of order built into them although the method to move from a lower to a higher degree of order may not be linear.
- A taxonomy can provide a common language for clinicians to frame assessment and intervention.

What is the Dual Task Taxonomy?

- A framework for single and dual task selection and task analysis.
  - Requires clinical decision making regarding deficits that are being measured or targeted for intervention.
    - Clinicians must understand movements as they relate to the task constraints.
  - Is flexible in application to include all possible dual task pairings so that an entire picture of dual task cost can be considered.
    - Tasks do not inherently belong to a category but depend on specific patient and task interactions.

Building a Taxonomy

<table>
<thead>
<tr>
<th>TASK TYPE</th>
<th>Task Novelty</th>
<th>Task Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGLE MOTOR</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>SINGLE COGNITIVE</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>MOTOR-</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>MOTOR</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>MOTOR COGNITIVE</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
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<td>SINGLE MOTOR</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td></td>
<td>Drinking a cup of water</td>
<td>Walking with a cup of water</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
<td>Tree Pose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Walking with crutches</td>
</tr>
<tr>
<td>SINGLE COGNITIVE</td>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td></td>
<td>Counting to ten</td>
<td>Calculating a tip</td>
</tr>
<tr>
<td></td>
<td>HIGH</td>
<td>Saying the alphabet backward</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paced auditory serial addition task (PASAT)</td>
</tr>
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</tr>
<tr>
<td>Single Cognitive</td>
<td>HIGH</td>
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</tr>
<tr>
<td>Motor-Motor</td>
<td>LOW</td>
<td>HIGH</td>
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#### Recommendations for using the dual task taxonomy in the clinic:

1. Have a clinical hypothesis that you wish to test with the patient.
2. Select tasks that target areas of interest for your patient. Understand the task goals and constraints on movement.
3. Use dual task assessment to measure key aspects of the motor and/or cognitive task performance in single and dual-task conditions.
   a. Be sure that single tasks have clear objective measures
   b. Use more than one combination of tasks
4. Determine the relationship between outcomes and clinical deficits for targeted interventions.
5. Evaluate changes in one task in relation to the other as part of a dual task intervention.

#### Categorizing Interventions

**Motor**
- Walking
  - Forward
  - Backward
  - Obstacles
- Balancing
  - SOT
  - Dynamic weight shifting
  - External perturbations
- External Cueing
  - Speed
  - Stride length
  - Timing/metronome

**Cognitive**
- Listening to music
- Listening to talk-radio
- Verbal fluency
- Answer autobiographical questions
- Serial 3-subtraction
- Information processing tasks
- Counting backwards
- Auditory choice reaction time task
- Visuospatial task of pattern matching

#### Clinical application of the dual-task taxonomy:

**COGNITIVE, MANUAL, AUDITORY, VISUAL**

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Hierarchy of modalities

- Cognitive
- Visual
- Auditory
- Manual

Which one is highest or most demanding?
Do any of the “others” NOT include cognitive?

**Screening** DT tolerance across four modalities of concurrent tasks:

**Tenets of screening:**
1. Overlapping of modalities will happen
2. Testing is *not* intended to be task-specific or functional
3. Test EACH primary and distracter alone
4. Dual task CAN enhance primary motor
5. To cue, or not to cue? Prioritization must be consistent...

**Intervention** across four modalities of concurrent tasks:

**Tenets of intervention:**
1. Overlapping of modalities will happen
2. Intervention MUST be task-specific/functional
3. Interventions consider patient preference
4. Underestimate patient expectations in DT
5. Follow DT with single task
6. Either vary or choose NOT to cue prioritization

**Intervention** across four modalities of concurrent tasks:

**Questions of motor learning:**
1. How do we know who will respond to DT?
2. How do we know when to introduce DT?

**Intervention** across four modalities of concurrent tasks:

**Responders** will:
- Increase vigilance in forewarned DT training
- Be able to accept a reduction in performance
- Demonstrating improvements in single task (primary)
- Have capacities/experience in secondary task (single)

**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: Timing

Primary tasks should:
- Have potential (motor control and resources) remaining to reduce impairments such as:
  - Ankle inversion
  - Genu recurvatum
  - Fall
  - Fear
- Considerations of prognosis (cognitive and motor)

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: Tenets of intervention:
1. Overlapping of modalities will happen
2. Intervention MUST be task-specific/functional
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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

Re-measure
- Use measurable change to guide your efforts
- Use tests that are sensitive and specific
- Be willing to challenge yourself:
  - Is WHAT I am doing working or not: FITT
    - Frequency
    - Intensity
    - Type
    - Time

Case Studies
Questions & Discussion