A language-based lens to the working memory struggles of children with Developmental Language Disorder

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Slides available:
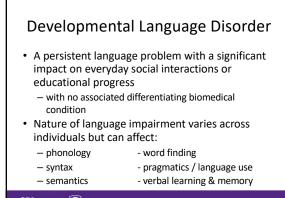http://bit.ly/lwmpubs →
Presentations
(or use QR code)

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2

Overview

1. Working memory & DLD
2. What is working memory?
3. Working memory training results
4. Language-based strategies for supporting working memory

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3

Developmental Language Disorder

- A persistent language problem with a significant impact on everyday social interactions or educational progress
  - with no associated differentiating biomedical condition
- Nature of language impairment varies across individuals but can affect:
  - phonology   - word finding
  - syntax   - pragmatics / language use
  - semantics   - verbal learning & memory

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Bishop et al., 2017

4

Verbal Learning & Memory in DLD

- Some individuals with DLD have difficulties with working memory
  - Vugs et al., 2014; Lum et al., 2012
- But not all individuals with DLD have working memory difficulties
  - Gray et al., 2019; Archibald & Joanisse, 2009

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5

Verbal Learning & Memory in DLD

- Working memory difficulties in DLD, specifically linked to
  - New word learning
    - Jackson et al., 2021; McGregor et al., 2020
  - Linguistic tasks with a high cognitive load
    - Noonan et al., 2014; Frizelle & Fletcher, 2015

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6

Verbal Learning & Memory in DLD

- In word learning studies, the difficulty for individuals with DLD seems to be in encoding and not retention
  - McGregor et al., 2020; Jackson et al., 2021
- Declarative (long-term) memory appears to be a relative strength in DLD
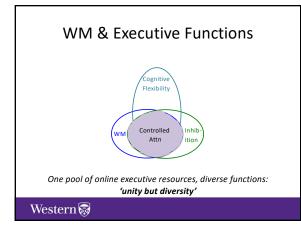 - Lum et al., 2012

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7

Working Memory

- The ability to hold & manipulate task-relevant information in highly activated & accessible state
  - Our mental workspace
  - Limited in capacity
    - Tasks with high cognitive load can exceed capacity

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8

WM & Executive Functions

Cognitive
Flexibility

WM · Controlled Attn · Inhib-ition

One pool of online executive resources, diverse functions:
'unity but diversity'

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9

Working Memory Jobs

1. Storage and processing of information
   - Not just maintenance of material
   - Build temporary relationships
     - Transformation of information
     - Derivation of new information
2. Maintain appropriate information
   - Activate needed information
   - Suppress irrelevant information

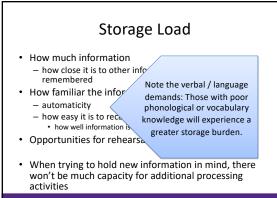Western

10

Storage Load

- How much information
  - how close it is to other information trying to be remembered (can it be chunked?)
- How familiar the information is
  - automaticity
  - how easy it is to recall
    - how well information is organized in the brain
- Opportunities for rehearsal

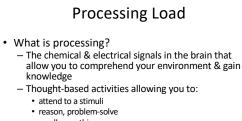- When trying to hold new information in mind, there won't be much capacity for additional processing activities

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11

Storage Load

- How much information
  - how close it is to other info
    remembered
- How familiar the infor
  - automaticity
  - how easy it is to reca
    - how well information is
- Opportunities for rehearsa

Note the verbal / language demands: Those with poor phonological or vocabulary knowledge will experience a greater storage burden.

- When trying to hold new information in mind, there won't be much capacity for additional processing activities

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12

Processing Load

- What is processing?
  - The chemical & electrical signals in the brain that allow you to comprehend your environment & gain knowledge
  - Thought-based activities allowing you to:
    - attend to a stimuli
    - reason, problem-solve
    - recall something
    - associate information in new ways
    - formulate conversational turns
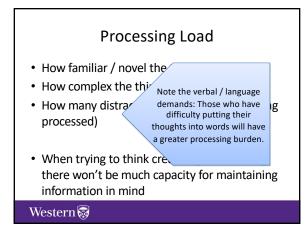 - Processing tasks vary in signals / thoughts required to complete the task
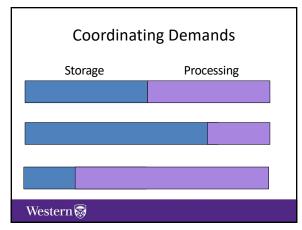
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13

Processing Load

- How familiar / novel the thinking routine is
- How complex the thinking routine is
- How many distractions are occurring (& being processed)

- When trying to think creatively & effortfully, there won't be much capacity for maintaining information in mind

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14

Processing Load

- How familiar / novel the
- How complex the thi
- How many distra processed)

> Note the verbal / language demands: Those who have difficulty putting their thoughts into words will have a greater processing burden.

- When trying to think cre there won't be much capacity for maintaining information in mind

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15

Coordinating Demands

Storage   Processing
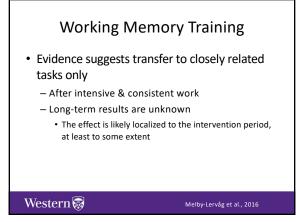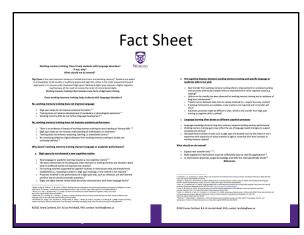
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16

Tasks in the Mental Workspace

- 3 + 5 =
- What do these letters spell?
- Remember the animals unless they're smaller than a loaf of bread
- How do you feel about working late?

What are you storing?
What are you processing?
What processes are you using?

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17

Working Memory Training

- Evidence suggests transfer to closely related tasks only
  - After intensive & consistent work
  - Long-term results are unknown
    - The effect is likely localized to the intervention period, at least to some extent

Western   Melby-Lervåg et al., 2016

18

Fact Sheet

19

Does Working Memory Training Help Students with Language Disorders?

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20

Working Memory Training Does Not Improve Language

- No reliable training effects on:
  - Other letter or word lists (Norris et al., 2019)
  - Vocabulary (Melby-Lervåg et a., 2016)
  - Lexical decisions (Gathercole et al., 2019)
  - Sentence repetition (Delage et al., 2021)
  - Sentence comprehension (Gathercole et al., 2019)

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21

Working Memory Training Does Not Improve Academic Performance

- No reliable training effects on:
  - Decoding (Melby-Lervåg et a., 2016)
  - Reading comprehension (Melby-Lervåg et a., 2016)
  - Arithmetic (Melby-Lervåg et a., 2016)

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22

Why Doesn't WM Training Improve Language or Academic Performance

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23

No New Routine

- Digit spans do not require a new routine
  - Repeating digits is a commonly occurring routine so established early in development
  - Rehearsal mechanisms are well-established

- New language & academic learning requires a new cognitive routine!

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Too Much Cognitive Distance

- Transfer occurs between tasks that are closely matched (i.e., require the same routine)
- Digit spans draw on automatic routines, which are difficult to alter
- Training routines are very different from new language & academic learning

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25

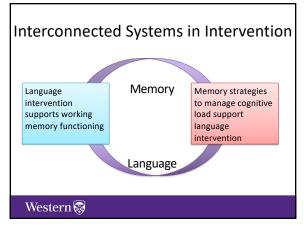## Different Cognitive Processes

- Language knowledge gets established in long-term memory
- Working memory performance can improve for language-based reasons:
  - Language-based strategies supporting retention & recall
  - Experience and knowledge related to verbal material reduces cognitive load

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26

Near Transfer is the Rule

- Broadly speaking, the evidence suggests near transfer
  - for cognitive training
  - even for linguistic training, far transfer is mediated by trained skills

➢ spend your therapy time on knowledge & skills the child needs

Western   Sala & Gobet, 2017; Melby-Lervåg et al., 2020

27

Interconnected Systems in Intervention

Memory

Language intervention supports working memory functioning

Memory strategies to manage cognitive load support language intervention

Language

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28

Language Intervention

- Improving language skills will have a positive effect on working memory
  - better word knowledge will reduce storage load
  - more fluid formulations will reduce processing load
  - not a far transfer effect (i.e., we're not increasing WM capacity with language therapy)
  - it's more of a functional change ->
    - increasing the chunk size (reduces storage load)
    - increasing processing efficiency (reduces processing load)
      - > improves WM functioning

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29

Working Memory Strategies

- Storage-related strategies
  - focus on retention of new information (minimizing processing load)
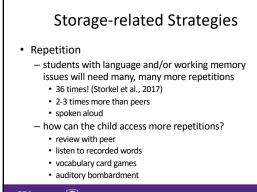- Processing-related
  - facilitating thinking routines / schema (minimizing storage load)
- General learning principles

➢ Remember: learning a strategy imposes a cognitive load!

Western   Further information & key references:
https://www.ldatschool.ca/working-memory-overload/

30

Storage-related Strategies

- Repetition
  - students with language and/or working memory issues will need many, many more repetitions
    - 36 times! (Storkel et al., 2017)
    - 2-3 times more than peers
    - spoken aloud
  - how can the child access more repetitions?
    - review with peer
    - listen to recorded words
    - vocabulary card games
    - auditory bombardment

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31

Storage-related Strategies

- Rehearsal
  - holding information in mind takes cognitive effort
  - decay or 'overwriting' can happen very quickly
    - no support from prior knowledge
    - shift attention to processing activity or distraction
  - rehearsal may need to be explicitly taught
    - restating information immediately
    - repeat rehearsal shifting gradually from spoken aloud to silent (i.e., 'in their head')
  - ask the child about their rehearsal strategies
    - how are you going to remember what I'm telling you?

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32

Storage-related Strategies

- Phonological strategies
  - activities emphasizing phonological structure of a word
    - counting syllables
    - identifying sounds
  - improve phonological representation
  - impose lower working memory demands than semantic strategies
    - semantic connections will need to be taught too, but can be layered in

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33

Storage-related Strategies

- Distributed practice / spaced learning
  - initial memories are fragile
  - spacing out learning episodes support retention
    - relieves working memory in short term
    - encourages effortful retrieval
    - facilitates long-term memory encoding
  - unique learning events re-engage the child
  - engages repeated retrieval
  - when correct responses are supported, correct pathways are reinforced
  - allows for consolidation between practice episodes
  - can promote generalization

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34

Multiple Means of Learning

- Different processes support verbal or visuospatial information retention
  - provide complementary effects rather than increasing cognitive load
- Multiple means promotes high quality representations with connections established broadly across the brain
- Provides alternate means of access and demonstrating learning
- Embodied learning
  - make connections & engage physical movement

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35

Processing-related Strategies

- Connections with long-term memory
  - activating background knowledge
  - word & world knowledge
  - increases activation associated with information & supports retention
  - facilitates chunking of information
  - self-generated connections are most effective

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36

Processing-related Strategies

- Using highly familiar or automatized information
  - allows cognitive capacity for creative thinking
    - e.g., writing a persuasive essay about a sport you know lots about
- Consistent with automatization efforts:
  - fluent word recognition
  - memorized math facts

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37

Processing-related Strategies

- External aids
  - we use these all the time!
  - help your students use them too!
  - alleviate working memory by providing a permanent record (so you don't have to hold in mind)
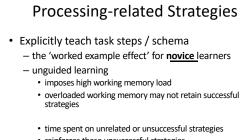   - e.g., graphic organizers; key word lists

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38

Processing-related Strategies

- Retrieval practice
  - studying & recalling information increases ease of accessibility and durability of the representation
  - self-testing: challenging yourself to generate the newly learned information on your own
  - better than recognition at supporting learning
    - e.g., students read a text, set it aside, then recall & write down what they remember
  - also increases child's awareness of what they know, which can lead to strategy development & use
  - facilitates consolidation

Western   https://www.cultofpedagogy.com/retrieval-practice/

39

Processing-related Strategies

- Explicitly teach task steps / schema
  - the 'worked example effect' for **novice** learners
  - unguided learning
    - imposes high working memory load
    - overloaded working memory may not retain successful strategies

    - time spent on unrelated or unsuccessful strategies
    - reinforces these unsuccessful strategies
    - causes frustration
  - fade out guided learning as learning increases

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40

Processing-related Strategies

- Desirable difficulty
  - prolonged use of strategies that provide too much support can deter learning
    - too much repetition
    - too much reliance on worked examples
  - prolonged struggling with a task that is too hard or overloads memory can deter learning
    - frustration
  - desirable difficulty imposes just enough challenge to engage processing fully but doesn't overload

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41

Processing-related Strategies

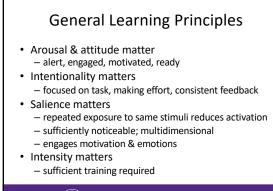- Keep focused on the task
  - interference deters learning
  - manage the amount of information
    - avoid distractions
    - unnecessary or redundant information can impede learning
    - pictures are helpful provided they are relevant, add something to the information, and are integrated into the instruction

Western   Willingham, 2017

42

General Learning Principles

- Arousal & attitude matter
  - alert, engaged, motivated, ready
- Intentionality matters
  - focused on task, making effort, consistent feedback
- Salience matters
  - repeated exposure to same stimuli reduces activation
  - sufficiently noticeable; multidimensional
  - engages motivation & emotions
- Intensity matters
  - sufficient training required

Western   Katz & Dack (2012)

43

General Learning Principles

- Cognitive distance matters
  - not all neuroplastic responses are alike (limits generalizability?)
  - sufficiently similar to real life applications
- Cognitive miserliness matters
  - tendency to avoid cognitive expenditures
  - prefer to see (reinterpret) things as familiar
  - complex thinking requires cognitive effort
  - consider cognitive fatigue
    - interleave tasks of differing cognitive demands

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44

If you are…

- Improving language knowledge
  - sufficient intensity
  - high quality representations
  - well-connected to existing knowledge
- Managing working memory load to support learning
- Teaching working memory strategies for the child to use

then you are…

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45

Addressing the working memory needs of your student

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46

Thank you!

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47

48

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49

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50