Relationships Between Executive Functions and Language Variables

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Language processing is more than a linguistic task…

- Information processing models of language impairment take into account
  - Linguistic factors
  - Perceptual factors
  - Cognitive factors (processing speed, attention, working memory, executive functions…)

(Gomes, Wolfson, & Lalperin, 2007; Leonard, et al., 2007; Montgomery, 2002; Montgomery & Windsor, 2007; Snyder, Dabasinskas & O’Conner, 2002).
Executive Dysfunction

- Executive functions, in particular, are cognitive functions thought to influence language performance.
- Executive functions (or executive skills) “allow us to organize our behavior over time and override immediate demands in favor of longer-term goals.”

(Dawson and Guare, 2004, p.1).
Executive functions include…

- Follow through, sustained attention, performance monitoring, inhibition of impulses, goal-directed behavior, and working memory.

(Dawson & Guare, 2004)
Working memory

- Phonological working memory, in particular, is hypothesized to be a significant contributor to on-line language processing, reading comprehension, and some types of language formulation.

(Archibald & Gathercole, 2006; Baddely, 1986; Baddeley, Gathercole, Alloway, Willis, & Adams, 2006; Leonard, et al., 2007; Montgomery, 2002; Westby & Watson, 2004)
Research purposes

• To examine a number of executive functions, and determine if executive functions (as measured by the BRIEF) are related to language performance (on the CELF-4) in referred children.
  – Which executive functions are most predictive of language test performance?
  – Are teacher or parent executive dysfunction ratings most predictive of language performance in children?
  – Which executive functions are most predictive of language performance?
  – Which measures of language functioning can be best predicted by executive functioning.
Subjects

- $N = 17$
- 11 male
- 6 female
- average 115.76 months (about 9 ½ years) of age
  - minimum = 91 mo
  - maximum = 162 mo.
Subjects:

• Referred for “Auditory and Language Processing” assessment.

• All experience learning difficulties such as “trouble listening in the classroom,” academic failure, reading disability, difficulty following directions, language disorder.
Methods

- Behavior Rating Inventory of Executive Functions (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000)
  - parent form
  - teacher form

- Composite scores from the Clinical Evaluation of Language Fundamentals (CELF-4; Semel, Wiig, & Secord, 2003)
  - Working Memory
  - Core Language
  - Receptive Language
  - Expressive Language
  - Language Content
Methods

• BRIEF completed by
  – parents and
  – classroom teacher of each child

• CELF-4 administered by supervised graduate student as part of interdisciplinary assessment.
Methods

• T-scores from the BRIEF:
  – Behavior Regulation Index (Composite)
    • inhibiting impulses
    • shifting attention
    • maintaining emotional control
  – Metacognitive Index (Composite)
    • initiating actions
    • working memory
    • planning/organization
    • organization of materials
    • self monitoring
  – Global Executive Composite
Methods

• CELF-4 composites:
  - Working Memory
  - Core Language
  - Receptive Language
  - Expressive Language
  - Language Content
Statistics

- SPSS for Windows 10.0
- Alpha level set at .05
- Analyses used: Stepwise Linear Regressions
Results of first analysis

• Independent (predictor) variables:
  – BRIEF composite scores from Parent and Teacher forms

• Dependent
  – CELF-4 composite scores
Results

- Teacher BRIEF Metacognitive Index scores predicted CELF-4 Working Memory ($R^2 = .340$, $R^2_{adj} = .280$, $F(1,11)=5.67$, $p=.036$), and CELF-4 Receptive Language Scores ($R^2 = .318$, $R^2_{adj} = .266$, $F(1,13)=6.07$, $p=.029$).
Results

- **Teacher BRIEF Global Executive scores** predicted **CELF-4 Core Language composite scores** ($R^2 = .356$, $R^2_{adj} = .310$, $F(1,14)=7.74$, $p=.015$)
• No BRIEF composite scores predicted Language Content or Expressive Language

- Language Content (CELF-4 composite score)
- Expressive Language (CELF-4 composite score)
• Parent BRIEF composite scores had no predictive value.
Teacher Metacognitive Index and Global Executive Functioning were predictive of language scores (elevated T-scores).
CELF-4 composite scores

- Depressed

<table>
<thead>
<tr>
<th>Component</th>
<th>Mean</th>
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<tr>
<td>CELF-IV Core Language</td>
<td>90</td>
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<td>CELF-IV Expressive L</td>
<td>92</td>
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<tr>
<td>CELF-IV Receptive La</td>
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<td>CELF-IV Language Con</td>
<td>98</td>
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<tr>
<td>CELF-IV Working Memo</td>
<td>100</td>
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Results of 2nd analysis

- Subcomponents of Metacognitive Index were used to determine if specific variables existed that had predictive values for language
  - Initiate
  - Working Memory
  - Planning/Organization
  - Organization of Materials
  - Monitor
These T-Scores show that almost all the metacognitive subscale scores were at least one standard deviation from the mean.
Results

• **BRIEF Planning/Organization predicted CELF-4 Working Memory scores** ($R^2 = .537$, $R^2_{adj} = .491$, $F(1,10) = 11.67$, $p = .007$).

• **BRIEF Working Memory predicted CELF-4 Receptive Language scores** ($R^2 = .350$, $R^2_{adj} = .300$, $F(1,13)=7.00$, $p = .020$),

• **BRIEF Initiate predicted CELF-4 Language Content** ($R^2 = .474$, $R^2_{adj} = .403$, $F(1,12) = 10.79$, $p = .007$).

• **No metacognitive predictors of Core Language or Expressive Language**
Teacher Metacognitive Index Scores

- Planning/Organization
- Working Memory
- Initiate

Working Memory CELF-4 Scores
Receptive Language CELF-4 Scores
Language Content
Core Language
Expressive Language
Summary/Conclusions

• Only teacher ratings of executive function predicted language, parent ratings did not.
• Of the teacher BRIEF ratings, Metacognitive composite scores and Global Executive Composite Scores, but not Behavior Regulation composite scores, had predictive value for language.
Summary/Conclusions

- Three Metacognitive subscale scores were strongly related to language.
- BRIEF Working Memory scores were predictive of Receptive Language, as the literature might predict, but other executive functions (Initiate, Plan/Organize) were also significant predictors of language performance.
- All CELF-4 variables studied except Expressive Language had executive function predictors – either composite scores or metacognitive subscale scores.
Summary/Conclusions

- Core Language and Expressive Language had no Metacognitive subscale predictors – perhaps because these measure largely sentence-level processing which may not tax higher level executive functions such as attention and working memory.

- Language is not uniformly related to executive functions, as some, but not all, CELF-4 composites had executive function predictors.
Summary/Conclusions

• Children with language and learning disorders must be evaluated for executive dysfunction, as it is strongly related to language and learning difficulties.
Summary/Conclusions

• Future studies should be done to determine if improving executive functioning (either through behavioral therapy or medication) also improves language performance.
  – There is some recent evidence that methylphenidate does improve language processing in children with ADHD (McInnes, et al., 2007).
  – See handout, Appendix A, for more information regarding pharmacological and behavioral intervention for executive functions (particularly working memory.)
References

References


Suggested Readings and Websites

Here’s a website that answers many questions on working memory:
- http://psychology.dur.ac.uk/research/wm/FAQWM.htm

This is an article in the British Journal of Developmental Psychology (2005) on working memory and its relation to classroom learning in preschoolers:
- http://www.york.ac.uk/res/wml/Alloway%20BJDP.pdf

The Working Memory Test Battery for Children:

Children’s Test of Nonword Repetition: A Test of Phonological Working Memory

Article includes a section on training working memory:
• The BRIEF (Behavior Rating Inventory of Executive Function) has teachers’ and parents’ rating scales of executive function (which includes working memory). It is norm-referenced, and can be found here:

• Working Memory, Language and Reading by Maxine Young
  – [http://www.brainconnection.com/topics/?main=fa/memory-language](http://www.brainconnection.com/topics/?main=fa/memory-language)

• The Neurological Scratchpad: Looking at Working Memory by Kumar Narayanan
  – [http://www.brainconnection.com/topics/?main=fa/working-memory](http://www.brainconnection.com/topics/?main=fa/working-memory)
Appendix A
Clinical Recommendations in the Literature Regarding Working Memory and Language

  
  – Westby (2004) states: “Particularly on more complex language tasks, a student’s poor performance may be primarily due to WM deficits rather than linguistic deficits.” (She recommends testing both language and working memory in assessment.)

- Ideas involve reducing the “processing load” when teaching a child new linguistic material. For example, he states: “….interventionists should analyze the demands placed on working memory by a specific task and attempt to reduce processing loads when first introducing new language forms.”

- Furthermore, he states: “…clinicians can mitigate capacity limitations in children with SLI by working to increase automaticity of newly acquired language skills. As more aspects of linguistic processing become automatic, fewer resources are used so that the net effect is increased capacity. Automaticity is accomplished through practice…..clinicians can promote automaticity by providing repeated opportunities for meaningful use of particular language forms and functions and by firmly establishing language skills before advancing to new goals.”

– In this article, Gillam and van Kleeck state that they believe that if clinicians target **phonological awareness** in therapy with young children, both early literacy development and phonological working memory may improve.

  - In terms of intervention, again he suggests the usefulness of early intervention of **phonological processing** as a “preventive intervention.” For older students other ideas include the use of **verbal rehearsal strategies**, **chunking memory strategies**, and **paraphrasing** may help to “condense a large volume of language material into smaller, well-integrated units. By having him/her restate and rephrase the material, the student’s comprehension, integration, and retention of the material should be improved by maximizing the dual operations of storage and processing” (Montgomery, 2002, p. 89).

- This article reviews the role of WM in reading, mathematics, and learning in general. In terms of remediation the author writes:
- We CAN change children’s ability to learn by “reducing working memory demands in the classroom” (p. 137). Here are some ideas the author offers in this regard. Reduce processing demand by:
  - Using common vocabulary in sentence generation tasks to reduce memory load;
  - Improve sentence processing by using simple sentences;
  - Use of external memory aids (visuals) that can help a child remember the steps in a task (but children need practice in using these external reminders);
  - Encourage kids to continue complex tasks instead of giving up;

(cont.)
• Foster “comprehension monitoring” strategies; that is, train kids to recognize when they are having trouble remembering, and to ask for help, or take other actions to complete a task;
• Provide instructions that are as brief and as simple as possible;
• Break instructions and tasks into the smallest possible steps;
• Frequent repetition of instructions;
• “For tasks that take place over an extended period of time, reminding the child of crucial information for that particular phase of the task rather than repetition of the original instruction…” (p. 138);
• Ask the child to repeat information given to them.
• There is **some evidence** that intensive training can improve working memory and change prefrontal and parietal activity in the brain. See:
  
  
  
  • These researchers used a computer-based training program, Cogmed Cognitive Medical Systems, which is now available commercially: [http://cogmed.com/cogmed/](http://cogmed.com/cogmed/)
  

  - In a recent placebo-controlled, double-blind study with children with ADHD, *methylphenidate* (Ritalin) *was found to improve higher-level language functioning* (making inferences about spoken passages), but not basic language processing (remembering facts from spoken passages and understanding isolated sentences). They also found the drug improved visual-spatial working memory, but not verbal working memory.
  - In a placebo-controlled, double-blind study, found virtually no effect of methylphenidate on executive functioning in neuropsychological testing.

- Found methylphenidate improved attention, deportment, and an academic-related measure in children with ADHD.
• Faraone, Wigal, & Hodgkins (2007). Forecasting three-month outcomes in a laboratory school comparison of mixed amphetamine salts extended release (Adderall XR) and atomoxetine (Strattera) in school-aged children with ADHD. *Journal of Attention Disorders, 11*(1), 74-82.
  
  These researchers found Adderall to be more effective than Strattera in improving attention, deportment (behavior), and academic performance in children with ADHD, and improvements maintained over time.