Training and transferability of conflict resolution skills to parsing and non-parsing domains

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Questions

• Traditional research agenda in psycholinguistics:
  – How do nonlinguistic cognitive abilities contribute to language processing?  
    (Individual differences/Correlational)

• Today:
  – Can nonlinguistic cognitive abilities be trained? If so, how do they generalize to untrained measures of language processing?  
    (Causal relationship)
Cognitive Control

• The ability to regulate mental activity in the face of conflict to adapt flexibly to new task demands
  – Override biases
  – Important for a range of tasks (memory, language)

(Jonides et al., 1998; Milham et al., 2001; Miller & Cohen, 2001; Thompson-Schill et al., 2005; inter alia)
When processing sentences…

Recovering from misinterpretation during reading

(Altmann & Kamide, 1999; Novick et al., 2005; Tanenhaus, 2007)
Temporarily Ambiguous:

While the thief hid the jewelry that was elegant *sparkled brightly.*

Readers temporarily (mis)interpret this phrase as the object of ‘hid’

Comprehension questions probe for misanalysis:

Did the thief hide himself? (yes)

Unambiguous:

The jewelry that was elegant sparkled brightly while the thief hid.

(Ferreira et al., 2001; Christianson et al., 2006)
• Children & left PFC patients: *fail to revise initial interpretations – related to poor cognitive control*  
  (Trueswell et al., 1999; Novick et al., 2009; 2010)

• Neuroimaging in healthy adults: *co-activation in left PFC ‘cognitive control network’*  
  (January et al., 2009; Ye & Zhou, 2010)

• Training in healthy adults: *improved garden-path recovery following n-back training*  
  (Hussey & Novick, 2012; Novick, Hussey et al., 2013)
Improvement on $n$-back—and no other training task—predicted:

- Increases in comprehension accuracy (Did the thief hide himself?)
- Less difficulty processing regions introducing conflict ("sparkled brightly")

Today:

- Is ‘conflict resolution’ specifically related to improvements?
- Isolate cognitive control demands during training

(Novick, Hussey et al., 2013)
The Present Study: *N*-back Training

**Pretest**
- Parsing
  - Garden-path recovery
  - Parsing relative clauses
- Non-parsing
  - Stroop

**Conflict Group**
+ Adaptive / + Lures
(N = 29)

**No-Conflict Group**
+ Adaptive / - Lures
(N = 22)

**No-Conflict 3-Back Group**
- Adaptive / - Lures
(N = 28)

**Posttest**
- 3- & 6-back-with-Lures
- Parsing
  - Garden-path recovery
  - Parsing relative clauses
- Non-parsing
  - Stroop

~5 Weeks

(Brehmer et al., 2011; Holmes, Gathercole, & Dunning, 2009; Persson et al., 2007)
Normalized N-Back Score Training Curves

[Graph showing the normalized N-back score training curves for different groups over training sessions.]

- Conflict Group
- No Conflict Group
- No Conflict 3-Back Group
Verifying Training Effects: 3-Back vs. 6-Back

3-Back

6-Back

Adaptivity ✓
Conflict ☐

(Burgess et al., 2011; Gray et al., 2003)
Verifying Training Effects: Lure Trial Accuracy

3-Back

6-Back

(Burgess et al., 2011; Gray et al., 2003)
## Untrained Pre/Post Assessment Tasks

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<thead>
<tr>
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<th>Transfer Result</th>
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<tr>
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(Christianson et al., 2006; Ferreira et al., 2001; Novick, Hussey et al., 2013)
## Untrained Pre/Post Assessment Tasks

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**Transfer Assessments:**

- **Offline:** Comprehension questions probing for misanalysis
  
  *(Did the thief hide himself?)*

- **Online:** Eye movements indexing reanalysis in the presence of conflict
  
  *(While the thief hid the jewelry...*sparkled brightly.*)

(Christianson et al., 2006; Ferreira et al., 2001; Novick, Hussey et al., 2013)
Comprehension Accuracy

Significant Main Effect of Assessment (no pretest accuracy differences across groups)
Regression-Path Time

While the thief hid the jewelry that was elegant sparkled brightly.

\[ \text{time}_6 + \ldots + \text{time}_{10} \]

(Just & Carpenter, 1980; Rayner, Kambe, & Duffy, 2000; Sturt, 2007)
Regression-Path Time

High-Conflict Ambiguous Items

Significant Training Group X Assessment interaction (no pretest regression-path differences across groups)
Regression-Path Time

High-Conflict Ambiguous Items

Low-Conflict Unambiguous Items

Significant Training Group X Assessment interaction (no pretest regression-path differences across groups)
Residual Second-Pass Time

**High-Conflict Ambiguous Items**

*Selective effect*

**Low-Conflict Unambiguous Items**

Significant Training Group X Assessment interaction (no pretest second pass differences across groups)
## Interim Summary

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Is this just about difficulty? (as opposed to process-specificity)
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<td><strong>Transfer Assessment:</strong></td>
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<td></td>
<td></td>
<td><strong>Second Pass (Re-reading) Time</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>The farmer who the expert questioned</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>the product at the fair.</em></td>
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<td><strong>Relative Clause Parsing</strong></td>
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<td><strong>Object-Extracted</strong></td>
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<td><strong>Subject-Extracted</strong></td>
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<td><em>(Low Difficulty)</em></td>
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(Caplan, Alpert, & Waters, 1998; Fedorenko, Gibson, & Rohde, 2006; *inter alia*)
Residual Second-Pass Time

High-Difficulty Object-Relative Clauses

Low-Difficulty Subject-Relative Clauses

No Training Group X Assessment interaction
Summary of Parsing Measures

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Summary & Closing Remarks

Parsing Measures

1. The Conflict group demonstrated selective cross-assessment improvement related to revision for *only* high-conflict (ambiguous) sentences.

2. Cases where conflict is minimized (unambiguous sentences) even in the face of difficulty (relative clauses) resulted in no benefits for the Conflict group.

Non-Parsing Measures
## Transfer to Non-Parsing Measures

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<th>Assessment Task</th>
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<tr>
<td>Stroop</td>
<td><strong>GREEN</strong> (High Conflict)</td>
<td>Conflict Group Only</td>
</tr>
<tr>
<td></td>
<td><strong>BLUE</strong> (Low Conflict)</td>
<td>No Groups</td>
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<th>Recognition Memory</th>
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<td><strong>JET</strong> (High Conflict)</td>
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<tr>
<td></td>
<td><strong>JET</strong> (Low Conflict)</td>
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(Milham et al., 2011; Oberauer, 2005)
Summary & Closing Remarks

Parsing Measures

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2. Cases where conflict is minimized (unambiguous sentences) even in the face of difficulty (relative clauses) resulted in no benefits for the Conflict group.

Non-Parsing Measures

3. The Conflict group—and no other group—improves on just high-conflict conditions of two untrained non-parsing measures.
## Parsing Measures

1. The Conflict group demonstrated selective cross-assessment

   - Cognitive control may be a malleable skill that people can improve
   - Benefits generalize to a range of tasks where information must be re-characterized
   - Substantiated cognitive control/ambiguity resolution link
Thank you for your time & feedback!

Support

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