

How Exercising (Your Brain) Improves Language Use



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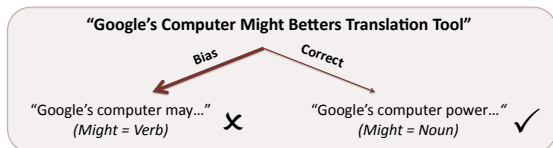
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BACKGROUND & HYPOTHESES

Language Processing is Incremental: (Altmann & Kamide, *Cognition* 1999)

- As readers/listeners encounter linguistic input, they develop interpretations on-the-fly without having to wait until an entire sentence/utterance unfolds. Sometimes later-arriving evidence suggests a new meaning that is inconsistent with one's developing expectations, causing temporary difficulty (Tanenhaus, in *Eye Movements*, 2007)
- For example, consider the temporary ambiguity in this *New York Times* headline --



Cognitive Control for Sentence Processing:

- The general ability to regulate mental activity to override biases and resolve conflict
- Necessary to revise early, incorrect meanings as new input interferes with developing analyses (Novick, et al., *CABN* 2005; Novick, et al., *Cog. Neuropsych*, 2010; January, et al., *JCN*, 2009)
- Example: Left prefrontal patients suffering broad cognitive control impairments also have difficulty revising initial meanings of a sentence (in the *Times* example, they would report the verb meaning) (Novick, et al., *CABN* 2005)

Cognitive Control Ability is Malleable:

- Can be improved through extensive practice (Jaeggi, et al., *PNAS*, 2008; Chein & Morrison, *PBR*, 2010)
- Training gains transfer across domains to new, untrained measures that rely on shared mechanisms, yet no one has tested whether language use can be improved with non-syntactic training

Can readers' ability to revise interpretations be improved with training on a task unrelated to reading?

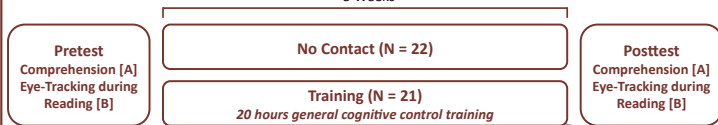
- Compared to untrained controls, trainees receiving general-purpose cognitive control training should have improved sentence reanalysis as reflected by:

- Readers' overall accuracy to comprehension questions gauging sentence meaning
- Real-time eye movement measures that index reanalysis (Frazier & Rayner, *Cog Psych*, 1982)

- Individual training gains should predict the degree of reanalysis improvement after training

METHOD

2 Groups of Healthy Adults: Trained vs. Untrained Controls
~5 Weeks



Example Sentences
(Christianson, et al., *Dis Proc.*, 2006)

Ambiguous

(Must deploy cognitive control to reanalyze meaning)
While the thief hid the jewelry sparkled brightly.

vs.

Unambiguous

(No conflict, so no need for cognitive control!)

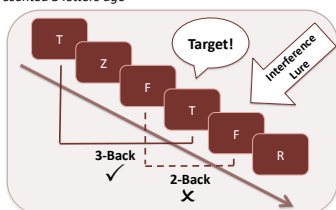
The jewelry sparkled brightly while the thief hid.

[A] Comprehension Question
Did the thief hide himself?
(Note: "No" response indexes failure to revise)

Performance-adaptive* training tasks were given.
All involved the regulation of mental activity.

For example: **N-Back Task**

- Design: letters are presented sequentially, one at a time.
- Task: respond when the current letter matches the one presented n-back
- Example: in 3-back condition, respond only if the current item matches the item presented 3 letters ago --



*Task difficulty changes to keep participants at the threshold of their best performance. As participants get better/worse at the current task, n-level and the number of lures increases/decreases.

[B] Eye-Tracking Measure: Go-Past Time (Indexes reanalysis)

Total reading time to go past a region, from the point of entering the region from the left to exiting it to the right

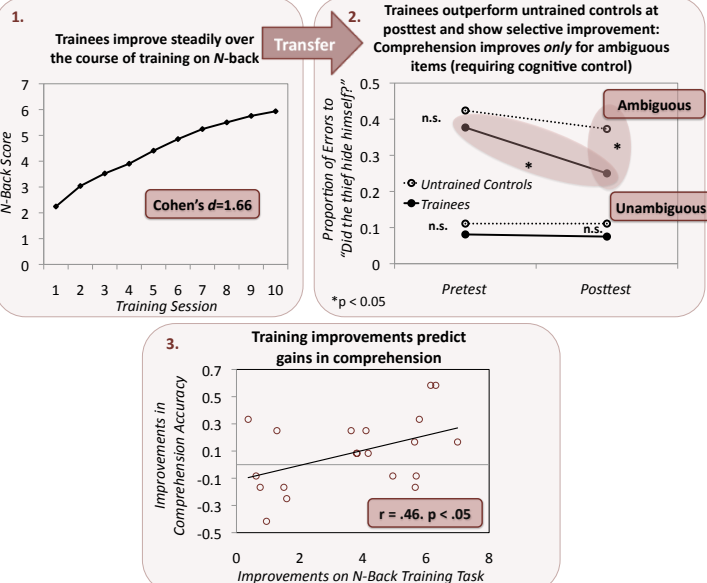
While the thief hid the jewelry sparkled brightly.

1 → 2 → 3 → 4 → 5 → 6 → 7 → 8

Go-past time for "sparkled" is the sum of reading times associated with fixations 5, 6, 7, 8

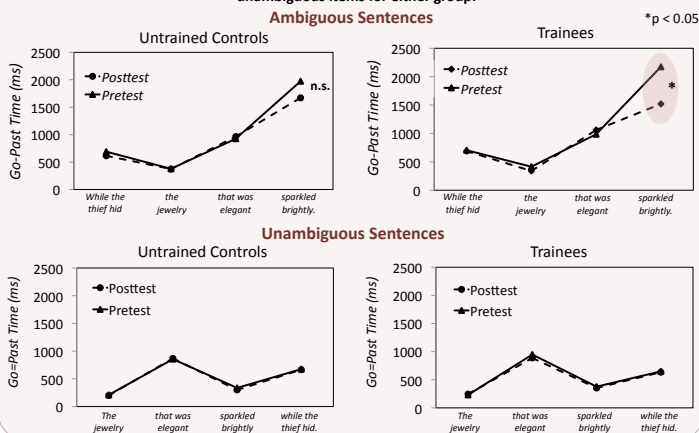
RESULTS

Training Gains and Changes in Comprehension



Changes in Real-time Processing: Eye Movements

4. Trainees spend less time at posttest rereading when conflicting evidence ("sparkled brightly") is encountered! Untrained controls do not show this pattern. No differences emerge in unambiguous items for either group.



SUMMARY & CONCLUSIONS

- Trainees' (but not untrained controls') accuracy improved selectively for comprehension questions following ambiguous sentences, those requiring reanalysis (Figure 1).
- N-back training gains predicted comprehension improvements for sentences requiring cognitive control (Figure 3).
- Eye-movements reflecting improved real-time reanalysis were shown selectively for trainees (Figure 4).
- N-back requires subjects to practice resolving interference (through overriding familiarity of lures); thus, it reliably predicts improvements in interpretation revision, a task that employs common interference resolution mechanisms.
- An exciting implication is that general-purpose cognitive control training may help in the treatment of patients with cognitive impairments that affect language skills.