Anita B. Delahay
M.Ed., Instructional Technology
M.A., Experimental Psychology
Ph.D. Student, Psychology

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Assessing Prior Knowledge (Using a Keyword Sorting Task) to Support Personalized Instruction

Carnegie Mellon University

Background & Motivation

1. The typical finding in *testing effect* studies is that retrieval practice (i.e., active practice before the final test) that is more difficult leads to better gains on a final test (Carpenter, 2011; Dunlosky et al., 2014). This can be explained by the desirable difficulties framework (Bjork & Bjork, 2011).

2. It is unknown whether retrieval practice primarily benefits factual knowledge, or also leads to gains in comprehension (Butler, 2010; Tran, Rohrer, & Pashler, 2015).

3. Kintsch (1994) identified a text-related factor (text cohesion) that interacts with a reader-related factor (prior knowledge of the text topic) on measures of text comprehension, such that highly coherent texts benefit readers with low prior knowledge, whereas less coherent texts benefit high knowledge readers. Therefore, for readers with more background knowledge, longer-term retention may occur when the reader works harder to fill in text gaps in a low-coherence text (i.e. a desirable difficulty), thereby linking the text more actively with the existing knowledge base.

The critical research question of this study was to determine which activity or combination of activities would lead to gains on text comprehension measures:

A. Retrieval practice, or
B. High-knowledge readers' engagement with a low coherence text, or
C. The two activities together.

Dependent measures for comprehension were problem-solving exercises and a key-word sorting exercise, per McNamara, Kintsch, Butler-Songer, & Kintsch, 1996.

General Procedure & Design

		Group 1	Group 2	Group 3	Group 4
Day 1	Step 1	All Ss: Pre-test of General Topic Knowledge			
	Step 2	Low Coherence Text	Low Coherence Text	High Coherence Text	High Coherence Text
	Step 3	Retrieval Practice	Reread	Retrieval Practice	Reread
Day 6	Step 4	All Ss: Final Test			

- 101 Ss were randomly assigned to Text Coherence and Retrieval Practice conditions; 96 returned for Day 6 testing.

- We used a 2 (Prior Knowledge: some/none) x 2 (Text: high coherence/ low coherence) x 2 (Retrieval Practice: yes/no) factorial design.
  - Prior Knowledge was measured by a pre-test.
  - Text coherence and Retrieval Practice were manipulated.

- The four dependent measures on the final test were: (1) Detail-old questions (had seen during retrieval practice), (2) Detail-new questions (had not seen during retrieval practice), (3) Case-based, problem-solving questions, and (4) Key-word sort.
  - (1) and (2) are textbase (factual) measures and,
  - (3) and (4) are situation model (comprehension) measures (Kintsch, 1994).

- A factorial MANOVA was used in the data analysis.
- Additionally, correlations were run between: (1) scores on the retrieval practice and the detail-old questions; and (2) scores on the pre-test and the key-word sort activity.

Discussion & Recommendations

- These results indicated that all 3 variables, retrieval practice, text cohesion, and prior knowledge, matter when measuring text comprehension.

  Considering the desirable difficulties framework (Bjork & Bjork, 2011), a certain threshold of "difficult enough" and also "active enough" practice (retrieval + low text coherence) may be needed in order for desirable difficulties to result in measurable performance improvement on comprehension in students with sufficient prior knowledge.

- A surprising result was just how much text coherence mattered for low-knowledge readers in the retrieval practice condition. With access to a high-coherence text, the low-knowledge readers' performance was brought up to the level of the high-knowledge readers on the situation model measures and surpassed their level of performance on the detail measures, whereas performance was significantly worse after reading a text with low global coherence.

  These results confer a cautionary note that retrieval practice may not benefit all readers with all materials. Materials and practice activities should ideally be matched to the existing knowledge-level of the reader.

- They keyword sort proved particularly useful in determining prior knowledge level, seen with a significant positive correlation between performance on the pre-test and on the key-word sort, $r = .20$, $p < .05$. As prior knowledge increased, scores on the key-word sort increased. This same relationship was not found for the detail measure, and, more importantly, was not found for the second situation model measure, the problem-solving questions.

  The key recommendation from this research is to match learning materials and activities to the learners' knowledge level. The keyword sort is a relatively easy measure to create and score, and could be a useful tool to quickly assess students prior knowledge of a topic, which could then be used to inform instruction.

Materials

Materials were modified from the Open Learning Initiative's (OLI; http://oli.cmu.edu) *Introduction to Psychology* course (passage topic: neuroimaging techniques). OLI materials were used under the Creative Commons Attribution: Noncommercial-Share Alike 3.0 License.

1. Pre-Test: Six questions, general topic knowledge, multiple-choice
2. Two text passages covering the same information:
   - High-coherence text: Approximately 1,050 words in length.
   - Low-coherence text: Approximately 1,000 words in length
3. Retrieval practice activity:
   - 20 questions covering details from the text; short answer responses
4. Final test:
   - For the factual knowledge measure, 17 short answer, detail questions were used, similar to what the retrieval practice condition experienced.
   - For the situation model measures, 5 case-based, multiple choice questions, and a Key-word Sort Task: 17 key-words, to be sorted into 4 categorical "buckets," one labeled for each of the major techniques discussed in the texts

Results

- A significant main effect of Retrieval Practice on Detail-old questions, $F(1, 88) = 4.17$, $p < .05$, $\eta_p^2 = .045$, such that engaging in retrieval practice led to better performance on this measure of factual knowledge after a 5-day delay. The same gain was not see on the comprehension measures.

- Kintsch's (1994) interaction of prior-knowledge and text coherence was not replicated across all conditions, but only in the Retrieval Practice condition, leading to this 3-way interaction:

- A significant three-way interactions of retrieval practice, prior knowledge, and text coherence on three of the four final measures: Detail-old, $F(1, 88) = 5.97$, $p < .05$, $\eta_p^2 = .064$; Problem-solving, $F(1, 88) = 5.51$, $p < .05$, $\eta_p^2 = .059$; and the Key-word sort, $F(1, 88) = 5.29$, $p < .05$, $\eta_p^2 = .057$

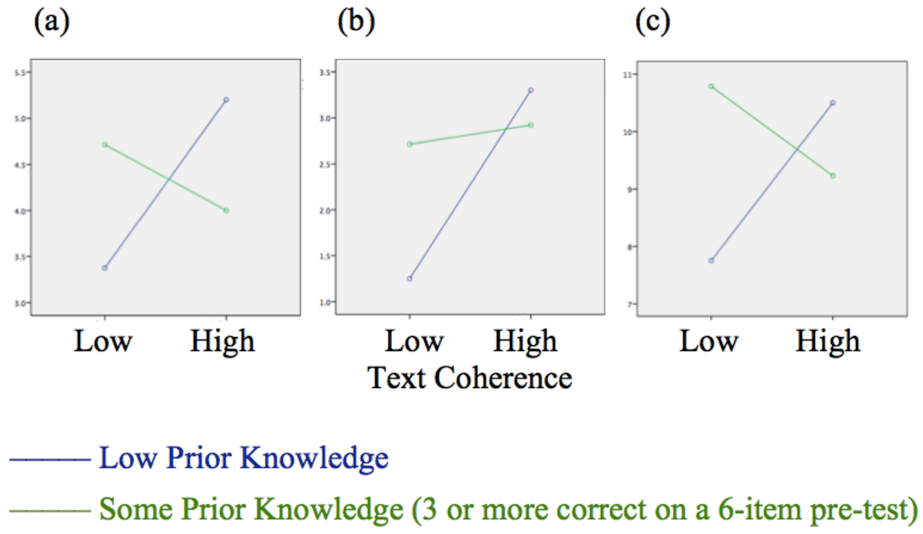
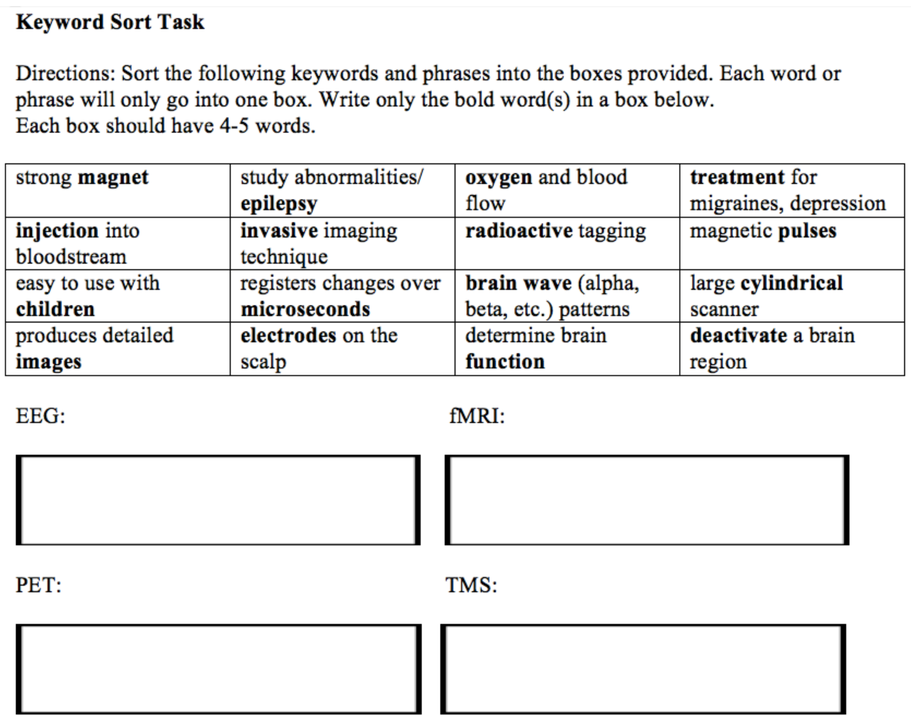


Figure 1 Retrieval Practice Condition: (a) Detail-Old Questions, (b) Problem-Solving Questions, and (c) the Key-word Sort. In each graph, the performance for low-knowledge participants was significantly worse after reading a text with low global coherence compared to reading a text with high global coherence. The performance for high-knowledge participants was the same or better after reading a text with low global coherence (graphs not shown).



Keyword Sort Task

Directions: Sort the following keywords and phrases into the boxes provided. Each word or phrase will only go into one box. Write only the bold word(s) in a box below.
Each box should have 4-5 words.

strong **magnet**	study abnormalities/ **epilepsy**	**oxygen** and blood flow	**treatment** for migraines, depression
injection into bloodstream	**invasive** imaging technique	**radioactive** tagging	magnetic **pulses**
easy to use with **children**	registers changes over **microseconds**	**brain wave** (alpha, beta, etc.) patterns	large **cylindrical** scanner
produces detailed **images**	**electrodes** on the scalp	determine brain **function**	**deactivate** a brain region

EEG: fMRI:

PET: TMS:

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