

Cognitive processing in banked gapfill items: Linking eye-tracking traces with testing theory



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Aims of the Presentation



- **Aim 1:** To provide a very brief introduction to eye-tracking in reading
- **Aim 2:** To report on the results of a study which used eye-tracking to investigate cognitive processing in banked gapfill items
- **Aim 3:** To discuss some methodological issues I encountered when using eye-tracking in reading research

Main Areas this Discussion will Cover



- **Eye-movements, a window on the brain?:** Eye-trackers and their use in first language reading research.
- **Linking data to theory:** Khalifa and Weir's (2009) model of cognitive processing in reading comprehension and L1 eye-tracking studies.
- **Eye-tracking and L2 reading:** Eye-tracking to investigate the cognitive processes underlying responses to banked gapfill items

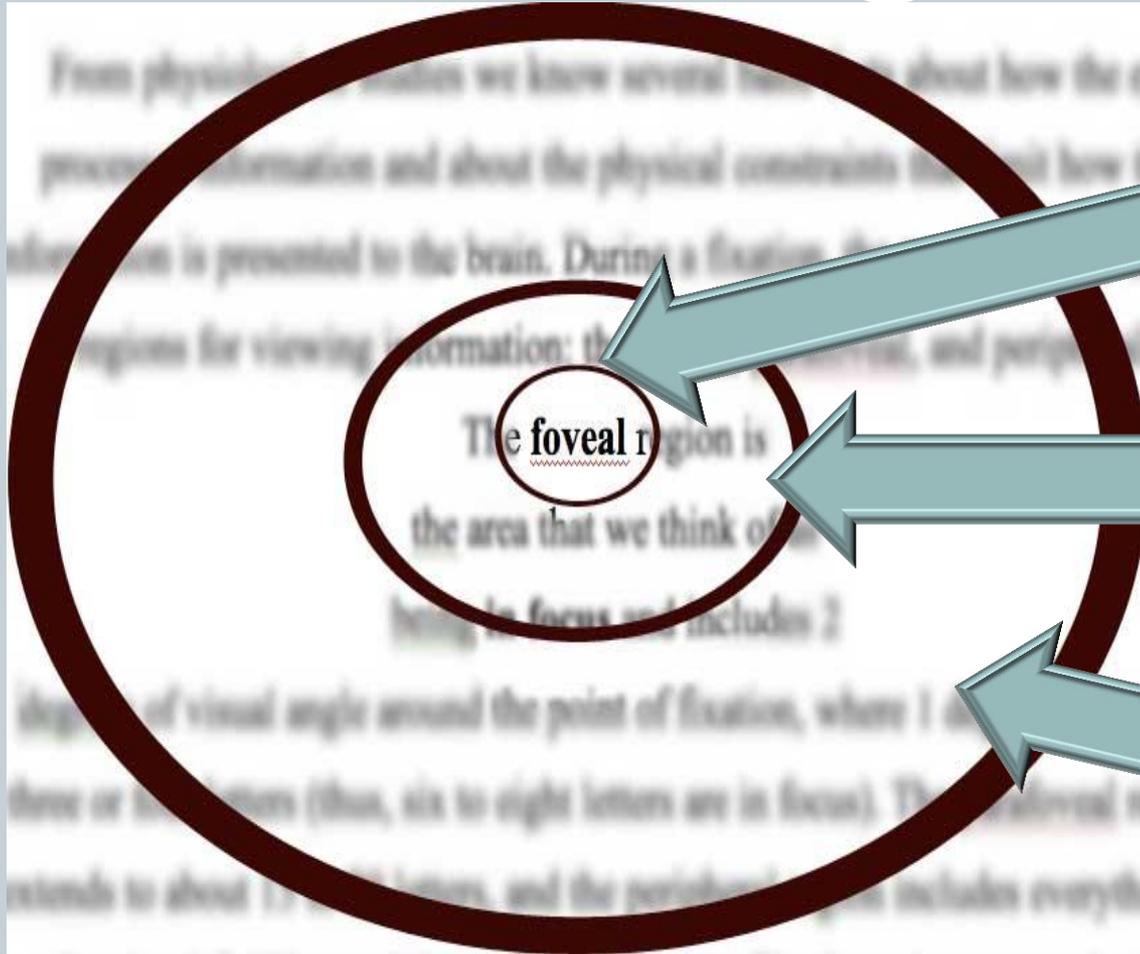
Let's look at ...



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Eye-movements, a window on the brain?

Regions of *acuity*



Foveal Region
Central 2°

Parafoveal Region
Central 2° - 5°

Peripheral Region
Outside 5°

Eye-movements, a window on the brain?

Terminology



- **Saccades** - small jumps along the line being read.
- **Fixations** - at the end of each saccade the eyes fixate on a point on the page for a short period of time.
- **Fixation time** – the time a reader spends looking at a particular area of a text.
- **Gaze duration** - is the sum of the fixation times on a particular area of the text.
- **Regression** – is a backwards movement by the eyes, relative to the direction of the text.

Eye-movements, a window on the brain?

The Tobii 300 eye-tracker



Stimulus Presentation
Area

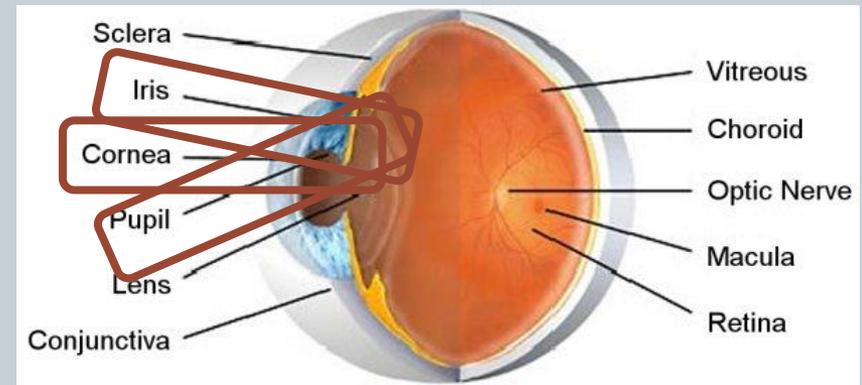
Eye-Tracker

Eye-movements, a window on the brain?

How the Tobii 300 works



- Near-infrared illuminators, invisible to the human eye, create reflection patterns on the cornea of the eyes.



- Sensors register the image of the user's eyes.
- Image processing is used to find the eyes, detect the exact position of the pupil and/or iris, and identify the correct reflections from the illuminators and their exact positions.
- A mathematical model of the eye is used to calculate the eyes' position in space and the point of gaze.

Let's look at ...

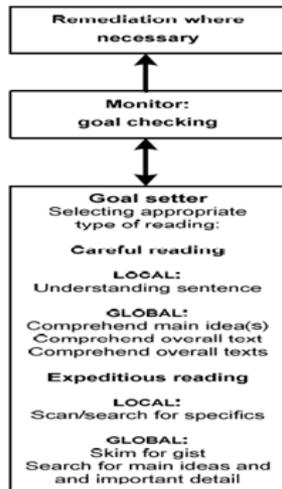


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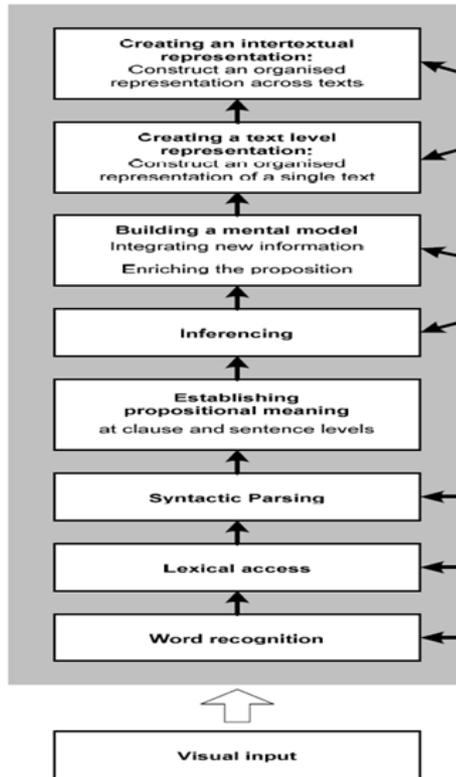
Linking data to theory

Khalifa and Weir's (2009) model of cognitive processing in reading

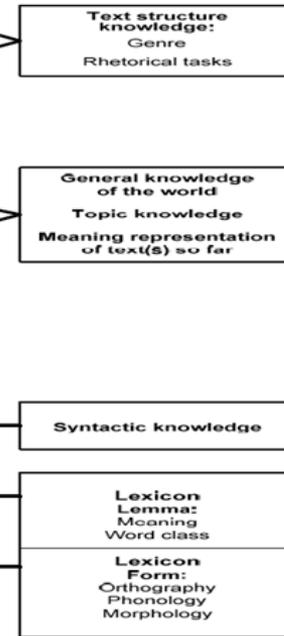
Metacognitive Activity



Central Core



Knowledge Base



Higher-Level Processes

Lower-Level Processes

Linking data to theory

Results from L1 reading studies



- As **text difficulty** increases, **fixation length** and number of **regressions** increase, while saccade length decreases (Jacobson 1979; Rayner 1989)
- The **frequency** of a word, as derived from corpus data, is an indicator of fixation length (Inhoff and Rayner 1986)
- The greater the **familiarity** of the word, as measured by asking participants to rate their acquaintance with a particular word, the lower the fixation duration (Williams 2004).
- The earlier the **age-of-acquisition** of a word the lower the fixation duration (Juhazs 2005)

Linking data to theory

Results from L1 reading studies



- Higher ***lexical ambiguity*** leads to, on average, longer fixation times (Sereno 2006)
- ***Morphological effects*** have been shown to have an influence on fixation times (Miller & Rayner 2004; Hyönä 1998; Pollatsek 2000)
- The ***contextual constraint*** of preceding words impacts on the fixation duration (Rayner 2004; Ashby 2005)
- ***Plausibility*** has been shown to affect fixation duration (Rayner 2004)

Let's look at ...

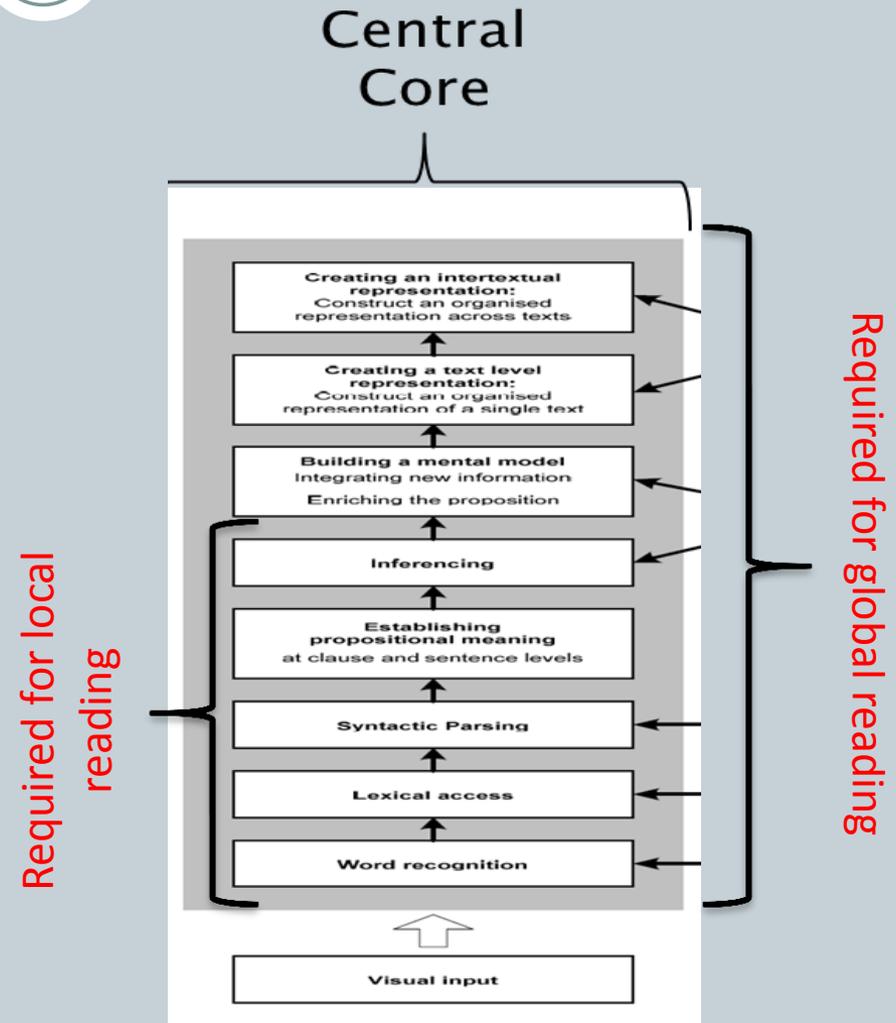


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Applying Eye-tracking

A quick detour into cloze literature

- The primary controversy surrounding cloze tests is whether they can measure more global reading or just more local reading.



Applying Eye-tracking

A quick detour into cloze literature



- Cloze tests **can** measure higher-level reading processes:

(Bachman, 1982, 1985; Brown, 1983; Chavez-Oller, Chihara, Weaver, & Oller, 1994; Chihara, Oller, Weaver, & Chavez-Oller, 1977; Cziko, 1978; Gamarra & Jonz, 1987; Jonz, 1987, 1990; McKenna & Layton, 1990; Oller, 1975; Taylor, 1957)

- Cloze tests **cannot** measure higher-level reading processes:

(Alderson, 1979, 1980; Kibby, 1980; Klien-Braley, 1983; Leys, Fielding, Herman, & Pearson, 1983; Markham, 1985; Porter, 1978, 1983; Shanahan & Kamil, 1982, 1983)

Eye-tracking and L2 reading

The central research issue



- Brown (2004) synthesis:
 - ✦ For lower proficiency test-takers, cloze tests are likely testing **more at the sentential processing level** as these test-takers cannot handle more complex textual information, whereas for higher proficiency test-takers, cloze tests likely **test sentential and inter-sentential processing** as these test-takers have the linguistic ability to make use of more global textual information.
- What about banked gapfill? Can banked gapfill measure higher-level reading processes?

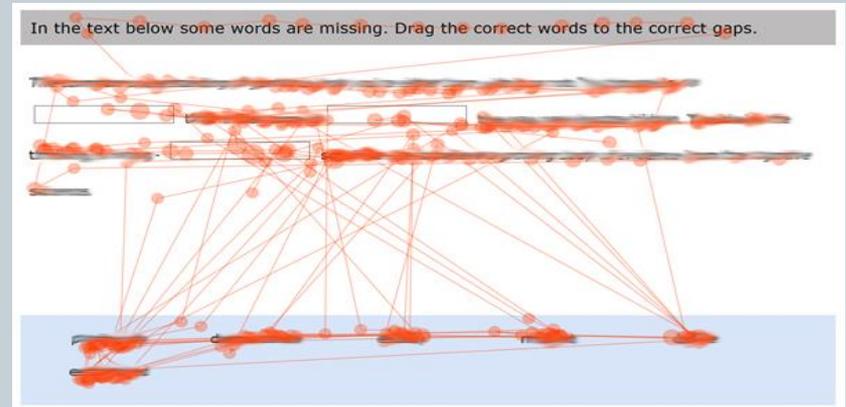
Eye-tracking and L2 reading

Participants

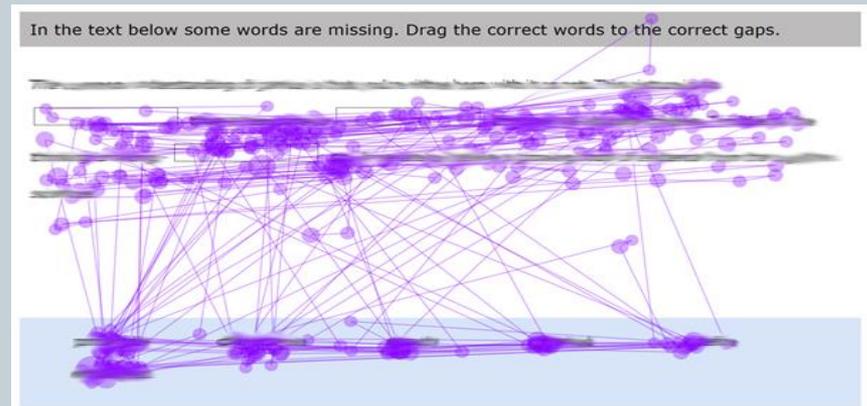


- In total **N=50** participants with a range of first languages answered **24 items** across **6 tasks**
- 22 participants were rejected as their data was unsatisfactory.
- In total the analyses were performed on **N=28** participants

Accepted



Rejected



Eye-tracking and L2 reading

What makes someone unsuitable for eye tracking?



- ✗ coloured contact lenses
 - ✗ bifocal glasses
- ✗ glasses with narrow lenses
- ✗ glasses of greatly varying strengths
 - ✗ occlusions in the eye
 - ✗ strabismus (cross-eyes)
- ✗ long eye lashes which covered the eye
 - ✗ mascara
 - ✗ “droopy” eye lids

Eye-tracking and L2 reading

Participant L1 and overall score



- The participants' L1 and the proportion of correct responses to the gapfill items are shown below.
- The English native speakers (except for one) got all the answers correct.

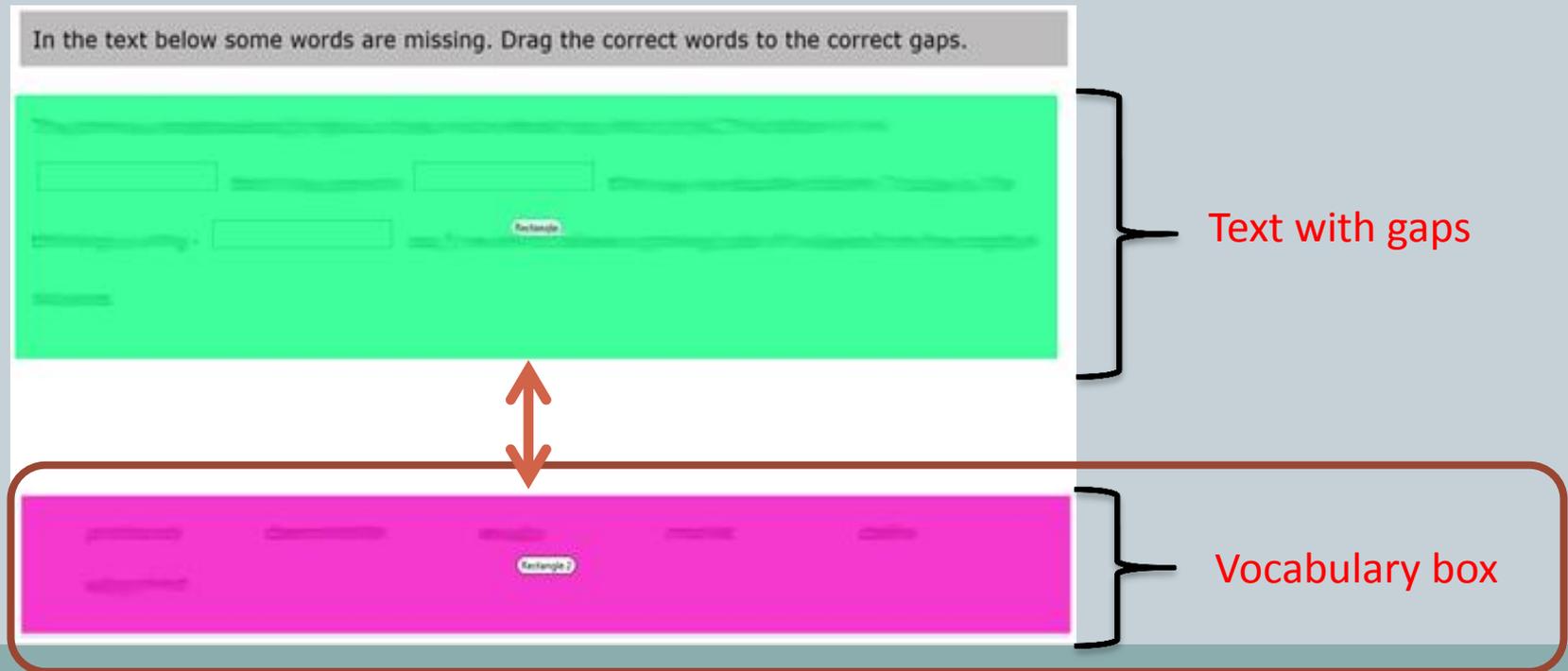
L1	Proportion correct	L1	Proportion correct	L1	Proportion correct	L1	Proportion correct
Chinese	0.375	Chinese	0.583	Chinese	0.667	Arabic	0.917
Chinese	0.417	Arabic	0.583	Chinese	0.750	Italian	0.917
Chinese	0.458	Chinese	0.583	Sinhalese	0.750	English	0.957
Chinese	0.500	Arabic	0.625	Chinese	0.750	Chinese	0.957
Thai	0.542	Spanish	0.625	Sinhalese	0.792	English	1.00
Hungarian	0.542	Italian	0.625	German	0.833	English	1.00
Chinese	0.583	Russian	0.667	Chinese	0.895	English	1.00

Eye-tracking and L2 reading

Analysis 1 - the relationship between performance and attention directed to the vocabulary box vs. text.



- **Hypothesis 1:** poorer performers will spend proportionally more time focusing on the vocabulary box and thus, on the lower-level processes.
- **Hypothesis 2:** the lower performing test-takers will make more transitions between the text and the vocabulary box exemplary of a more fragmented approach to item response.



Eye-tracking and L2 reading

Analysis 2 - The relationship between performance and attention focused closer to the gaps.



- **Hypothesis 3:** It is hypothesised that the lower-performing learners will spend proportionally more time on the three words surrounding the gaps as they are likely to rely more on the 'lower-level' syntactic information around the gap than the semantic information more distant from the gap.

In the text below some words are missing. Drag the correct words to the correct gaps.

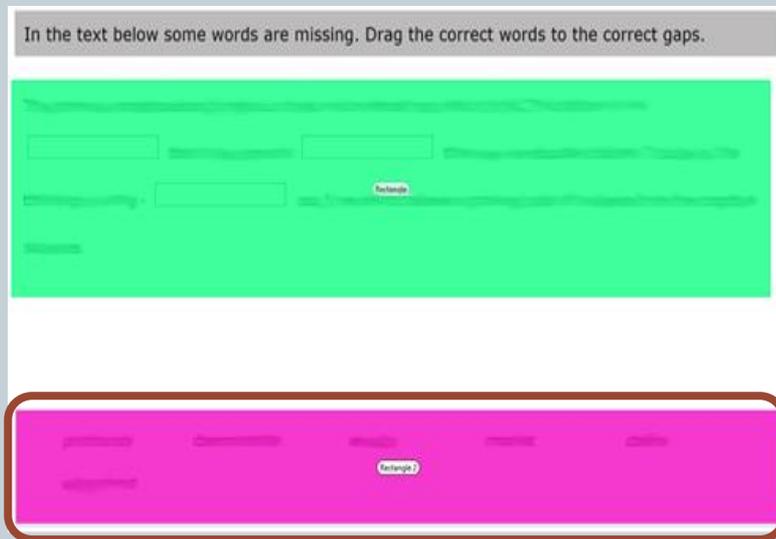
The screenshot shows a reading exercise with five gaps in a text. The gaps are labeled 'Gap 1' through 'Gap 5'. The text is partially obscured by the gaps. Below the text is a word bank with five words: 'energy', 'mind', 'time', 'space', and 'place'. The gaps are located at various positions in the text, with 'Gap 1' being the furthest from the word bank and 'Gap 5' being the closest.

Eye-tracking and L2 reading

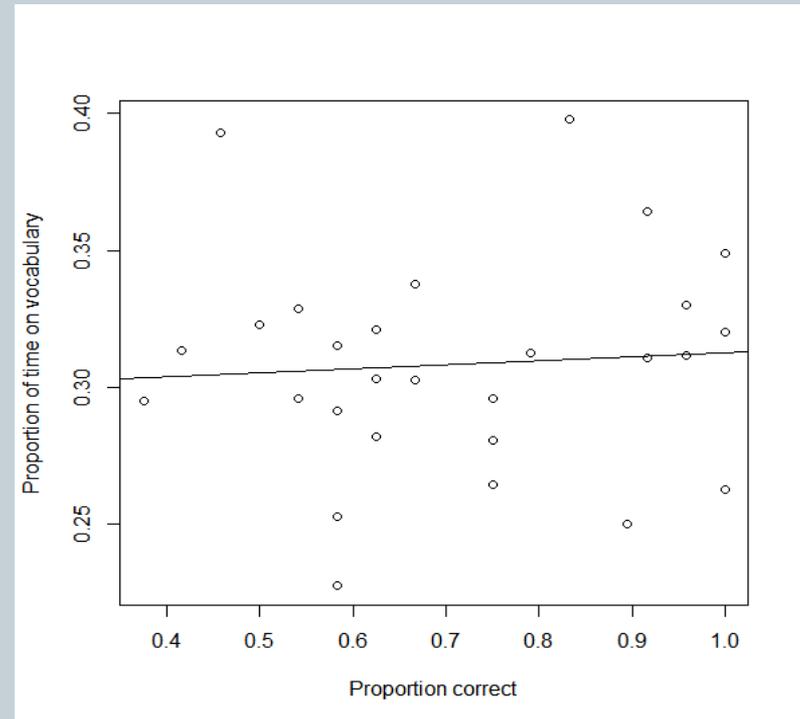
Selected results



Hypothesis 1: poorer performers will spend proportionally more time focusing on the vocabulary box and thus, on the lower-level processes.



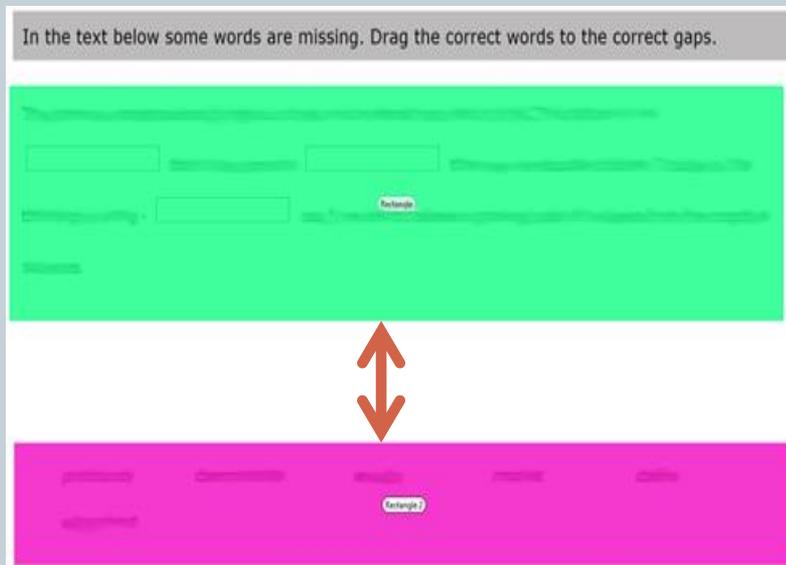
**Proportion correct vs.
proportion of time on
vocabulary**
($r = 0.070$)



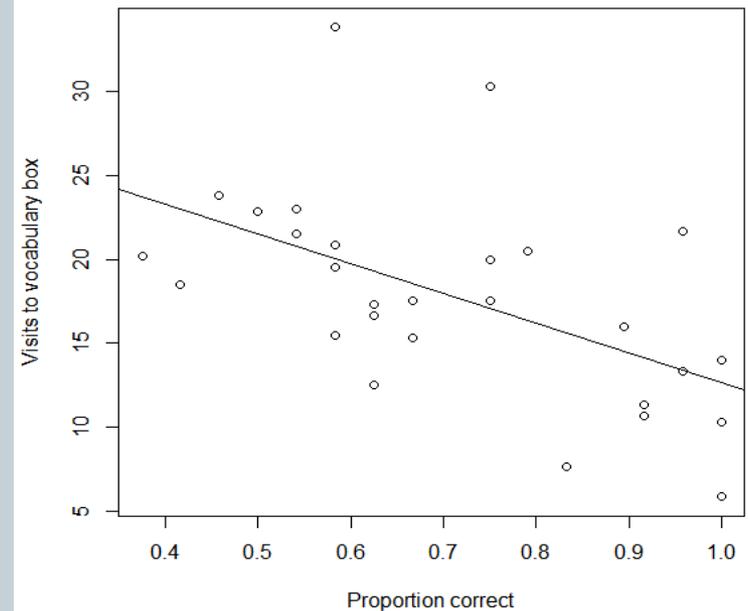
Eye-tracking and L2 reading

Selected results

Hypothesis 2: the lower performing test-takers will make more transitions between the text and the vocabulary box exemplary of a more fragmented approach to item response.



Proportion correct vs. number of visits to vocabulary box
($r = -0.541^{**}$)

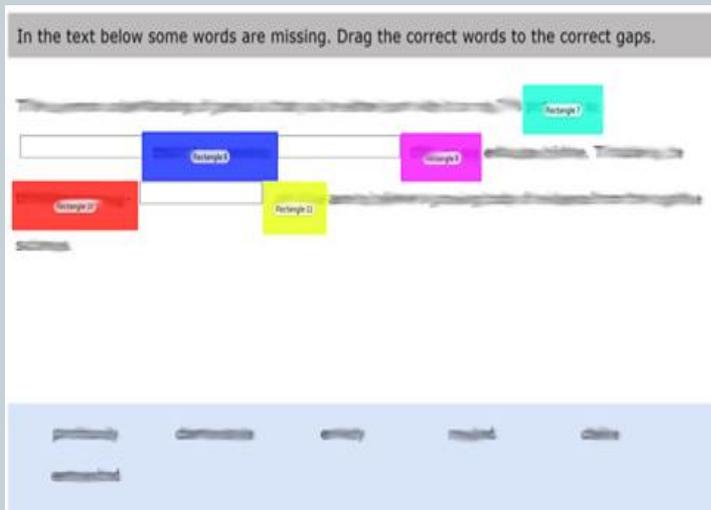


Eye-tracking and L2 reading

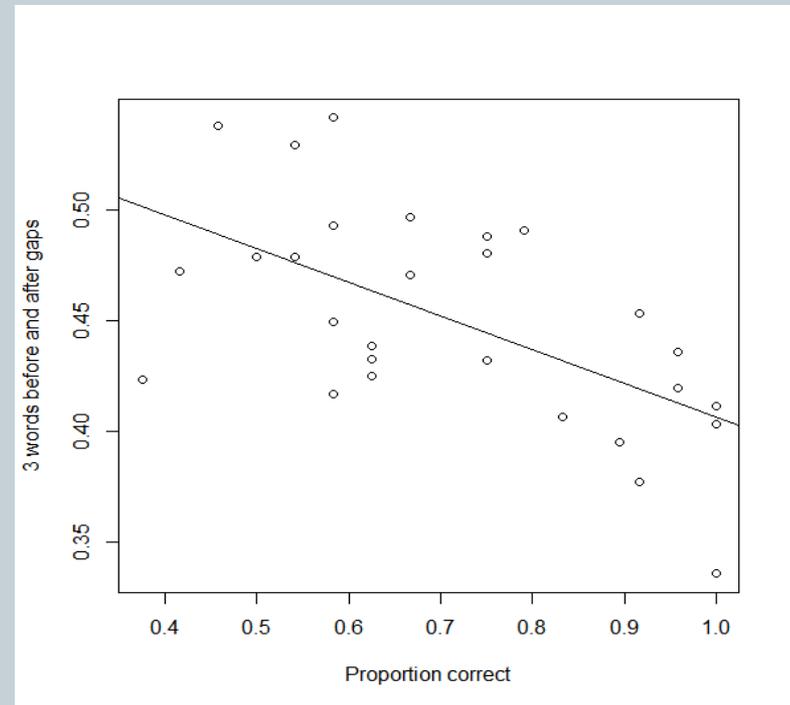
Selected results



Hypothesis 3: It is hypothesised that the lower-performing learners will spend proportionally more time on the three words surrounding the gaps as they are likely to rely more on the 'lower-level' syntactic information around the gap than the semantic information more distant from the gap.



Proportion correct vs. proportion of time on 3 words either side of a gap
($r = -0.594^{**}$)

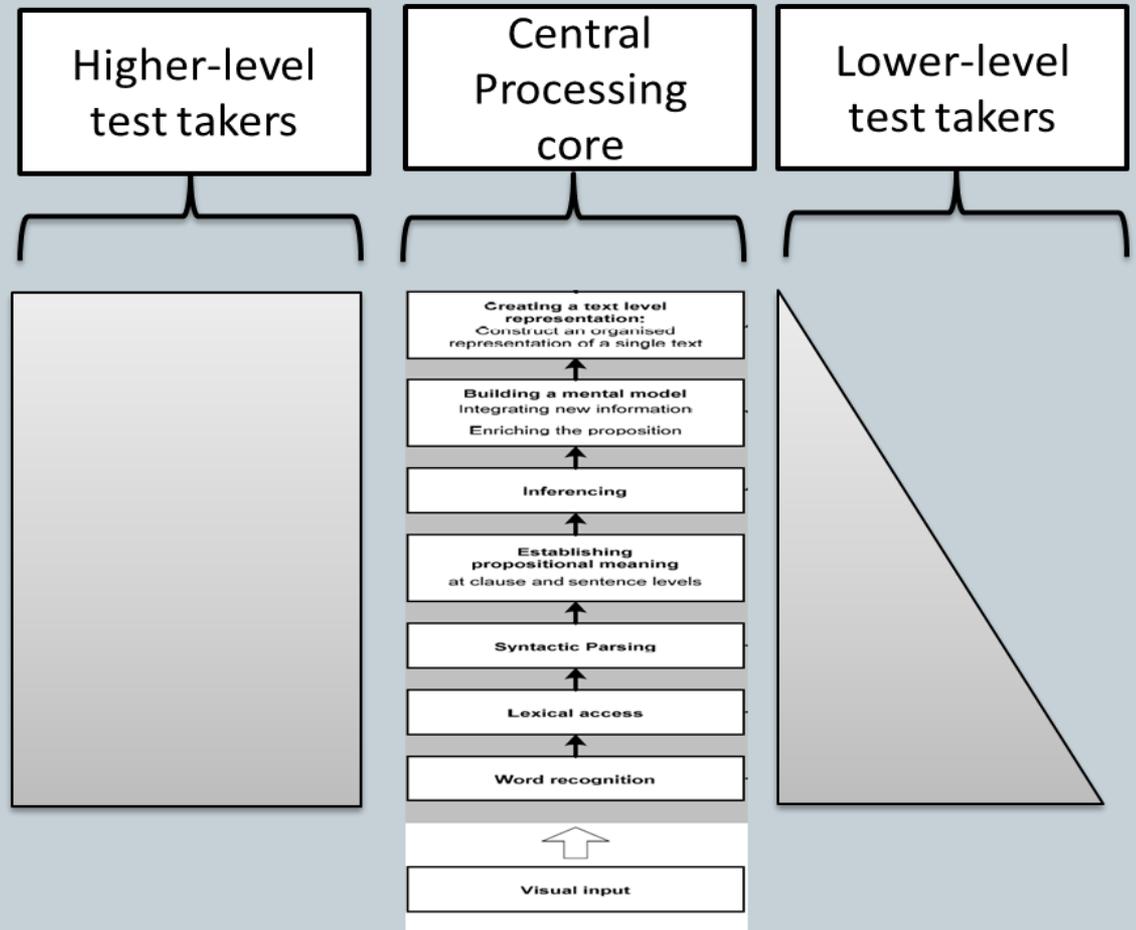


Eye-tracking and L2 reading

Conclusions of the study



- It was felt that evidence had been found that for banked gapfill items lower-level test-takers did not exhibit as much global reading as higher-level test takers.



Thank you



QUESTIONS?

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