

The usefulness and limitations of eye-tracking in the study of reading (and writing)

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Eyes are a window to the soul.

➔ The eye-mind hypothesis (Just & Carpenter, 1980)

Out of sight, out of mind.

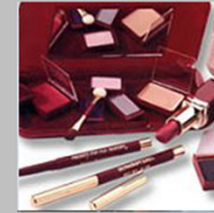
➔ "the outside world is considered as a kind of external memory store which can be accessed instantaneously by casting one's eyes to some location" (O'Regan, 1992)

Eye-mind hypothesis

= There is a close relationship between what the eyes are gazing at and the mind is engaged with.

Most likely to hold when information intake takes place in the visual modality (reading, scene perception, driving, writing, etc.).

May also hold for spoken language comprehension, when the discussed world is also visually depicted (*visual world paradigm*; Cooper, 1974; Tanenhaus et al., 1995).



'On the screen you see Ville, who comes from Tervakoski and Saara, who comes from Kauniainen. Yesterday on the phone Ville talked with Saara about a make-up artists' possibilities to create impressive theater make-ups.'

(Pyykkönen, Hyönä & Van Gompel, 2010)

➔ Automatic gender-stereotype activation

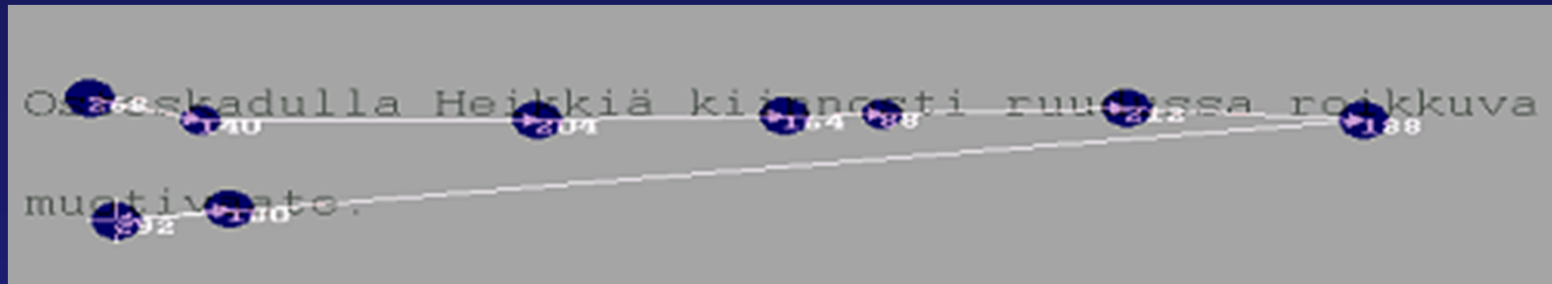
Reading

= From abstract symbols to writer's thoughts

A simple view of reading = decoding + comprehension
(Gough & Tunmer, 1986)

A. Decoding

- serial process → words are decoded one at a time; attention needs to be shifted from one word to the next
- abstract letter sequences are decoded into word meanings



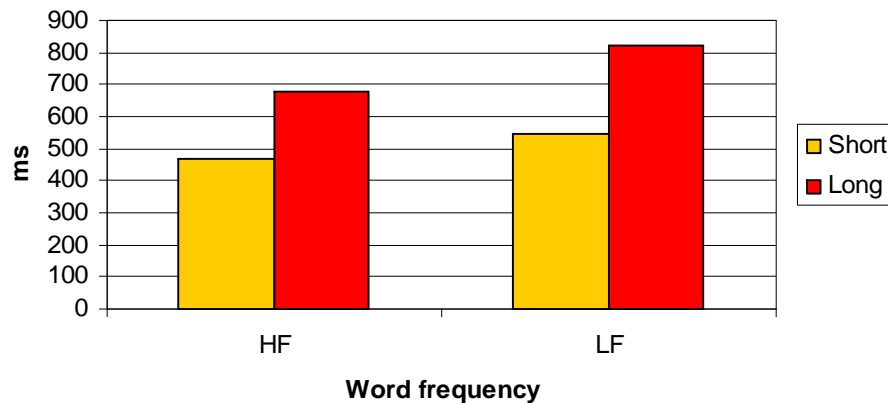
- The eye movement technique is a perfect measure of guidance of visual attention during reading.
- There is also ample evidence demonstrating that fixation times on words truthfully reflect word decoding.

Reading for meaning vs. proofreading

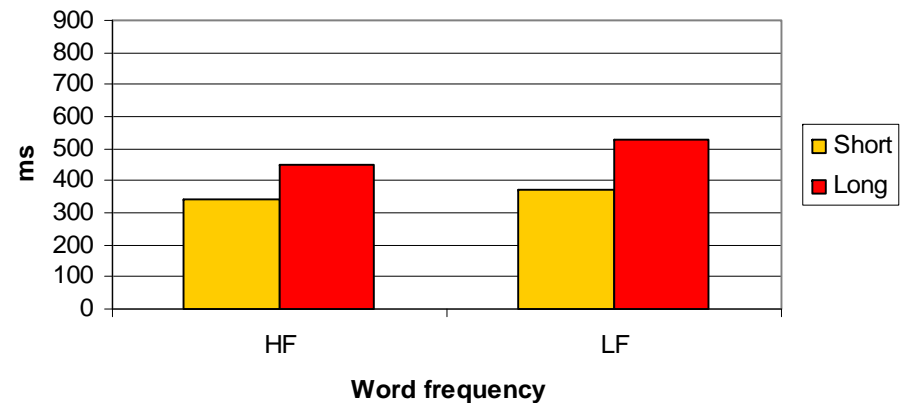
(Kaakinen & Hyönä, 2010)

Gaze duration

Proofreading (GD)



Reading for meaning (GD)



HF = high frequent

LF = low frequent

0 ms: Sam wore the horrid coat though his pretty girlfriend complained.

*

60ms: Sam wore the horrid though his pretty girlfriend complained.

*

Readers fixated for longer time the empty space when it was previously occupied by an infrequent than a frequent word (Rayner et al., 2003).

Bears some resemblance to the "**looking-at-nothing phenomenon**" (Altmann; Ferreira et al.): By activating a mental representation of an object, its previous spatial location is also activated, triggering an eye movement to that location.

A mental imagery study of Johansson et al. is an excellent demonstration of this.

B. Comprehension

I will focus on effects of reading perspective.

A specific reading goal (or perspective) makes some information in the text **relevant** and other information **irrelevant**.

In our earlier studies (e.g. Kaakinen, Hyönä, & Keenan, 2003), we have found that perspective-relevant sentences are fixated for longer time than perspective-irrelevant sentences.

In order to study how **readers' prior knowledge** affects goal-directed reading, we had participants read two long expository texts, one of **familiar contents** and another of **unfamiliar contents** (Kaakinen & Hyönä, 2007).

Here is a text about familiar diseases. Imagine that you're a school teacher and you'd have to tell the kids things about flu. Read the text in order to be able do the job.

... The best treatment to diarrhea is to drink as much liquids as possible, for example blueberry soup or fruit juices. You should switch gradually back to solid food when you start to feel better. Usually the recovery is spontaneous and the diarrhea only lasts a few days. The best treatment to flu, on the other hand, is to rest. If you have a flu, you should avoid all heavy exercise because it might cause complications. You should also drink a lot of hot liquids, for example blackcurrant juice. Breathing steam may also make you feel better.

In order to study how perspective-taking influences goal-directed reading, the Familiar Diseases and Unfamiliar Diseases texts were read

- 3 times in close succession; twice from the same perspective (and once from a new perspective).

To obtain a more detailed picture of the time course of processing, **word-level analyses** were conducted (words in the target sentences were grouped into **sentence-initial, sentence-medial, and sentence-final words**).

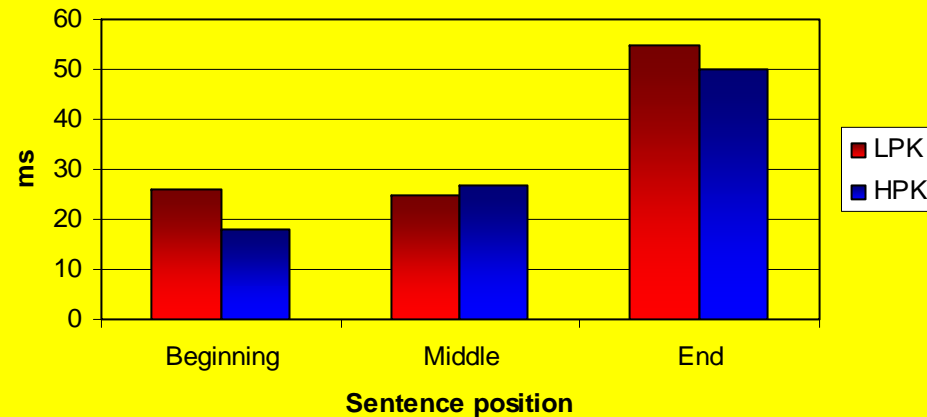
PE = relevant – irrelevant (perspective effect)

LPK = low prior knowledge

HPK = high prior knowledge

Initial encoding / First reading

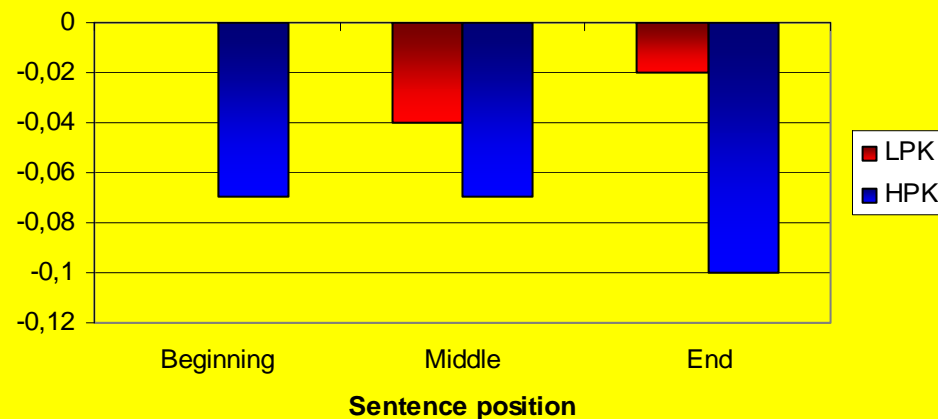
Perspective effect in gaze duration



Gaze duration

PE shows up most strongly as a sentence wrap-up effect.

Perspective effect in skipping rate

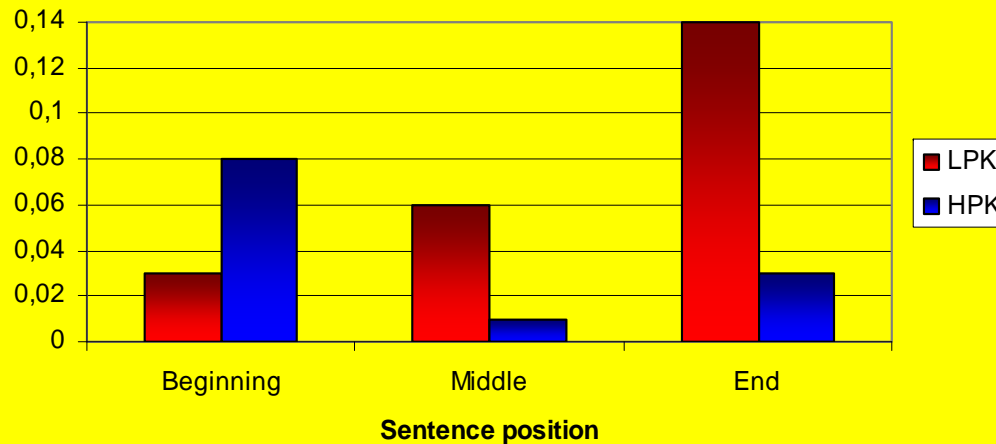


Skipping rate

PE is bigger and earlier when prior knowledge is available.

Integrative processing / First reading

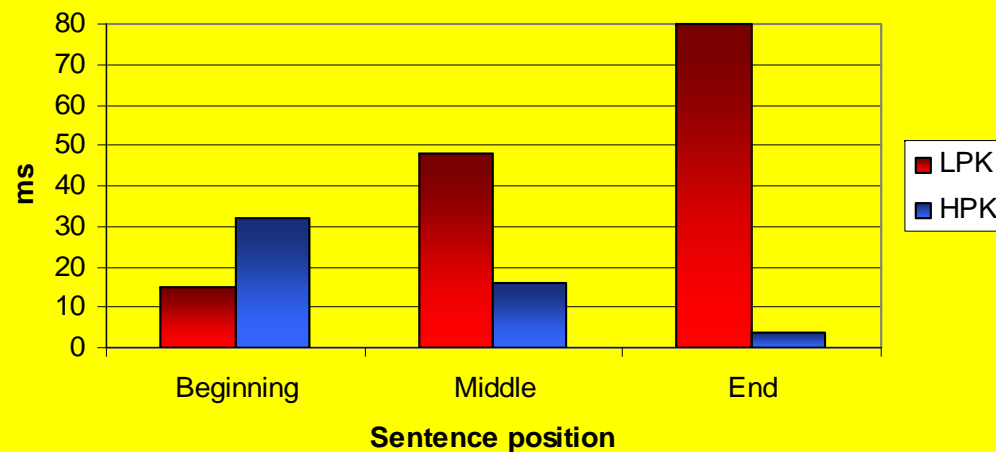
Perspective effect in probability of regression



Prob. of regression

PE is earlier and smaller when prior knowledge is available.

Perspective effect in rereading time



Rereading time

PE is earlier and smaller when prior knowledge is available.

Repeated reading

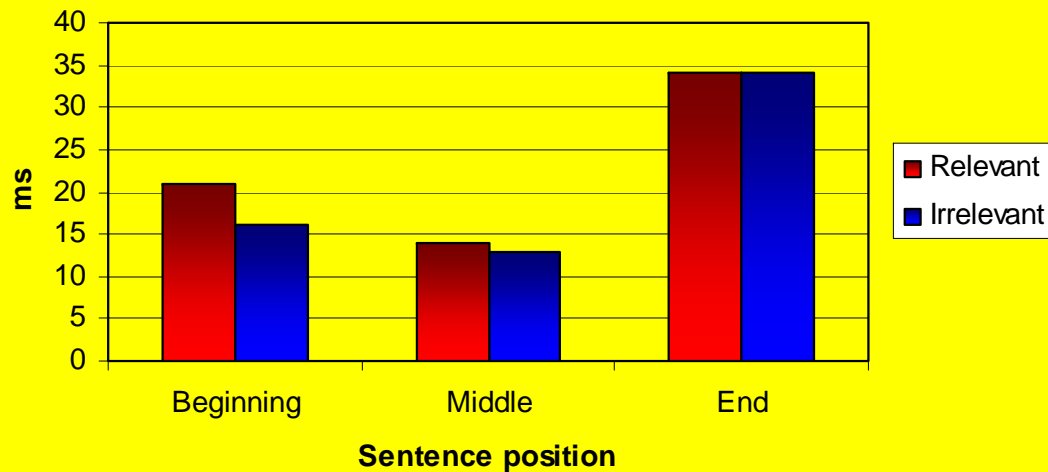
When the same text was read three times, twice in close succession, third time a week after, there is a global facilitation effect affecting all eye movement parameters (Hyönä & Niemi, 1990)

- fixations become shorter and fewer
- saccades become longer
- number of regressions decrease

Repetition effect = 1st reading – 2nd reading

Repetition effects

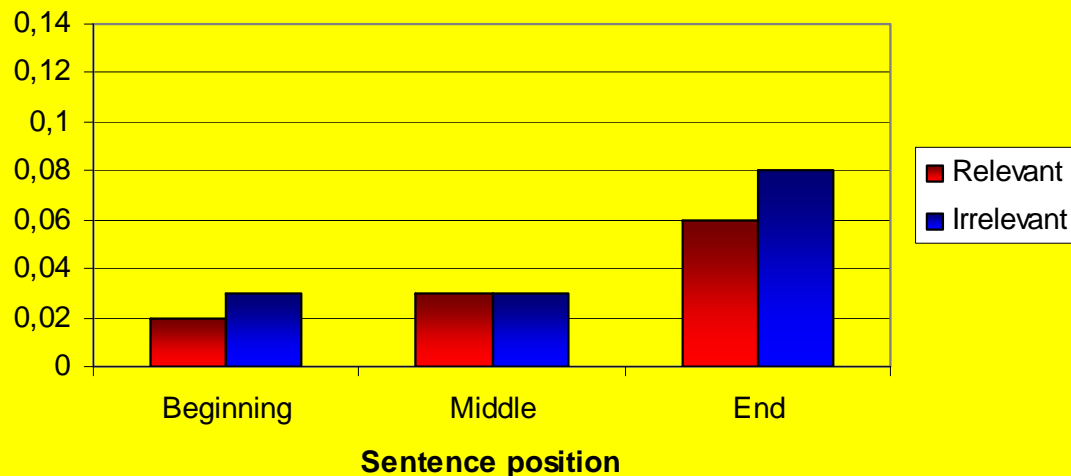
Repetition effect in gaze duration



Gaze duration

Largest repetition effects were observed in the sentence end.

Repetition effect in probability of regression



Prob. of regression

Rereading reduced the need to regress, particularly from the sentence end.

Did the perspective effect become bigger when the text is **reread** from the same perspective?

No. PE of similar size was observed during both readings.

→ This suggests that having read the text once did not lead to more strategic processing during the second reading.

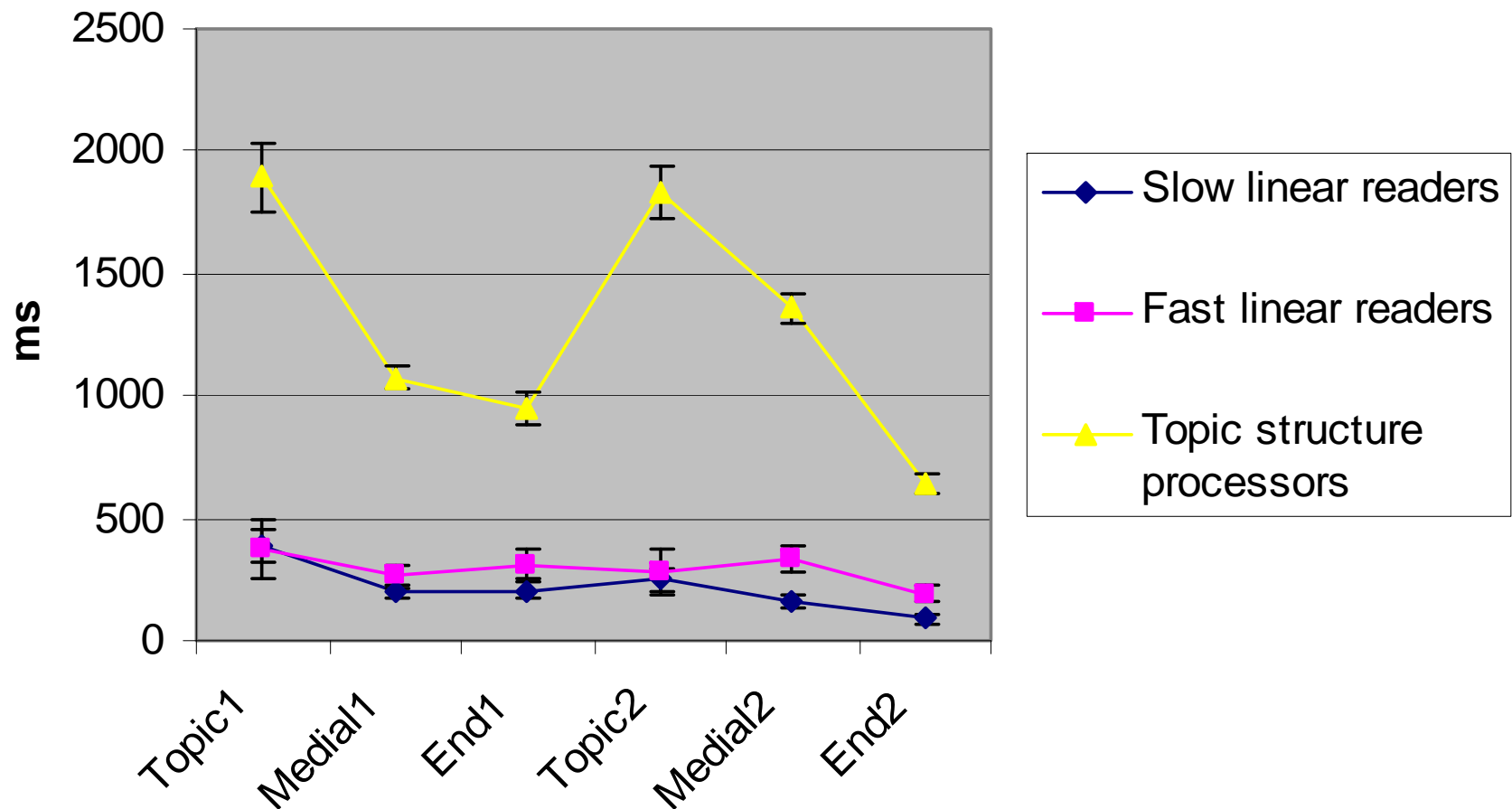
In the third reading (text was read from a different perspective),

- a repetition benefit for reading previously relevant information as irrelevant
- a repetition cost for reading previously irrelevant information as relevant

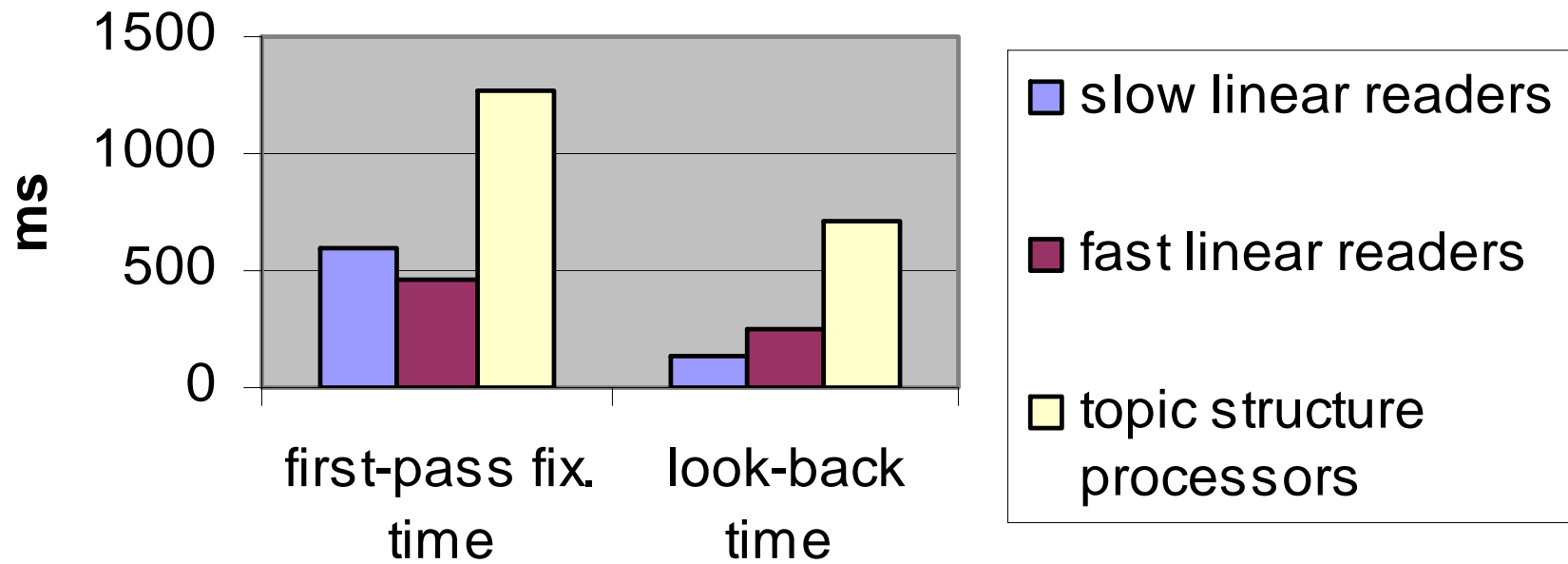
Individual differences in online text processing

Clustering adult readers into subgroups on the basis of their eye movement patterns.

Look-back fixation time (Hyönä & Nurminen, 2006)



Fixation time on topic headings



Hyönä & Nurminen, 2006

Possible limitations of the eye-tracking methodology

(1) Eye movements cannot reveal whether a comprehension difficulty, reflected in the eye movement record, leads to a comprehension failure or success.

→ Off-line comprehension measures are needed to complement on-line measures

<i>Measure</i>	<i>Target Sentence</i>			
	<i>Relevant</i>		<i>Irrelevant</i>	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
First-pass progressive fixation time ^a	34.39	1.51	32.19	1.48
First-pass rereading time ^a	24.42	2.52	17.05	1.63
Look-back time ^a	4.85	1.31	3.65	1.05
Recall (%)	45.17	3.44	24.52	3.63

(2) Eye movements cannot reveal thought contents.

→ Collection of think-alouds may remedy this.

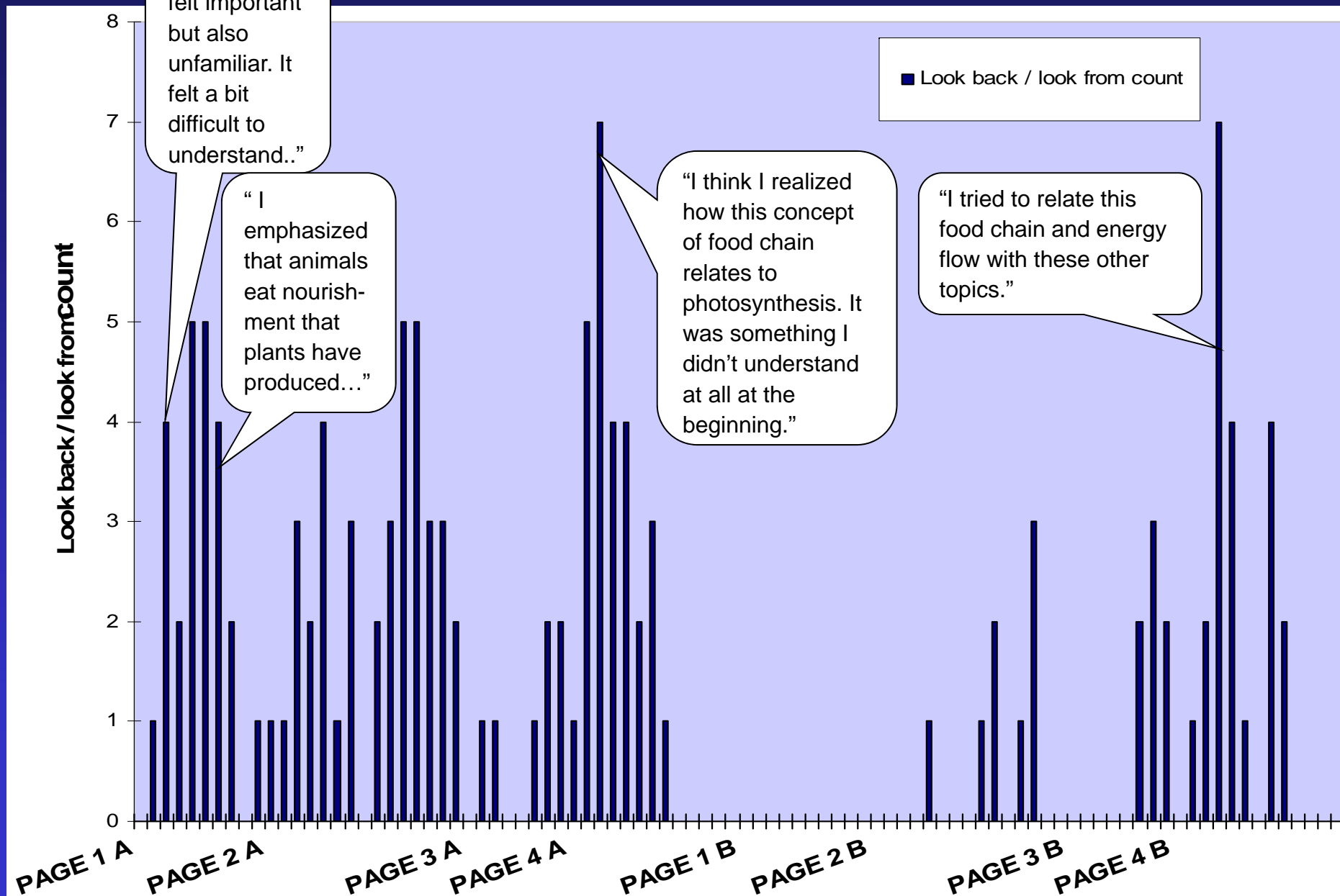
<i>Response Category</i>	<i>Target Sentence</i>							
	<i>Relevant</i>				<i>Irrelevant</i>			
	<i>f</i>	<i>n</i>	<i>P</i>	<i>SE</i>	<i>f</i>	<i>n</i>	<i>P</i>	<i>SE</i>
Association	74	27	.23	.04	80	25	.25	.05
Self-explanation	72	25	.22	.04	77	24	.24	.05
Paraphrase	125	28	.38*	.07	80	30	.24	.03
Monitoring	157	34	.49	.05	164	35	.50	.05
Question	74	26	.23	.05	62	20	.20	.05
Other	43	17	.15	.04	44	15	.14	.04

Kaakinen & Hyönä, 2005

An attractive version is one where the participant's eye movements are played to him/her, and the participant is asked to comment on them (e.g., Jarodzka et al., 2010).

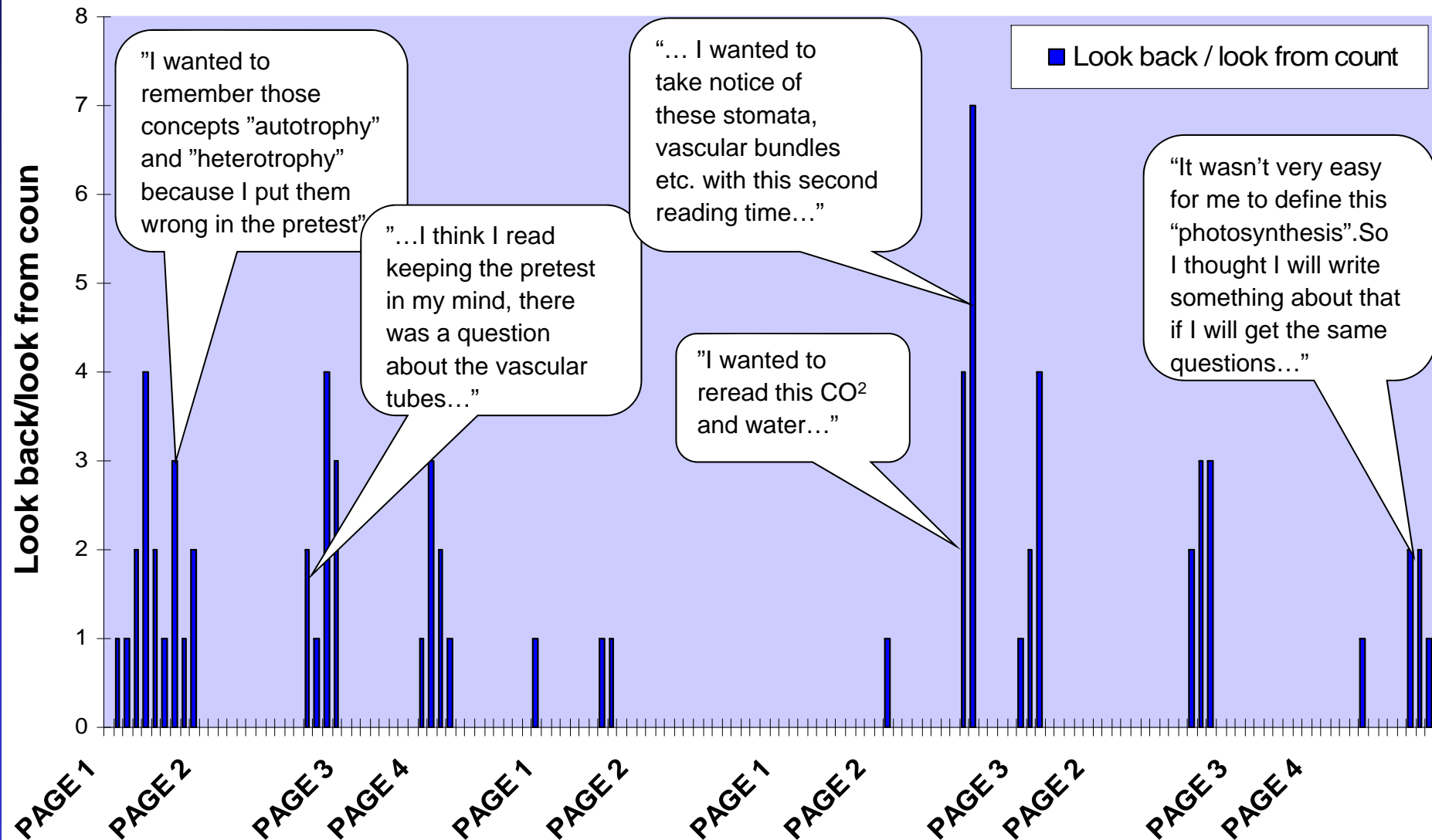
Anna's self-explanation

Mikkilä-Erdmann, Ahopelto,
Anto & Penttinen, 2009



Emma's self-explanation

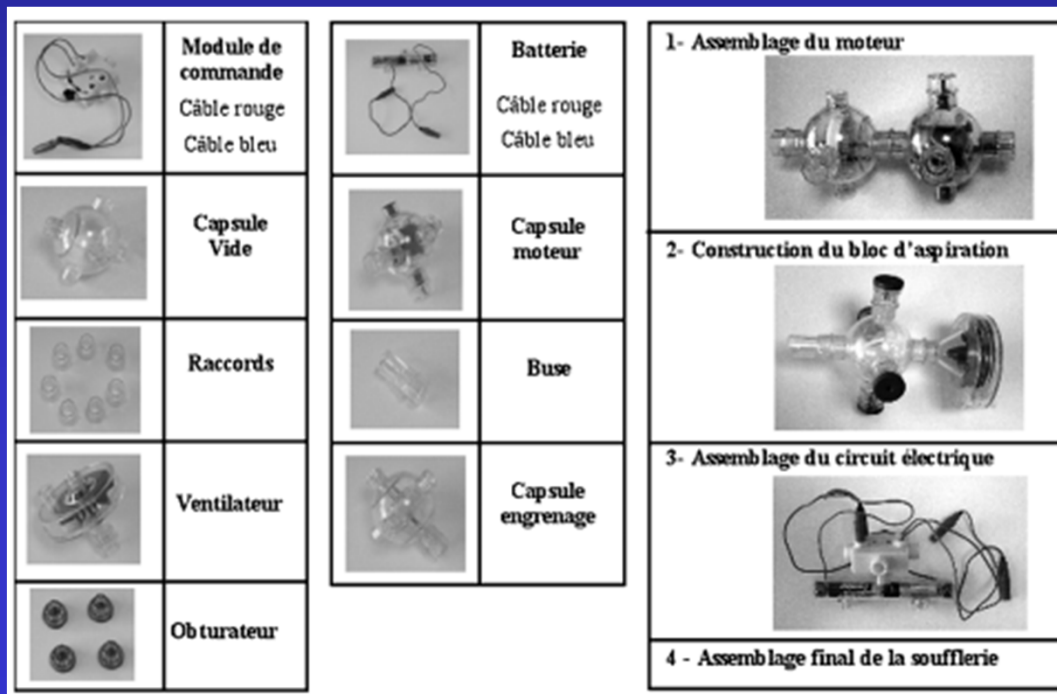
Mikkilä-Erdmann, Ahopelto, Anto & Penttinen, 2009



Eye movements during writing

Pioneering work (see also Wengelin, Torrance, Holmqvist, Simpson, Galbraith, Johansson & Johansson, 2009):

- Eye and Pen (Chesnet & Alamargot, 2006)
- ScriptLog + TimeLine (Strömqvist & Karlsson, 2002)
- EyeWrite (Simpson & Torrance, 2007)



Alamargot, Dansac,
Chesnet & Fayol, 2007

- In 90% of the time the eyes were aligned with the pen, due to the need of eye-hand coordination.
 - The non-aligned fixation time ~ 600 ms on average.
 - It correlated with lexical and graphomotor fluency.
-
- By contrast, in typing only 3.4% of character inserts were accompanied by a fixation on the word currently being typed (Wengelin et al., 2009).

Keyboard gazers vs. monitor gazers (Johansson, Wengelin, Holmqvist & Johansson, 2009)

Alamargot, Plane, Lambert & Chesnet (2010) tested 5 writers at different skill levels

- three analysis regions: incipit, text produced so far (TPSF), "blank page" (gaze aversion)
- time on TPSF and blank page decreased as a function of writing proficiency
- gaze aversion may reflect the writer's inclination to distance herself from the text when thinking hard about a possible continuation

Van Waes, Leijten & Quinlan (2010)

- error correction during writing
- eye fixations were used as indices of error detection

A methodological suggestion: Probing think-alouds retrospectively by playing back the eye and pen movements (or keystrokes).

Thanks! Kiitos!