

# Levels of Text Comprehension, Eye Movements and the Experience of Conceptual Change During Reading

*Marjaana Penttinen*

*Department of Teacher Education and Centre for Learning Research, University of Turku  
Assistentinkatu 5, 20014 University of Turku  
mapent@utu.fi*

*Erkki Anto*

*Department of Teacher Education and Centre for Learning Research, University of Turku  
Assistentinkatu 5, 20014 University of Turku  
emanto@utu.fi*

*Mirjamaija Mikkilä-Erdmann*

*Department of Teacher Education and Centre for Learning Research, University of Turku  
Assistentinkatu 5, 20014 University of Turku  
mirmik@utu.fi*

**Abstract.** The purpose of this study was to examine theory-based connections between the levels of text comprehension, eye movements and conceptual change. In Experiments 1 and 2 university students ( $N = 15$  and  $23$ ) read a text on photosynthesis, explained their reading processes retrospectively (cued with their own gaze videos), and answered written pre- and post-tests. In Experiment 1, categorizations were developed for (i) the expressions in retrospective reports referring either to situation model or textbase construction and (ii) eye movement processing. In Experiment 2, high prior knowledge lead to the greatest extent of explanations referring to situation model construction, whereas when no shift from initial conceptions to scientific-like conceptions occurred, the percentage for this category was the lowest. In the retrospective reports, look-backs to previous sentences received a relatively high portion of explanations referring to textbase construction and re-readings within a sentence explanations referring to situation model construction.

**Keywords:** Eye tracking, re-reading, situation model, text comprehension

## Introduction

A reader forms two kinds of usable mental representations during reading, the textbase and the situation model, the latter resulting from conscious inferencing (Kintsch & Rawson, 2005). The experience of conceptual change, *i.e.* the reorganizing of knowledge structures, is also considered to be an effortful and intentional process (*e.g.*, Sinatra & Mason, 2008). Conceptual change during reading can be assumed to appear as changes in situation models, where the initial conceptions of learners are gradually replaced with scientific conceptions (*e.g.*, Mason, Gava & Boldrin, 2008). In addition, readers may process complicated texts by either re-reading a difficult sentence or returning to previous sentences (*e.g.*, Hyönä, Lorch & Rinck, 2003). It could be hypothesized that all three, situation model construction, conceptual change and regressions during reading are linked, the last one being a traceable (and potentially strategic) indicator of the high-level cognitive processes. We will present two experiments, in which the reading processes of university students were examined with written pre- and post-tests, eye tracking, and participants' cued retrospective reports for their eye movement processing. We hypothesize that explanations expressing the construction of a situation model are related to the experience of conceptual change, and also examine the possible relations between text processing and the construction of situation model and textbase as well as text processing and conceptual change.

## Experiment 1

*Method.* Fifteen students from the University of Turku answered written pre- and post-test questionnaires and studied a text on photosynthesis in a laboratory setting. Eye movements during reading were recorded using a Tobii 1750 Eye Tracker. After post-test, the researcher and the participant watched a gaze video of the participant's reading process, and the interviewer asked questions on why the reader had fixated a lot on/re-read/looked back to a particular sentence or word. The interview was video recorded. The entire session lasted from one to two hours.

*Results.* Situation model construction was assumed to be expressed through thinking outside the text contents, whereas textbase construction would be tightly connected to text contents. Following ways of expressing situation model and textbase construction emerged from the participants' explanations. First, situation model construction contained the elaboration of the text contents, relating the text contents to prior knowledge, or explicitly stating the building of a coherent model on the phenomenon. Second, textbase construction consisted of expressions referring to the remembering of the text contents or the checking, combining or understanding the text itself without a reference to prior conceptions or information sources outside the text. It was noted that conceptual change was indeed manifested in the explanations referring to situation model construction, supporting the notion that these theoretical frameworks are linked. The examination of eye movements demonstrated that in addition to instant re-readings of a sentence or look-backs to previous sentences, the participants were also able to explain atypically long fixations. Based on these findings, guidelines for the categorization of the retrospective reports as well as eye movement processing were created for Experiment 2.

## Experiment 2

*Method.* The participants were twenty-three students from the University of Turku. The procedure was similar to Experiment 1 apart from the presenting of a one-page refutational passage prior to reading. This passage directly refuted three unscientific conceptions related to the nourishment supply of plants observed to appear in Experiment 1. In the data analysis, first the participants' prior knowledge and learning outcomes were analysed based on the pre- and post-test questionnaires. Second, eye movement processing was categorized as occurring within one, two or three or more sentences. The fourth category consisted of atypically long fixations. Third, post-reading explanations were categorized as representing *situation model construction*, when they demonstrated thinking outside the text contents, or *textbase construction*, when they consisted of expressions referring to the memorization of the contents or text processing without a reference to information outside it (see Experiment 1). Also a third category, *no explanation*, was added. Two judges independently marked explanations considered relevant according to the criteria described above with an interrater reliability of 73 %. Explanations marked relevant by either of the judges were included in the analysis. The judges independently categorized all relevant comments with an interrater reliability of 94 %. Differences were settled through discussion.

*Results.* The participants were classified into conceptual change (CC) group (N = 9), no-CC group (N = 5) or as experts (N = 9). First, no significant differences emerged between the three learner groups in

the relative amounts of the four eye movement processing categories. However, the three groups did differ in their relative amounts of no explanations and situation model construction<sup>1</sup> (Kruskal-Wallis analysis:  $\chi^2(2) = 6.22, p < .05$  and  $\chi^2(2) = 9.84, p < .01$ , respectively); the no-CC group demonstrated the largest percentage of no explanations and experts the largest percentage of situation model construction. In addition, the percentages of eye movement processing categories within the three explanation categories (Table 1) revealed significant differences in processing within one and within three or more sentences; the former received a relatively high portion of expressions referring to situation model construction, and the latter to textbase construction (Friedman test:  $\chi^2(2) = 6.56, p < .04$  and  $\chi^2(2) = 18.10, p < .001$ , respectively).

Table 1: The Mean Percentages (with SD's in Parenthesis) for the Four Eye Movement Processing Categories within All Three Explanation Categories. Data from 19 participants.

Explanation categories	Processing categories			
	Processing within one sentence	Processing within two sentences	Processing within three or more sentences	Atypically long fixations
No explanation	57.07 (33.62)	19.13 (28.31)	11.90 (24.30)	11.91 (24.94)
Textbase construction	63.56 (16.74)	6.09 (6.92)	20.59 (16.08)	9.76 (12.50)
Situation model construction	76.62 (29.51)	8.22 (16.44)	0.58 (2.55)	14.58 (27.33)

## Conclusion

The theoretical separation between the levels of text comprehension was visible in the ways learners explained their reading processes. Through this distinction, differences between learners with qualitatively differing learning outcomes were manifested. The findings give support to the theoretical relationship between conceptual change and situation model construction. It also appears that textbase may be constructed by looking back to previous sentences, whereas instant re-readings may be, at least to some extent, also linked with problem-solving and model building on a deeper level of comprehension.

## References

- Hyönä, J., Lorch, R.F. Jr., & Rinck, M. (2003). Eye movement measures to study global text processing. In J. Hyönä, R. Radach & H. Deubel (Eds.), *The mind's eye: Cognitive and applied aspects of eye movement research* (pp. 313-334). Amsterdam: Elsevier Science.
- Kintsch, W. & Rawson, K.A. (2005). Comprehension. In M.J. Snowling & C.J. Hulme (Eds.). *The science of reading: A handbook (Blackwell Handbooks of Developmental Psychology)*. (pp. 209-226). Wiley-Blackwell.
- Mason, L., Gava, M., & Boldrin, A. (2008). On warm conceptual change: The interplay of text, epistemological beliefs, and topic interest. *Journal of Educational Psychology*, 100 (2), 291-309.
- Sinatra, G.M., & Mason, L. (2008). Beyond knowledge: Learner characteristics influencing conceptual change. In S. Vosniadou (Ed.). *International handbook of research on conceptual change*. (pp. 560-582). Netherlands: Springer.

<sup>1</sup> Mean percentages (with SD's in parenthesis) for no explanations; CC group: 22.44 (20.50), no-CC group: 27.93 (19.06), Experts: 9.23 (8.95). Mean percentages (with SD's in parenthesis) for situation model construction; CC group: 13.25 (9.74), no-CC group: 6.35 (5.01), Experts: 36.88 (23.94).