

Conclusion

6

This thesis set out to test whether it matters if a long text is read on paper or on a screen. Chapters 3 to 5 reported a within-subjects experiment with forty-eight undergraduates and interviews with sixteen of them, combined in the convergent design described by Creswell and Plano Clark (2018). This chapter brings the two strands together and sets out what they mean for teaching and for the design of reading software.

6.1 What the study found

Table 6.1 summarises the results. On literal questions, answerable from a single sentence, the medium made no difference. On inferential questions, which required connecting ideas across paragraphs, paper readers scored higher. The difference points the same way as the meta-analyses of Delgado et al. (2018) and Clinton (2019), which found the paper advantage in expository rather than narrative texts.

Calibration showed the larger difference. Screen readers predicted higher scores than paper readers and obtained lower ones, so the gap between confidence and accuracy was nearly three times as wide. The result repeats the overconfidence that Ackerman and Goldsmith (2011) found in students who

Table 6.1. Main results by medium

Measure	Paper	Screen
Literal comprehension (of 10)	7.8	7.7
Inferential comprehension (of 10)	6.4	5.6
Predicted score (%)	75	78
Actual score (%)	71	66.5
Calibration bias (points)	+4.0	+11.5
Look-backs per text	5.8	3.1

Means for 48 participants. Bias is the predicted minus the actual score.

read on screen and set their own study time. Such readers stop once they judge a text understood, so overconfidence cuts their study short.

Paper readers also turned back almost twice as often as screen readers scrolled back, most often just before an inferential question. In the interviews, eleven of the sixteen participants remembered where on a page an idea had been (“top left, next to the diagram”), and three gave up looking for a passage on the tablet because “it could have been anywhere”. Liu (2005) described a drift towards browsing and keyword spotting on screen; these readers went through the whole text but had fewer landmarks to return to.

6.2 Implications for teaching and design

For short texts and factual questions, screens serve as well as paper. For long expository texts that students must understand rather than search, paper remains the safer choice. Where it is not available, students should test their understanding instead of trusting their sense of it: in the pilot sessions, a short self-test after reading halved the overconfidence on screen.

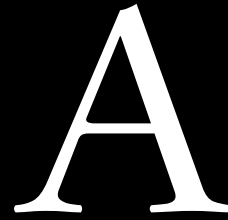
Readers also used the fixed position of text on a page as a map, one of the uses of paper that Sellen and Harper (2002) observed in offices. Reading applications that keep a stable page and show the reader’s place in the whole text may restore some of that map.

6.3 Limitations and further work

The participants were students at one university who read English fluently, and the medium matters more for some readers, texts and tasks than it does for others (Singer & Alexander, 2017). The texts were expository and about 1,800 words long, and the screen condition used a single tablet. A replication with a larger sample, several devices and the eye-movement recording reviewed by Rayner (1998) would show where on the page the two media part company.

Huey (1908) thought that a complete analysis of what we do when we read would be almost the acme of a psychologist’s achievements. The experiments reported here add a small part to that analysis; the replication proposed above could measure how far readers rely on the position of a passage on the page when they look back.

Interview guide



The interviews took place within a week of each participant’s second session. They were audio-recorded, transcribed in full and analysed thematically following Braun and Clarke (2006); Table A.1 gives their timing. The questions were asked in this order, and a prompt only when the participant had not already covered its point.

1. Tell me about the last long text you read for a course.
 - Where did you read it, and on paper or on a screen?
2. Which of the texts in this study do you remember best, and why?
3. When you wanted to check an earlier passage, what did you do?
 - How did you know where to look?
4. How sure were you of your answers? What made you more or less sure?
5. Did reading on the tablet feel different from reading on paper?
6. Some students say they read more carefully on paper. Do you?
7. What would the ideal way to read a long text for study be like?

Table A.1. Timing of an interview session

Part	Content	Minutes
1	Welcome, consent and a check of the recorder	3
2	Free recall of the two study texts	5
3	Questions 1–4: reading habits, look-backs and confidence	12
4	Questions 5–7: the two media and an ideal design	12
5	Debrief	3

Glossary

Words in italics are defined under entries of their own.

calibration The agreement between a reader's confidence in having understood a text and the accuracy of that understanding, measured here as the difference between predicted and actual scores.

comprehension, inferential

Understanding that requires the reader to connect information from different parts of a text or to add knowledge the text does not state.

comprehension, literal Understanding of what a single sentence or passage states directly.

confidence judgement A reader's estimate, made after reading and before seeing the questions, of how many answers will be correct.

convergent design A mixed-methods design in which quantitative and qualitative data are collected in the same period, analysed separately and then compared.

expository text A text written to explain or inform, such as a textbook chapter or a report, as opposed to a narrative text.

fixation A pause of the eyes, typically about a quarter of a second, during which the reader takes in text; fixations alternate with *saccades*.

look-back Any return to an earlier part of a text during reading: turning back a page, scrolling up or following a link to a previous section.

metacomprehension A reader's knowledge and monitoring of their own understanding of a text; *calibration* is one of its measures.

navigation The movements a reader makes through a text as a whole, as distinct from the movements of the eyes along a line.

overconfidence Positive *calibration* bias: predicting a higher score than the one actually obtained.

saccade A rapid movement of the eyes from one *fixation* to the next, during which little or no text is taken in.

screen inferiority effect The finding that comprehension of the same text is lower on screen than on paper, most consistently for *expository texts* read under time pressure.

self-regulated study Reading in which the reader, not the experimenter, decides how long to spend on a text.

spatial memory for text Memory of where on a page or in a document a piece of information appeared, used as a cue for *look-backs*.

thematic analysis A method for identifying, analysing and reporting patterns of meaning across qualitative data such as interview transcripts.

within-subjects design An experimental design in which every participant takes part in every condition, here reading on both paper and screen.

References

*Every work cited in the thesis, set in
APA style (7th edition).*

- Ackerman, R., & Goldsmith, M. (2011). Metacognitive regulation of text learning: On screen versus on paper. *Journal of Experimental Psychology: Applied*, 17(1), 18–32.
- Baron, N. S. (2015). *Words onscreen: The fate of reading in a digital world*. Oxford University Press.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
- Clinton, V. (2019). Reading from paper compared to screens: A systematic review and meta-analysis. *Journal of Research in Reading*, 42(2), 288–325.
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.
- Delgado, P., Vargas, C., Ackerman, R., & Salmerón, L. (2018). Don't throw away your printed books: A meta-analysis on the effects of reading media on reading comprehension. *Educational Research Review*, 25, 23–38.
- Dillon, A. (1992). Reading from paper versus screens: A critical review of the empirical literature. *Ergonomics*, 35(10), 1297–1326.
- Huey, E. B. (1908). *The psychology and pedagogy of reading*. Macmillan.
- Liu, Z. (2005). Reading behavior in the digital environment: Changes in reading behavior over the past ten years. *Journal of Documentation*, 61(6), 700–712.
- Mangen, A., Walgermo, B. R., & Brønnick, K. (2013). Reading linear texts on paper versus computer screen: Effects on reading comprehension. *International Journal of Educational Research*, 58, 61–68.
- Noyes, J. M., & Garland, K. J. (2008). Computer- vs. paper-based tasks: Are they equivalent? *Ergonomics*, 51(9), 1352–1375.
- Paterson, D. G., & Tinker, M. A. (1940). *How to make type readable*. Harper & Brothers.
- Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124(3), 372–422.
- Sellen, A. J., & Harper, R. H. R. (2002). *The myth of the paperless office*. MIT Press.
- Singer, L. M., & Alexander, P. A. (2017). Reading on paper and digitally: What the past decades of empirical research reveal. *Review of Educational Research*, 87(6), 1007–1041.
- Tinker, M. A. (1963). *Legibility of print*. Iowa State University Press.
- Wolf, M. (2018). *Reader, come home: The reading brain in a digital world*. Harper.

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