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Profiling reading in print and digital mediums

Lauren M. Singer Trakhman*, Patricia A. Alexander, Alexis B. Silverman

University of Maryland, United States

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ABSTRACT

Real-time processing behaviors and processing time for 57 undergraduates reading information texts in print and digitally were used to identify distinct performance profiles. Students underlined the printed text as they read and followed along with their cursor when reading digitally. Immediately after reading, students answered three comprehension questions for each text about the main idea, key points, and other information and judged their performance on the comprehension test. Four profiles were identified using deeper and more surface-level processing behaviors and reading time for both mediums (i.e. Regulators, Plodders, Gliders, and Samplers) and comprehension and calibration (i.e., self-assessment accuracy) data were analyzed by medium and profile. An overall medium effect for comprehension, along with various profile differences were identified. No overall calibration difference by medium was found, although various effects by profile were identified. Implications of outcomes for future research on reading in print and digitally are forwarded.

1. Introduction

Given the pervasiveness of the Internet in the lives of the citizenry of postindustrial societies, there is every likelihood that you, as a member of such a society, are reading this article digitally. The pervasiveness of smart technologies extends into contemporary educational settings as well and to the processing of texts central to academic experiences (Timms, 2016). In fact, there is no longer any question of *if* today's students will engage in digital reading, but rather *when*, *how*, and *how well*. For over a generation, the research surrounding digital reading has focused on the manner in which students navigate the ever-expanding and ever-shifting landscape of the Web (Lankshear & Knobel, 2007). There have also been innumerable studies investigating the effects of various technological affordances on reading and learning from text, including search capabilities, text-to-speech features, and in-text definitions (Falloon, 2013).

As witnessed by this special issue, there is also growing interest in the way media (e.g., graphics or diagrams) embedded within sources interact with text to influence text processing (Cromley & Wills, 2016; Van Meter, Yokoi, & Pressley, 1994), especially digitally-conveyed texts (Azevedo, Cromley, & Seibert, 2004). Richard Mayer (2002), for instance, has forwarded multimedia principles derived from decades of empirical research that seek to explain the interplay of graphic and textual content. Similarly, there is increased awareness that 21st century reading often involves multiple texts selected from the seemingly unlimited digital sources on any topic or issue (List, Alexander, & Stephens, 2017). Thus, understanding how sources are culled from the universe of Websites, or how the credibility of sources and the veracity of their content are judged has become the subject of extensive investigation (Barzilai & Eshet-Alkalai, 2015; List & Alexander, 2017).

For some within the research community, there is now sufficient evidence to argue for a model of digital literacy that distinguishes this form of processing from what has been articulated for print (Lankshear & Knobel, 2007). Those holding to this position contend that the unique features populating online sites alter the very act of reading (Coiro, Knobel, Lankshear, & Leu, 2014). Whether this argument for a new digital literacy is warranted or not, it appears to be predicated largely on the extra-textual elements conveyed by the medium and does not address the medium per se as an influential force. In effect, there is the apparent expectation that simply moving text from *on the page* to *on the screen* in an unadulterated fashion should have little if any bearing on the process of reading (Mangen, Walgermo, & Brønnick, 2013). There is also the assumption that what would be understood from the same text similarly displayed on paper or on computer would be comparable (Singer & Alexander, 2017b).

The aforementioned expectations and assumptions seem quite reasonable when no additional text features or affordances are introduced via technology (Mangen, Walgermo, & Bronnick, 2013). Further, questioning the possible effects of medium alone may seem fruitless when one considers the amount of time this generation spends with one form of smart technologies or another (National Center for Education Statistics, 2013). There is good reason why the label “digital native” has been bestowed upon those born in the 21st century (Prensky, 2001). These individuals have never known a world or a classroom without

* Corresponding author. Department of Human Development and Quantitative Methodology, University of Maryland, College Park, MD 20906, United States.
E-mail address: trakhman@umd.edu (L.M. Singer Trakhman).

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smart technologies. So, why would encountering text on a screen instead of on paper matter to how these individuals read or what they ultimately comprehend? Surprisingly, the fact is that medium does matter.

1.1. Prior studies

In light of the networked and technologically-advanced world in which today's students live and learn, it should come as no surprise that when we recently asked undergraduates whether they preferred to read an informational text on paper or on computer, they overwhelmingly voiced a preference for digital reading (Singer & Alexander, 2017a). Concomitantly, those undergraduates were far more likely to judge their performance on the comprehension test they were administered as better when they read online than in print. However, paradoxically, those students' actual comprehension performance was significantly better on paper than on screen when they answered questions that required more than a gist or general understanding of the readings.

This unexpected outcome showing a comprehension advantage for print over digital reading led us to undertake a second investigation of medium effects. In that follow-up study (Singer Trakhman, Alexander, & Berkowitz, 2017) we included longer informational texts and tracked reading times. These modifications were included on the basis of a systematic literature review (Singer & Alexander, 2017b) that suggested that text length and processing time were influential factors in reported comprehension differences by medium (Lenhard, Schroeders, & Lenhard, 2017). Specifically, the longer the text and the more scrolling involved, the greater the likelihood that reading on the page was found to be more advantageous to comprehension than reading on the screen (Dundar & Akcayir, 2012). In addition, there were researchers who documented faster times for digital reading than for print and who hypothesized that this rapid processing negatively affected comprehension performance (Dyson & Haselgrove, 2000).

In that follow-up investigation (Singer Trakhman et al., 2017), the same paradoxical pattern re-emerged. Again, the clear preferences students displayed for digital reading and their confident performance judgments on a just-completed comprehension test conflicted with actual results. In contrast to what the students predicted, their comprehension was superior in print when called upon to list the key points or to recall any other relevant information from the readings. Only when the focus was on the main idea of the passages did the effect for medium fail to manifest. There was also a marked time difference for the two conditions. Reading digitally took significantly less time than reading in print. In accordance with the speed-accuracy tradeoff hypothesis (Wickelgren, 1977), we surmised that the speed of processing texts digitally may well have been a contributory factor in the lower comprehension scores in that medium.

1.2. Current investigation

In the present study, we delved deeper into the effect of medium on text comprehension by not only including longer texts and recording reading times, as in prior studies, but also by studying students' use of more shallow and deeper processing behaviors while reading. Dinsmore and Alexander (2016) contend that more surface-level strategies are the actions related to “the basic encoding of textual content” (p. 214), whereas deeper processing entails the “use of strategic and monitoring behavior that involves a more extensive manipulation or transformation of a task or text” (p. 215). Previously, eye tracking has often been used to record students' movements through digital texts as a means for examining such processing behaviors (Ariasi & Mason, 2011; Ariasi, Hyönä, Kaakinen, & Mason, 2016). Some researchers have also associated particular eye movements patterns with more surface versus deeper processing (Catrysse et al., 2017; Hyönä, Lorch, & Kaakinen, 2004). For example, Catrysse et al. (2017) used eye-tracking data from students as they read expository texts along with an inventory of students' learning strategies to create strategic profiles. Their cluster analysis identified four learning profiles with differing reliance on surface or deep processing: all-lows—low scores on both deep and surface processing; surface—high scores on surfacing processing and low scores on deep processing; deep—high scores on deep processing and low scores on surface processing; and, all-high—high scores on both deep and surface processing.

However, eye tracking cannot be applied to the reading of print as it can be with digital materials, thus limiting its use in a study of medium effects on comprehension. Therefore, in this investigation, we devised a method for gathering real-time processing data while students read both print and digital texts. Our intention was to use those real-time data to ascertain whether reliable and valid processing profiles could be extracted for print and for digital mediums. Through the addition of this person-centered approach, we hoped to garner insights into the unexpected advantage for print over digital reading documented in our prior studies. Further, because we intended to extract these processing profiles independently for print and digital conditions, we could ascertain whether the resulting configurations of processing behaviors that distinguished groups in print were the same for reading digitally.

Both of the aforementioned analyses should shed light on important and ongoing theoretical questions about medium effects when texts are presented in an unadulterated state, without the technological affordances often included in digital environments. If we find marked differences in participants' reliance on certain processing behaviors when reading in print versus digitally or if we find a significant number of participants who manifest one profile in the print condition display a different profile in the digital condition, arguments for a specific model of digital reading distinct from print reading would garner support. If we find that neither of these patterns manifest, then it might seem that the medium per se may not be the catalyst for what those invested in digital literacy have perceived as a unique mode of reading. Rather, it could be the technological “bells and whistles” commonplace to websites that alter the course of text processing within digital environments.

As in our prior investigations, we also wanted to explore undergraduates' comprehension ability at varying levels of question specificity (i.e., main idea, key points, and other relevant information), as well as their calibration ability. Calibration refers to the degree of accuracy between individuals' predicted performance and how well they actually perform (Alexander, 2013; Fischhoff, Slavic, & Lichtenstein, 1977; Glenberg, Sanocki, Epstein, & Morris, 1987). Specifically, we wanted to see if any potential differences in comprehension by medium could be associated with calibration differences. There is the assumption in the calibration literature that students' poor judgments of their performance affect the amount of time and effort they dedicate to a learning task (Wickelgren, 1977), which consequently affects actual performance. We and others have also found evidence that calibration is affected by medium, which suggests that students are the worst at judging their performance after reading digitally (Ackerman & Goldsmith, 2011; Singer & Alexander, 2017a; Singer Trakhman et al., 2017).

However, there is still much to learn about the factors that account for this marked miscalibration when reading digitally. One plausible explanation comes from the work of Koriat, Ma'ayan, and Nussinson (2006) on the association between level of task effort and the judgments of learning (JOLs). Specifically, in the Koriat et al. investigation, the less effort that participants exerted in task performance, the higher their JOLs. Ackerman and Goldsmith (2011) reported a similar pattern and concluded that the ease and speed of reading digitally may have contributed to the miscalibration they witnessed by negatively affecting students' regulatory behaviors. Therefore, in the current study, we not only wanted to see if calibration differences by medium were evidenced again, but also whether such differences related in any way to the processing profiles that emerged for print and digital reading.

Given the aforementioned features in the design of this study, we sought to address the following variable-centered and person-centered