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Multiplicity in the digital era: Processing and learning from multiple sources and modalities of instructional presentations

Lucia Mason

Department of Developmental Psychology and Socialization (DPSS), University of Padova, Via Venezia 8, 35135 Padova, Italy

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ABSTRACT

This commentary on the five articles in the Special Issue will first introduce research issues regarding the processing of multiple texts in order to outline the scenario in which the contributions are placed. Then, in the light of the need to move beyond multiple text processing in the digital era, the commentary will illustrate how the five articles contribute to finding answers to some important open questions, furthering our understanding of the processing of instructional materials which feature multiple sources, multiple symbol systems, and multiple modalities of presentation. Finally, the commentary will suggest some issues arising from the outcomes of the studies in this Special Issue, which are worthy of further exploration.

In the Google era, students are very often required to process and comprehend multiple textual sources to acquire knowledge and gain a deep understanding of a topic or issue (Bråten & Strømsø, 2011; Stadtler & Bromme, 2013). As Internet has become "the" source of information, it is no longer necessary to possess books or visit libraries to carry out school assignments. With a simple click, students can access a disparate body of information from every type of source. It is therefore not surprising that in the last two decades research into multiple-text comprehension has flourished (e.g., Britt & Rouet, 2012; Bråten, Anmarkrud, Brandmo, & Strømsø, 2014; Bråten, Ferguson, Strømsø, & Anmarkrud, 2014).

However, students are very often confronted not only with texts but also with static and dynamic pictures, and videos. This commentary will first introduce research issues about the processing of multiple texts with the aim of outlining the scenario in which the five contributions are placed. In the light of the need to move beyond multiple text processing in the digital era, the commentary will then discuss how the five articles contribute to finding answers to some important open questions, furthering our understanding of the processing of instructional materials which feature multiple sources, multiple symbol systems, and multiple modalities of presentation. Finally, the commentary will suggest some issues arising from the outcomes of the studies in this Special Issue, which are worthy of further exploration.

1. Processing multiple texts

Research has offered various behavioral and cognitive models of multiple-text comprehension, based on empirical investigations – as a recent special issue of *Educational Psychologist* (vol. 52, 2017) shows. These consider, in different ways, the interactions between a number of components related to learner, text, task, and context in explaining multiple-text comprehension. For example, the models can be compared in terms of the importance given to internal (learner) or external (environment) factors in driving multiple-text comprehension, or the role of an assigned task, which may have a direct effect on processing, or an indirect effect mediated by readers' perceptions and goals (List & Alexander, 2017).

Processing multiple textual sources has attracted attention in several investigations. Methods such as note-taking, thinking aloud, eye movements, and more recently physiological measures, have been used to capture the complexity of the processes which users of multiple sources of information are involved in when reading (Mason & Florit, 2018). One of the oldest and easiest methods is note-taking, and research has indicated that generating summary notes while reading has both indirect, through recall of intratextual arguments, and direct positive effects on deeper multiple-text comprehension, as reflected in the comprehension of intertextual relations (Kobayashi, 2009). When considering the quality of note-taking, it has emerged that higher quality notes were associated with greater comprehension (Hagen, Braasch, & Bråten, 2014).

Thinking-aloud studies have also revealed, for example, that university students who were more able to discriminate between (and evaluate) more and less relevant information with respect to their task, were also those who produced higher-quality post-reading essays. Through thinking-aloud methodology, the relationship between epistemic beliefs about the justification of knowledge and multiple-text

E-mail address: lucia.mason@unipd.it.

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comprehension emerged clearly. Specifically, the belief that knowledge should be justified through the corroboration of multiple sources was a positive predictor of university students' argumentation in essays, after controlling for prior topic knowledge (Bråten et al., 2014).

Furthermore, eye-movement investigations have provided evidence that the allocation of visual attention while reading multiple digital sources is relevant. For example, a study compared a normal Google-like search result interface and a tabular interface that grouped the search results into three categories (scholarly, subjective, and commercial websites; Kammerer & Gerjets, 2012). Findings showed that when reading the tabular interface, university students processed the commercial sites for a shorter time compared with those who read the list interface. The former students also consistently selected objective sites more frequently and commercial sites less frequently than the latter.

2. Beyond texts: combining multiple sources and modalities of information presentation

In the digital era, not only texts but also different types of visualization, both static (e.g., pictures and diagrams) and dynamic (e.g., animations), and videos, are usual sources of information. Yet in the current literature, there is a gap between how instructional materials from multiple sources and in multiple modalities of presentation are processed and the impact of this processing on the integration and comprehension of information. The affordances of communication technology generate new scenarios for knowledge acquisition and pose challenging questions to educational researchers interested in how, and in what conditions, students may benefit more from multi-source and multi-modal presentations of disciplinary information.

It should be underlined that research on multiple-text comprehension has indicated that even college students may form only a superficial representation of a set of texts with conflicting information on the same controversial issue (e.g., Mason, Boldrin, & Ariasi, 2010). On the other hand, research on multimedia learning has documented that students do not automatically integrate verbal and graphical information when processing and trying to learn from illustrated texts (Mason, Tornatora, & Pluchino, 2013b; 2015; Stalbovs, Scheiter, & Gerjets, 2015), or from audio and graphical materials (Schmidt-Weigand, Kohnert, & Glowalla, 2010). Therefore, it is legitimate to expect that multi-source, multi-modal processing poses considerable challenges to students, who are asked to form a coherent mental model not only from text, the traditional learning medium, but also from other instructional materials from different sources and modalities of presentation.

This Special Issue aims to fill the gap in current research by focusing on the processes that lead students to comprehend multiple sources when these convey information through texts, and through a variety of media. In the next sections the papers of the Special Issue will be critically reviewed in the light of some open issues and the need to extend our knowledge of the essential processes that underlie learning in the digital era.

2.1. Paper and screen: reading comprehension in the traditional and digital medium

Comparisons between media − digital and printed text – are crucial for an understanding of how digital natives process reading. From outcome-oriented studies, we already know that when students read texts in print, they attain higher scores for comprehension, although they prefer reading on the screen (Mangen, Walgermo, & Brønnick, 2013; Singer & Alexander, 2017). Why? Understanding the processes that underlie successful reading performance in traditional and digital media will have important implications not only for theory, but also for educational practice.

The paper by Singer Trakhman, Alexander, and Silverman (this issue) has examined processing time and behavior in undergraduates, who read two passages about biology in print and on screen. They aimed to identify processing profiles for the two media and links to reading performance and calibration. Of note is that post-reading questions were presented in the same medium as the reading material. Behavioral processing during reading was captured by video, while real-time processing was also recorded. Interestingly, four profiles for printed medium emerged from the procedure, and were labeled Regulators, Plodders, Gliders, and Samplers. Regulators were students who engaged deeply with texts through re-reading, re-positioning, and questioning, and who took longer to process the verbal materials. Plodders were laborious students who process text in a linear way (little re-reading) but rather slowly. Gliders represented readers who were rather superficial but fast in their processing. Finally, Samplers were those who read in a linear way overall, but re-read selected areas of the texts.

Although the authors did not set out to find the same processing profiles for digital reading, the same four clusters of processing behaviors represented, reliably and validly, what occurred when reading on the screen. An interesting finding is that Regulator and Plodder readers of print maintained more or less the same processing behavior when reading digital texts, whereas Gliders and Samplers modified their reading to some extent. Most Sampler readers of print turned out to be Gliders (linear and fast) in digital reading, and many Gliders in print showed Regulator or Plodder processing behavior in the digital medium.

No significant interactions for medium and processing profiles emerged for overall comprehension performance and calibration ability. For the overall comprehension score, however, Regulators were better than Samplers for the digital medium. For calibration ability, differences again emerged in relation to processing profile within and across media. Regulators performed better both in print and digital reading compared with Plodders. Finally, greater calibration for Regulators occurred when processing on-line, while Gliders showed better calibration when reading in print.

Overall, these findings point to the fact that at university level, most students behave in a substantially similar way in the most important learning activity regardless of the medium used. It is intriguing to find that Gliders on the page are Regulators on the screen as they become slower and more deliberate in their processing. This may be because these students are metacognitively aware that digital reading, although more appealing, is not easier than reading on the page and may require even more effort, so they are able to self-regulate when reading on the screen. The current data allow only speculation in this respect and it seems both theoretically and practically relevant to move research further to understand why some students are more effective processors of digital than traditional media, especially because empirical investigations with college students have documented the opposite (Singer & Alexander, 2017).

It should be pointed out, however, that in this study the materials read on the screen comprised only pure texts. As Singer Trackhman et al. (this issue) have stated, reading on a computer is not a unidimensional phenomenon and the conceptualization of "digital literacy" may include a diversity of aspects that have implications for the assessment of reading performance. Future investigations on the intricate relationships between individual reader differences, text characteristics, and various technological affordances will enlighten unknown aspects of the processes and outcomes of Web-based learning.

Nevertheless, the paper by Singer Trackhman et al. (this issue) has the merit of identifying patterns of reading behavior in traditional and digital media, which is particularly useful from an educational point of view. The least productive patterns can be transformed into more effective reading behaviors through appropriate scaffolding in the service of text comprehension.