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Effects of linear reading, basic computer skills, evaluating online information, and navigation on reading digital text

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ABSTRACT

Reading and understanding digital text that is organized in a non-linear hypertext format can be challenging for students as it requires a more self-directed selection of text pieces compared to reading linear texts. This study aims at investigating how individual differences in students' skills in comprehending digital text can be explained by their navigation behavior and various underlying skills. Students' navigation behavior was operationalized by their selection of task-relevant hypertext pages; students' abilities in terms of reading linear texts, dealing with computer interfaces more generally, and evaluating the usefulness of online information were considered as underlying skills. We hypothesized that basic computer skills and evaluating online information would explain performance in digital reading above and beyond reading skills measured with linear texts. These effects were expected to be mediated by navigation behavior. A subsample of 15-year-old German students who participated in the Programme for International Student Assessment (PISA) 2012 was investigated ($N = 888$). The results confirmed the hypothesized mediation between linear reading, navigation behavior, and digital reading. Moreover, navigation behavior also mediated the relation between basic computer skills and digital reading but not the relation between evaluating online information and digital reading. Implications regarding processes in digital reading and navigation of hypertexts are discussed.

1. Introduction

Using the Internet to seek information, entertainment, or to communicate has become an integral part of many students' lives, and is a frequent activity both in leisure time and for school-related tasks. Several studies describing adolescents' media usage have shown that around 90% of teens are online and typically use several devices, such as desktop computers, laptops, mobile phones, or tablets (e.g., 88% of German adolescents: Feierabend, Karg, & Rathgeb, 2013; 95% of American adolescents: Madden, Lenhart, Duggan, Cortesi, & Gasser, 2013; 89% of adolescents in member countries of the Organisation for Economic Co-operation and Development: OECD, 2011). One result of the growing importance of such information and communication technologies (ICT) in society and the labor market has been the inclusion of competencies measuring skills in dealing with digital media in the Programme for International Student Assessment (PISA; OECD, 2013). The PISA study aims at monitoring students' learning and evaluating their preparedness for the challenges of adult life. Therefore, the knowledge, skills, and attitudes of 15-year-olds, who are approaching the end of compulsory education, are regularly assessed in the participating countries. The cross-curricular assessment of reading competency, for instance, is an integral part of PISA because reading is required for written communication and serves as a core ability for long-life learning. However, ICT have changed the way text is presented and received by readers, which can affect their comprehension of the text and their learning (e.g., Coiro, 2011; Leu, Kinzer, Coiro, & Cammack, 2004; Naumann, 2010; Rouet, 2006; Salmerón, Cañas, Kintsch, & Fajardo, 2005).

The present study seeks to gain insights into the cognitive skills and processes involved in the comprehension of digital text. In the following, we give a brief overview of (1) the concept and operationalization of digital reading, (2) research on navigation in

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digital reading, (3) the relations between digital reading, navigation, and skills in reading linear texts, and (4) the role of basic computer skills and evaluating online information in navigating and reading digital text. Finally, the study purpose and hypotheses are presented.

1.1. Digital reading

Digital reading is understood as proficiency in reading and comprehending text that is organized in a digital non-linear format (referred to as "hypertext"). According to the Construction–Integration (C–I) model and its extensions (e.g., Kintsch, 1998; Rouet, 2006; Rouet and Britt, 2011), comprehension of a text is the result of a task-driven construction process in which readers form a so called situation model. The situation model is a mental representation of the situation within a text. It integrates information from the text base and a reader's own knowledge. Although this construction process should be basically the same for reading text structured both linearly and non-linearly, hypertext imposes further demands on readers regarding their selection of read text pieces (e.g., Boechler, 2001; Coiro, Castek, & Guzniczak, 2011; Coiro & Dobler, 2007; Davis & Neitzel, 2012; Naumann, 2010; Naumann, Richter, Christmann, & Groeben, 2008; Salmerón et al., 2005).

Hypertexts like on the World Wide Web are mainly characterized by a huge information space, separated in several pages. Pages within a hypertext (referred to as "nodes") are interconnected and accessible through hyperlinks. While a specific page is presented, a huge quantity of other available information – more or less related to a particular topic – is usually not visible. Readers initially do not know how extensive the information space of a particular hypertext is and how it is organized. However, when reading for a specific purpose, readers need to locate and select text parts within the hypertext and create a text base of appropriate quality (cf., Boechler & Dawson, 2005; Gil-Flores, Torres-Gordillo, & Perera-Rodríguez, 2012; Leu et al., 2004). In the following, we will use the term digital reading referring to reading skills measured with digital hypertext and the term linear reading referring to reading skills measured with linearly structured texts.

For the assessment of digital reading in PISA, a set of items referring to different types of hypertext were developed (OECD, 2011, 2013). The hypertexts include topics about personal, educational, occupational, and public settings (e.g., official website of a town, private email exchanges, or a social media-like learning platform). For reasons of testing time and efficiency, the hypertexts contain only a limited number of pages (currently up to 33 nodes). Therefore, associated tasks are of short duration and can be completed within a few minutes. The tasks, which students had to perform within the hypertexts, were varied according to the intended text use (e.g., communicating via email, evaluating online news, seeking information about events), text types (e.g., descriptions, argumentations, lists, diagrams), and primary cognitive operations (e.g., finding explicitly stated information, making inferences about implicit relations, reflecting on text content and using it to form an opinion). Fig. 1 shows screenshots of two hypertexts. Example (a) presents a fictional homepage of the town Seraing. The task asks students to find out the name of a movie by using the hyperlinks to access the program of the community's cultural center. Example (b) starts with an email exchange between two girls who want to join a fitness studio. In order to complete the presented task, students need to identify the girls' specific needs on the basis of their email exchange and collect arguments from the web pages of suggested fitness studios. Finally, students are asked to recommend a fitness studio by providing two reasons which take the girls' interests into account. These and further examples of PISA digital reading items can be found at http://erasq.acer.edu.au/index.php?cmd=toEra2012 hosted by the Australian Council for Educational Research (ACER).

1.2. Navigation in digital reading

In digital environments, navigation describes a reader's movement through the pages of a hypertext system (Lawless & Schrader, 2008). The navigation metaphor reflects how readers access digital text parts and arrange their order to gain information, that is, how readers create their own text base by their selection and sequencing of pages. If readers fail to appropriately navigate through hypertext for a particular reading purpose, they will not locate relevant information. As a result, readers' text base will be less complete and coherent requiring an increased elaboration of knowledge-derived information (cf., Kintsch, 1998). Effective navigation is therefore assumed to be an important predictor of hypertext comprehension and knowledge acquisition. Empirically, navigation strategies and behavior have found to be closely related to successful hypertext reading and learning outcomes (e.g., Lawless & Kulikowich, 1996; Naumann, 2010; Naumann, Richter, Flender, Christmann, & Groeben, 2007; Salmerón & García, 2011; Salmerón, Kintsch, & Kintsch, 2010).

Operationalizations of navigation behavior are not direct measures of students' cognitive processes but rather the result of them (cf., OECD, 2011). Navigation indicators are frequently extracted from an overwhelming quantity of log-file data recording students' interaction with the computer platform during the test session. Several indicators try to capture students' navigational activity within one measure (cf., Lawless & Kulikowich, 1996; Naumann, 2010) – such as the frequency of task-relevant page visits. Task-relevant pages are defined as (1) pages that provide necessary information for task completion as specified by the item author or (2) pages that need to be passed through in order to access necessary information (OECD, 2011). Task-relevant navigation comprises the act of selecting task-relevant pages. For representing task-relevant navigation, two indicators are often used: (1) the number of relevant page visits and (2) the number of relevant pages visited uniquely. The first indicator counts all visits and revisits of relevant pages; it intends to represent the intensity of readers' engagement with relevant material. The second indicator only regards visits of relevant pages once; it thus represents the comprehensiveness of reader's selection of relevant text.

Task-relevant navigation has been shown to be positively related to digital reading and learning in empirical studies. Naumann et al. (2007), for instance, requested that undergraduate psychology students prepare three essays on topics about visual perception (e.g., an essay about "Important studies on perception of space"). The students had 1 h to learn with an expository hypertext, which was hierarchically structured and contained about 230 pages and 540 cross-references. According to the essay's topic, the number of relevant pages varied from 27 to 31 pages. The authors found significant correlations between students' number of relevant page visits and different learning outcomes ($r = .30–.52$). In the PISA 2009 digital reading assessment (OECD, 2011), task-relevant navigation was also highly predictive of students' digital reading performance across participating countries (number of relevant page visits: $r = .39–.75$, OECD average: $r = .62$; number of relevant pages visited: $r = .68–.86$, OECD average: $r = .81$). Furthermore, task-relevant navigation significantly accounted for variance in digital reading performance over and above skills in reading linear text. In the next section, the relationship between linear reading, navigation behavior, and digital reading is outlined in more detail.