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| RESEARCH ARTICLE

Cognitive Overload in the Hypertext Reading Environment

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| ABSTRACT
The amount of immediately accessible reading resources is almost limitless in the WWW. Therefore, students depend on different digital devices to read rich and diverse types of hypertexts. This phenomenal shift from paper-based to digital reading has made students read more hypertexts than ever before. Still, little is known about the effects of hypertexts' intricate complexities on readers' comprehension and the new reading challenges hypertexts might pose to readers. Therefore, this review aims to examine the cognitive overload challenge in the hypertext environment. A significant amount of previous research in hypertext reading has raised concerns about the cognitive overload challenge in the hypertext environment. This review examines the problem of cognitively overload with regard to research published in the field.

| KEYWORDS

Hypertext Reading, Hypertext Structure, Reading Comprehension, Cognitive Overload.

| ARTICLE INFORMATION

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1. Introduction

Technology today is a fundamental part of almost every aspect of life; people depend on it for entertainment, work, and study. Consequently, many daily activities have remarkably changed, and reading is no exception. People today spend more time using their computers, laptops, tablets, and other diverse technological devices than before. This technological proliferation brought about increasing dependence on digital reading, especially among young readers (Coiro, 2003).

Moreover, the recent Coronavirus pandemic has affected education worldwide, leading students, schools, and universities to resort to the online hypertext environment. Among all these changes, some futurists foresee the death of paper-based texts, speculating that all future works will be digital one day (Bleeker, 2010). Hypertexts, which feature texts in the World Wide Web, provide readers with more freedom and flexibility to read texts in the order they choose as well as have immediate access to "information in the sequence, volume, and format that best suits their needs at the time" (Grice, 1989, p. 22).

Overall, this review examines the phenomenological inquiry of hypertext reading. Specifically, the current review examines research related to the cognitive overload challenge ascribed to the hypertext reading environment.

2. What is a Hypertext?

Ted Nelson, one of the progenitors of hypertexts, was the first to use the term hypertext in 1965 to refer to non-sequential screen-based text chunks connected by links that allow readers to freely choose between multiple pathways (Protopsaltis, 2006). Nelson (1990) has described a hypertext (or hyperdocument) as "an assemblage of texts, images, and sounds-nodes-connected by electronic links so as to form a system whose existence is contingent upon the computer" (p. 56). In other words, unlike conventional texts that readers use to flicker through printed pages linearly, hypertexts display information via hyperlinks in a nonlinear, flexible manner (Thuring et al., 1991). Similarly, Tolhurst (1995) stated that "a hypertext can be viewed functionally as nodes of information that are linked, allowing readers to follow a variable reading path of associations based on semantic links" (p. 22).

In the same vein, Farkas (2004) defined hypertexts as onscreen reading content that includes hyperlinks to access information. Hyperlinks can take the form of words, phrases, or "hot areas" in the hypertext. According to Farkas, one of the fundamental characteristics of hypertexts is that they give readers more choices and freedom on what to read and how to read it without interruptions or restrictions. To make it plain, in the hypertext environment, readers are free to click on any link they choose to navigate and reach the intended nodes (units of content), thus accomplishing their reading objectives. In this way, links are deemed electronic pathways that readers use to navigate their way through the hypertext and jump from one node to another.

The hypertext environment allows readers to access an extraordinary sum of information. However, the multiplicity of links and flexibility that characterize the hypertext environment have been linked to reading challenges that may affect readers' comprehension performance (Lee & Tedder, 2003). A significant amount of researchers in hypertext reading (e.g., Blom et al., 2018; Coiro & Dobler, 2007; DeStefano & LeFevre, 2007; Dunser & Jirasko, 2005; Halamish & Elbaz, 2019; Scheiter & Gerjects, 2007; Sung et al., 2015; Zumbach & Mohraz, 2008) have raised concerns about the cognitive overload challenge in the hypertext reading environment.

3. Cognitive load in hypertext reading environment

Cognitive load is the efforts learners utilize or need to process information (Sweller, 1988). This includes encoding, activating, storing, and manipulating information while performing cognitive tasks (Baddeley, 2003). Cognitive load theory (CLT), proposed by Sweller in the 1980s, paved the way for the emergence of a new concept named cognitive overload. In the context of hypertext reading, cognitive overload can be defined as the limitation of the human working memory and cognitive difficulties processing information in the hypertext environment due to its nonlinear structure (Conklin, 1987).

Cognitive Load Theory (CLT) assumes that readers find difficulties processing information beyond their working memory capacity or/and when the environment that contains information is presented in a perplexing reading structure (Firat & Kuzu, 2011). According to the literature, cognitive overload can result from two types of cognitive loads: germane and extraneous (Moreno, 2004). Germane load refers to the level of difficulty of information or learning activity. That is, learning difficulties can occur due to high levels of germane cognitive load resulting from content beyond the proximal development of learners (Antonenko & Niederhauser, 2009). Also, the germane load is mainly related to readers' individual differences and learning characteristics, such as readers' background knowledge and cognitive and metacognitive strategies.

Conversely, extraneous load refers to the efforts employed to comprehend a particular structure or environment in which information is demonstrated. Accordingly, within the framework of hypertext reading, the extraneous load can occur when readers lack understanding or familiarity with the hypertext structure in which the information is presented (Firat & Kuzu, 2011). In other words, while germane overload occurs when the difficulty of information is beyond learners' working memory capacity, extraneous load occurs when the hypertext structure that contains information is presented in an unorganized, perplexing, and/or unfamiliar structure.

When reading in the hypertext environment, readers have immediate access to information "in the sequence, volume, and format that best suits their needs at the time" (Grice, 1989, p. 22). That is, hypertexts give readers more freedom and flexibility to read texts in the order they choose to construct meaning. This imposes additional cognitive demands, which leads to readers' cognitive overload (Landow, 1992). In fact, much of the past research in hypertext reading (e.g., Blom et al., 2018; Coiro & Dobler, 2007; DeStefano & LeFevre, 2007; Dunser & Jirasko, 2005; Halamish & Elbaz, 2019; Scheiter & Gerjects, 2007; Sung et al., 2015; Zumbach & Mohraz, 2008) concluded that cognitive overload is the major challenge that readers are likely to face when reading hypertexts.

4. Factors contributing to the cognitive overload in the hypertext reading environment

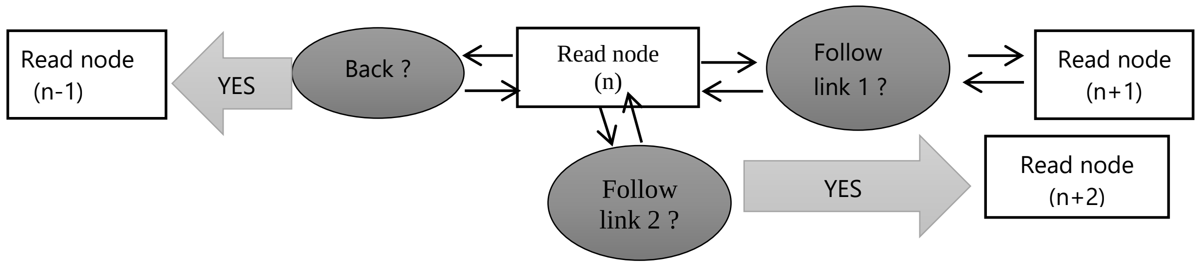
The following sub-sections discuss three main factors contributing to cognitive overload in hypertexts. These are decision-making, multitasking/scrolling, and coherence-building.

4.1 Decision-making and cognitive overload

According to DeStefano and LeFevre (2007), readers have to decide which hyperlinks to activate and in which order they can reach their reading objectives, which increases their cognitive load and impairs their comprehension. To illustrate, Figure 1 below explains the complexity of the hypertext reading process and how readers' navigation among the given links can cause a more significant cognitive load. Unlike conventional printed texts that demand readers to either move forward to the next page or backward to the previous one, the multiplicity of links that characterize hypertexts necessitates additional cognitive efforts. Thus, readers find themselves compelled to make decisions on which links to activate and which paths to follow (Landow, 1992). Accordingly, relying on both their reading objectives and the linking options embedded in the hypertext, readers must determine which information node to select first and which to select next.

Figure 1:

Example of the reading process of a hypertext adapted from DeStefano and LeFevre (2007). Rectangles represent nodes, and lines and arrows represent the connections among them.



DeStefano and LeFevre (2007) illustrated in the figure above that the number of links in a hypertext makes readers encounter more choices, which increases their navigational decision-making processes. Accordingly, DeStefano and LeFevre concluded that hypertexts, especially the ones containing a high number of links, impose more cognitive load, thus affecting comprehension negatively. Consistent with this view, an early study by Zhu (1999) presented some critical insights into the effect of links embedded in hypertexts on readers' cognitive performance. Zhu compared students' reading hypertexts containing 3 to 7 links per node to reading hypertexts containing 8 to 12 links per node. The study's findings indicated that participants who read hypertext with fewer embedded links outperformed those with more embedded links. A conclusion to be drawn from this study is that the number of links embedded in hypertexts contributes to more decision-making processes, which eventually leads to increased cognitive load.

Many other studies investigating cognitive load in hypertext reading affirm that the more a hypertext contains embedded links, the more decisions its readers have to make and the more comprehension challenges they have to deal with (Dunser & Jirasko, 2005). In this regard, Scheiter and Gerjects (2007) stated that the abundance of information that characterizes the hypertext environment, along with readers' interaction/behavior with the richness of its information, brings about cognitive overload. In the same vein, Lee and Tedder (2003) claimed that the multiplicity of choices and richness of information in hypertexts impose greater cognitive demands, thus resulting in readers' cognitive overload. Similarly, Zumbach and Mohraz (2008) asserted that hypertexts require extra mental exertion in navigation planning and monitoring.

From another perspective, Gygi (1990) ascribed the increased cognitive load in hypertexts to the latter's impact on the shared responsibilities between the writer and the reader. Writers of conventional texts write a well-organized, coherent, and sequential presentation of ideas that readers are expected to follow linearly from beginning to end. Conversely, hypertext designers provide their readers with the freedom to choose between multiple reading paths and the responsibility to choose the appropriate reading path (Kim & Hirtle, 1995). The breach of what Gygi called "the literacy contract" between readers and writers in the hypertext environment results in cognitive overload.

4.2 Multitasking/scrolling and cognitive overload

Another factor contributing to cognitive overload in hypertext reading is multitasking. According to Kim and Hirtle (1995), reading tasks that feature the hypertext reading environment are classified into three types: the navigational task, the informational task, and the coordination of both navigational and informational tasks. Regarding the navigational task, readers formulate reading plans that would help them successfully navigate hypertexts to achieve their reading objectives. As for the informational task, readers make connections between the information segments of the hypertext in order to comprehend it. With respect to the coordination of both navigational and informational tasks, readers have to design and execute a reading plan that responds to their reading objectives and simultaneously makes meaning of the hypertext content they are reading. Consequently, the negative effect of these tasks on readers' cognitive processes is ascribed to the fact that readers not only engage in reading comprehension processes but also in maintaining their navigational focus on the appropriate reading path. According to Kim and Hirtle, switching between navigational and informational tasks makes hypertext reading more cognitively demanding.

In a more recent study, Mangen et al. (2013) investigated the negative effects of digital texts on students' reading cognitive processes. According to the results of this study, the negative impact of computer screen digital texts on readers' cognitive load is ascribed to multitasking and scrolling. Regarding the problem of multitasking, Mangen et al. noticed that participants in the computer condition had to switch between different windows, which resulted in additional cognitive load. With respect to scrolling, Mangen et al. found that scrolling disrupts readers' mental representation/mental map of the text, which negatively affects their cognitive processes. Unlike conventional reading, in which readers can effortlessly be immersed in comprehension as they flip linearly over the pages, hypertext reading comprehension is hampered due to the scrolling activity imposed by digital platforms.

This finding is in agreement with Sanchez and Wiley (2009), who also indicated that scrolling could be considered an obstacle that increases cognitive load. This conclusion was based on an experiment that examined the effects of scrolling on students' comprehension and working memory capacity (WMC refers to the ability to process and store information simultaneously). In their study, Sanchez and Wiley divided 40 university students into an experimental and a control group. Readers in the experimental group had to scroll up and down to read a hypertext divided into thirteen individual pages, while readers in the control group read page-by-page hypertext format by clicking on "next" and "back" links at the bottom of each page. After reading the hypertexts, comprehension tasks and working memory capacity (WMC) assessment were employed to measure both comprehension and participants' WMC. The experiment's results revealed that scrolling negatively affects participants' comprehension and working memory capacity.

A possible explanation of the above-mentioned results is that scrolling demands readers to simultaneously maintain a surface representation of the text and engage in comprehension processes, which increases their cognitive load. In other words, readers, especially those with low working memory capacity, face challenges controlling their visual attention while scrolling. This subjects them to cognitive overload, which consequently affects their comprehension of hypertexts.

4.3 Coherence-building and cognitive overload

Unlike paper-based texts, which are static, unitary, and linear, hypertexts are non-sequential screen-based text chunks connected by links that enable readers to freely choose between multiple pathways (Protopsaltis, 2006). Thus, readers jump forward and backwards between segmented information units, which brings about discontinuance in processing information (Chen, 2009). Dee-Lucas and Larkin (1995) stated that "Interruptions in text study could interfere with the development of an integrated representation of the text as a whole" (p. 435). To illustrate, readers of hypertexts process and make connections between individual separate units, which are likely to disrupt information processing, thus increasing readers' cognitive load.

According to Dee-Lucas and Larkin (1995), the effects of reading disruptions on readers' cognitive processes can be described in terms of two levels. In the first one, readers connect individual units of the new information and their pre-existing knowledge. In the second level, readers' attention is not only focused on the information itself but also on the textual cues constituting individual units of the information. Therefore, since readers of hypertexts find themselves compelled to locate and comprehend specific information in multiple and diverse categories of sources of information and an extensive amount of text segments, building coherence is the most common cognitive operation that characterizes hypertext reading (Guthrie & Kirsch, 1987).

In the same vein, Van Berkel and de Jong (1999) concluded that cognitive overload in hypertexts can also be due to difficulties in establishing the coherence of its contents. Van Berkel and de Jong stated that difficulties in maintaining coherence while reading hypertexts lie in readers having to remember their location in the hypertext they are reading, making decisions about which hyperlink to activate next, monitoring their reading path, judging the relevance of the newly found information, and maintaining awareness of the links previously activated. Likewise, Antonenko and Niederhauser (2010) indicated that the increased load in hypertext reading lies in integrating the new information with their prior knowledge and, more crucially, developing a coherent understanding of the overall text they are reading.

To sum up, the above-mentioned studies indicated that hypertexts are designed in a way that causes information content to be discontinuously processed. As a result, readers encounter difficulties forming semantic relationships between information nodes and building a mental modal (expectations/beliefs) of how a text is structured, which impedes creating a coherent mental representation of hypertexts' content (Salmerón et al., 2005, 2006). However, although it has been concluded that readers face challenges building coherence while navigating hypertexts, such challenges diminish when readers have a great extent of mental models (how something works) and prior knowledge of hypertext structures (Gerdes, 1997; Lawless & Brown, 1997). Therefore, to maintain coherence while reading hypertexts, Van Berkel and de Jong (1999) recommended that readers have a conceptual representation of how information is stored and organized in a hypertext. Besides being fully aware of these challenges, hypertext designers are designing easily navigable hypertext structures to reduce cognitive load and support readers' coherence (Gerdes, 1997; Lawless & Brown, 1997).

Overall, much of the past research in hypertext reading recognized cognitive overload as the main problem of reading in the hypertextual environment. This problem is due to additional mental efforts resulting from decision-making, multitasking, scrolling, and coherence-building that the hypertext reading environment requires from its readers.

5. Re-examining the cognitive overload challenge in the hypertext reading environment

Most previously mentioned studies linked hypertexts to cognitive overload reading challenges. However, a weakness of this argument is that most of the studies mentioned were over ten years old. Otherwise stated, some studies' findings that hypertexts cause cognitive overload can be ascribed to dated research conducted on unsophisticated and ill-structured hypertexts (e.g., hypertexts that lack navigational aids). Hypertexts that include well-structured menus, browsing tools, hierarchical maps, spider maps, and other navigational tools are decisive in decreasing readers' cognitive load (Waniek et al., 2003).

On the other hand, the cognitive overload challenge disappears when readers become familiar with the hypertext reading structure. According to Kim and Hirtle (1995), cognitive challenges significantly diminish when readers become accustomed to hypertext structures, identify their reading goals, and plan to navigate the hypertexts. In this respect, Kymes (2005) affirmed that readers who have knowledge of the text structure and the organizational sequence of the information search and locate the required information easily. Moreover, Dewitt et al. (2013) stated that the community of digital native students is growing in higher education establishments; consequently, readers today have a high level of familiarity with different hypertext structures.

Similarly, Friedman (2005) indicated that the Internet is now the primary source of information retrieval; as a result, students nowadays are reading hypertexts more than ever before. In addition, Firat and Kuzu (2011) also pointed out that cognitive load diminishes when readers gain an understanding or familiarity with the hypertext structure in which the information is presented. Likewise, Kymes (2005) affirmed that readers who have knowledge of the text structure and the organizational sequence of the information search and find the required information easily.

Additionally, unlike critics who stressed the cognitive overload challenge that can characterize the hypertext reading environment, advocates and progressivists believe that the freedom and flexibility that characterize the hypertext reading environment do not cause any cognitive challenges. Contrariwise, researchers (e.g., Coiro & Dobler, 2007; Kalthoff & Möller, 2003; Spiro et al., 1991) believe that the dynamic structure of hypertext environments has more cognitive benefits than the conventional, simplified reading environment. Hypertext reading is advantageous over paper-based reading, which can be grounded in cognitive flexibility theory (CFT), which focuses on constructing knowledge and not consuming products of knowledge (Spiro et al., 1992).

CFT underlines that flexible approaches to reading and learning nurture learners' cognitive flexibility. According to Coiro and Dobler (2007), hypertexts place more responsibility on readers, which helps them create their individual reading path, increase their learning, and be actively engaged in constructing their own meaning. Similarly, Müller-Kalthoff and Möller (2003) indicated that hypertext structures engage readers in building connections between its information nodes, resulting in better text comprehension. Therefore, opposite to the simplification that characterizes paper-based texts and linear hypertexts, upholders of CFT recommend complex learning environments, such as the hypertext reading environment (Spiro et al., 1991).

6. Conclusion

In conclusion, a considerable amount of studies (e.g., Blom et al., 2018; Coiro & Dobler, 2007; DeStefano & LeFevre, 2007; Dunser & Jirasko, 2005; Halamish & Elbaz, 2019; Scheiter & Gerjects, 2007; Sung et al., 2015; Zumbach & Mohraz, 2008) concluded that cognitive overload remains the major challenge frequently ascribed to hypertext reading. Nevertheless, several studies (e.g., Amadieu et al., 2009; Lorch & Lorch, 1996; Mohageg, 1992; Potelle & Rouet, 2003; Salmerón et al., 2009; Waniek et al., 2003) have stressed the central role of the organizational structure and the navigational aids in decreasing students' cognitive load, thus improving their comprehension. On the other hand, advocates and progressivists believe that flexible approaches to reading and learning nurture learners' cognitive flexibility, which enriches readers' opportunities to use and construct knowledge in a more flexible manner.

This review contributed to the body of research attempting to increase understanding of cognitive processes in the hypertext reading environment. Therefore, the implications for hypertext reading comprehension are valuable and worth considering by hypertext designers, educators, policymakers, and practitioners alike. These implications include the following: (1) the need to raise awareness of the potential benefits of hypertext reading, (2) the need for hypertext designers to develop well-structured hypertexts that assist readers' comprehension and minimize cognitive overload, and (3) the need to raise awareness of the hypertext reading pitfalls and the best ways to overcome them.

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