Cognitive Load in Reading in Digital Environment

Communication & Journalism Research
2 (1) pp 17-23

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masscomhod@uoc.ac.in
ISSN 2348 – 5663

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Abstract

Reading hypertext is a task of exploration. Unlike print text, which is typically read in a sequence prescribed by the author, hypertext is presented in brief nodes that contain one or more concise expository paragraphs, for which the reader determines access sequence. The ubiquity of hyperlinked information as a medium for presenting content raised the issue of how reading processes are affected by the features that distinguish hypertext from linear text. The presence of links in text introduces decision-making process and interruptions to reading that can either enrich the reading experience and/or increase the complexity of the comprehension process. This paper discusses about how hypertext features influenced cognitive process in reading, with a focus on comprehension and navigation.

Keywords

Hypertext, Cognitive Load, Reading, Comprehension, Navigation, E-learning

Introduction

With the widespread use of digital resources has brought about significant changes in reading practice and behaviour as users spend more time on reading online. The scope of reading resources has changed drastically in the digital environment to include websites, webpages, e-books, e-journals, e-papers, e-mail, discussion boards, chat rooms, instant messaging, blogs, wikis, and other multimedia documents. Online reading behaviour is characterized by more time on browsing and scanning, keyword spotting, one-time reading, non-linear reading, and reading more selectively, while less time is spent on in-depth reading and concentrated reading, and sustained attention is decreasing. Online reading has also introduced a number of powerful advantages that are traditionally absent in the printed environment, such as interactivity, nonlinearity, immediacy of information and the convergence of text and images, audio and video (Liu, 2005).

Digital reading can be studied from several different perspectives: the field of cognitive psychology, education, information studies, and literary studies has all contributed to different aspect of current knowledge of digital reading. Different activities central to hypertext reading such as following links, that are not usually required in reading linear text,

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may influence mental load either directly, as when readers are required to make decisions upon encountering links, or indirectly, as when following link results in separation of related parts of a text and influences information integration. Hypertext presentation can often influence reading comprehension and navigation by increasing mental load.

Hypertext Theory

Hypertext theory has emerged as the most prominent theory of digital reading today (Mail & Dobson, 2001). Hypertext theory is based in the theories of postmodernism and post structuralism but also grows out of the world of the printed text and often exists in comparison to print forms. The term hypertext, first coined by Theodor H. Nelson, in the 1960s, can be defined as the text composed of blocks of words (or images) linked electronically by multiple paths, chains, or trails in an open-ended, perpetually unfinished textuality (Landow, 1997). Destenfano and LeFevre (2007) define hypertext broadly as a collection of documents containing links that allow readers to move from one chunk to another. Hypertext provides different degrees of context and choice to readers. Hypertext is described as non-linear because of this readers are seen as having the ability to create the text as they read, depending on the choices made when reading. Because hypertext is joined by links, each reader is able to create a unique path through the text, therefore having a role in the text's authorship. Each reader can then create a unique text according to the links followed (Carusi, 2006).

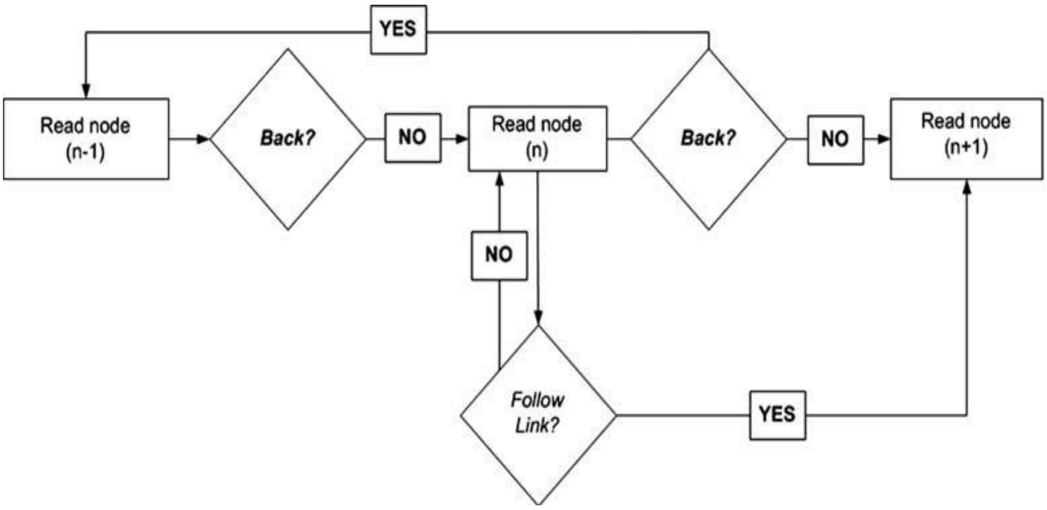
Hypertext consists of two components: links and lexias. A lexia, a reading unit or section of text, can be of varying length and composition. Lexias are joined by links. Through these links that lexias gain meaning and form the text as a whole. Depending on the readers choices this whole is changeable and can be formed again with each reading.

Cognitive Load

In hypertext, reading and navigating are likely to place demands on the working memory. Working memory is defined as the set of mental resources that people use to encode, activate, store, and manipulate information while they perform cognitive tasks (Baddeley, 2003). Working memory theories which provide a useful way of operationalizing the construct of cognitive load because a common assumption of working memory models is that a limited amount of information can be simultaneously processed. This leads to the assumption that increases in mental load are associated with reduced performance in hypertext reading. Cognitive load is a construct with three measurable dimensions: mental load, mental effort, and performance.

Hypertext reading introduces a new set of cognitive requirements to the reading task, thereby increasing working memory demands, and mental load increases. The following figure illustrates the sequence of steps involved in hypertext reading.

Fig.2. A process model for Hypertext Reading (DeStefano & LeFevre, 2007)



In a linear text, that has only the next and back links, a reader at node (n) makes the decision to either go on to the next node (n+1) or go back to the previous node (n-1). On this view linear text is the least demanding of cognitive load. But hypertext with embedded links demand that readers make an additional decision at each link, which is indicated in the above figure by the decision diamond marked 'Follow link? The reader either chooses to go on to the linked text, node (n+1) in the figure, or continuous reading the text in the current node (n). Each decision about whether to follow a link requires cognitive resources and thus hypertext with more embedded links should produce greater cognitive load than hypertext text with few or no embedded links.

Furthermore, every time a reader chooses to follow an embedded link, the text he or she encounters in node (n+1) potentially functions as an interruption of the ongoing comprehension process. Comprehension involves the development of situation models, which are complex mental representations formed when readers integrate the statements in the text with their knowledge. To the extent that the text in node (n+1) is related to and enhances the developing situation model, the interruption may have minimal effect on comprehension. To the extent that the text in a linked node is unrelated to the text in node (n), disruption of the developing situation model may occur. Furthermore, because the reader will be faced with additional choices when he or she is processing the linked text, that is, to either return to node (n) or possibly to follow other embedded links, the disruption to developing comprehension may be severe. Then it can be predicted that the situation model development should be better for hypertext structures in which links are restricted to closely related nodes, as in hierarchical hypertext. This interference with the comprehension process may be a source of disorientation that affects the hypertext reading (DeStefano & LeFevre, 2007).

Navigation and Comprehension in Hypertext Reading

To evaluate cognitive load in reading, examines the impact of secondary or additional tasks on reading performance. When two tasks are combines, performance suffers in either task to an extent. This leads to the conclusion that two tasks demand overlapping cognitive resources. Hypertext reading requires spatial cognitive resources, comprehension and navigation will be impaired when combined with additional spatial tasks, such as remembering visually presented shapes. To develop a multi-component model of working memory a dual-task methodology has been used extensively. Early research found that comprehension levels were lower on screen, but in more recent years the comprehension gap between reading on a screen versus on paper has been decreasing (Baddeley, 1986). It has been suggested that speed reading and browsing results in an overall decline in the level of comprehension. Plass, Chun, Mayer and Leutner (2003) found that reading comprehension was worse in the visual-annotations only condition as compared to the conditions with no annotations or both verbal and visual annotations. When presented alone, visual image annotations may have introduced confusion, especially for words that was difficult to depict visually, such as 'irritated' and 'instruct'.

Several researchers tested the impact of number of links on navigational efficiency, which serve as a measure of how well readers can process a text's structure. In studies of electronic menu navigation, people were asked to locate a text target, such as a word in an online dictionary. As the number of choices increased, people were slower to make each menu selection. Visual search for text targets was slower in pages with many links as compared to fewer links. This leads to the conclusion that the number of links may be an important source of cognitive load in hypertext to the extent that slowed performance reflects increased task difficulty.

Role of Cognitive Load in Hypertext Reading

Both print text and hypertext provide contexts for learning and organizing complex conceptual information. Processing of hypertext and print text occurs on many levels, from low-level processes like decoding characters, parsing sentences, recognizing words; to higher-level comprehension processes through which readers develop a situational model of the content by integrating new information into their existing knowledgebase. In addition to cognitive processes, reading also involves metacognitive activity. Skilled readers continuously monitor comprehension to identify possible information gaps in their situation model and selectively allocate resources based on relevance and importance of information (Reynolds, 2000).

Same reading processes is grounded in learning from print text and hypertext, but making meaning in a hypertext assisted learning environment places additional cognitive demands on the reader (Niederhauser, Reynolds, Salmen, & Skolmoski, 2000). After reading a given node, hypertext readers must actively decide which informational node to read next, given their interests and learning goals on one hand, and the potential relational-linking options provided by the interface links on the other. Through this process of selecting nodes and monitoring comprehension, readers engage in cognitive activity to integrate concepts from spatially distinct nodes and meta cognitive activity to consider various paths available to them, and choose some paths over other. The additional cognitive and metacognitive processes involved in navigating and making meaning from linked hypertext nodes appears to increase cognitive demands on the reader (Antonenko & Niederhauser, 2010).

Cognitive Neuroscience of Reading

While reading has historical, technological, social and behavioural contexts, it is obviously also a cognitive and neurological activity. Therefore it is reasonable to conclude that the practice of reading digital text is likely to have some neurological implication. Neuroscientific fact is that the structure and function of the human brain changes as a result of internal and external stimulation (Doidge, 2007). While reading has changed the brain, there is a limit to such cerebral plasticity. As cognitive neuroscientist Dehaene (2009) notes, the brain did not evolve for culture, but culture evolved to be learnable by the brain. Through history all writing systems have shared common traits – they tend to be a series of strokes that the brain can be trained to readily interpret. And so over the millennia that human have been reading, reading technologies have evolved from strokes on clay, to scrolls, to modern-day printed books, in order to meet the limited adaptability of the brain. The process of reading on screen tends to be cognitively different from the process of reading on paper, in terms of brain activation, the contextual environment, cognitive focus and reading speed.

Brain Activation

Searching the internet on a topic stimulates more neural circuitry than reading about the topic in a linear e-book (Small, Moody, Siddarth & Bookheimer, 2009). Searching for information and reading that information are two different activities and therefore difficult to compare, that online reading is a more "cognitively complex" process than reading in print due to the phenomenon of hyper linking (Coiro & Dobler, 2007). Linear reading and hyper textual reading are cognitively very different from each other. The choices offered to the reader by online hyperlinks require more mental decisions to be made, and thus require the use of more cerebral "real estate".

The Context is the Message

Another aspect of the cognitive difference between reading onscreen and on paper has to do with the context provided by each reading medium. Darnton (2010) describes how the literary critics 'notion of the "paratext" – the framework of a text – affects the meaning that a reader derives from the text. Just as a book's cover, dedication, and acknowledgements make a "frame" that shapes a reader's interpretation of a book's main text, the paratextual elements of online text are important.

Cognitive Focus and Multitasking

When working with digital information people switches activities every three to ten minutes, that leads to the conclusion that it is just not possible to engage in deep thought about a topic when switches so rapidly. Evidence suggest that multitaskers find cognitive focus difficult, that it takes longer to do two tasks simultaneously than it does to complete the same tasks one after other, and that knowledge gained in dual-task situations can be applied less flexibly in new situations.

Speed and Addiction

Early research found that comprehension levels were lower on screen, but in more recent years the comprehension gap between reading on a screen versus on paper has been decreasing. It has been suggested that speed reading and browsing results in an overall decline in the level of comprehension.

With respect to speed, in the early 1990s, Dillon (1992) found that reading was 20-30 per cent slower on a screen than on paper. More recent research continues to suggest that reading on paper continues to be faster, although some studies found no significant difference between the two. Internet addiction has become accepted as a psychological and medical disorder, and it includes an addiction to reading, writing, and sending of e-mail messages, as well as cell phone texting.

Conclusion

Hypertext systems, like the World Wide Web, provide a linked computer-based information storage and retrieval system, in which massive amount of information are organized into a vast semantic network. The unique characteristics of hypertext provide a mechanism for widening topics through hyperlinks, leading researchers to believe that this format of text presentation requires readers to take a more active approach to reading by interacting more directly with the content. However, despite initial hopes that using hypertext would enhance reading, little empirical evidence exists to supports these claims and cognitive consequences of hypertext assisted reading continue to be debated.

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