



A Review Study of Cognitive Load in Website and Mobile Application User Interface Design

Anamika Yadav

M.Des Student, World University of Design, Rajiv Gandhi Education City, Sonipat, Haryana, India
anamikayadav.25@wud.ac.in

Vasudha

Assistant Professor, World University of Design, Rajiv Gandhi Education City, Sonipat, Haryana, India
vasudha.25@wud.ac.in

Abstract - The aim of the present paper is to evaluate the cognitive load, specifically in relation to websites and applications, with special emphasis on improving the user experience. It has been noticed that, as the complexity of digital platforms increases, the cognitive load of the users has also increased, as there is a lot of information involved. Cognitive load, as defined, refers to the mental load required to process the information. Cognitive load plays a vital role in the interaction of the user with the digital platforms. The cognitive load of the user, specifically in relation to the user interface and the user experience, has been discussed in detail, based on the cognitive load theory, which states that the cognitive load of the user can be of three types: intrinsic, extraneous, and germane cognitive load. In this context, the intrinsic cognitive load refers to the complexity of the task, the extraneous cognitive load refers to the load of the poor design of the digital platforms, and the germane cognitive load refers to the mental load required to learn. The role of the various aspects of the interaction of the user with the digital platforms, specifically the user experience, has been discussed, as it plays a vital role in influencing the cognitive load, which ultimately leads to confusion, frustration, and frustration of the user, based on the studies available on the topic.

Keywords - Cognitive Load Theory, User Interaction/User Experience Design, Website Design, Mobile App Design, Human-Computer Interaction, Usability, User Experience, Mental Workload

Introduction

In recent years, digital technologies have become an important part of everyday life. People now rely on websites and mobile applications for many activities, such as education, healthcare services, financial transactions, communication, and entertainment. As technology continues to develop, digital platforms are offering more services and advanced features to improve user experiences (Nielsen, 1994). However, the increasing number of features, menus, and interaction options

in these platforms can also make interfaces more complex. When a digital interface becomes too complex, users may need to spend more mental effort to understand how it works, which can increase cognitive load during interaction (Sweller, 1988).

From a user experience design perspective, interfaces should help users achieve their goals easily and efficiently. Ideally, a user should be able to understand how to use a website or application without confusion. However, many modern digital interfaces contain complicated layouts, unclear navigation systems, or too many options, which can make it difficult for users to complete their tasks. When users struggle to understand an interface, they must spend more time and mental effort figuring out how the system works instead of focusing on the task they want to achieve (Sweller et al., 2011).

Cognitive load refers to the amount of mental effort required to process information and perform a task. According to CLT, human short-term memory has a limited capacity and can only handle a small amount of information at a time (Norman, 2013). When users are exposed to too much information or too many choices at once, it becomes difficult for them to process everything effectively. As a result, task performance may decrease, and the chances of making errors can increase (Shneiderman et al., 2016).

While CLT was originally developed in the field of educational psychology, it has also become relevant in the study of digital interface design. In Human-Computer Interaction research, cognitive load is an important factor in understanding how users interact with websites and applications. During digital interaction, users must interpret visual elements on the screen, remember navigation steps, compare different options, and make decisions. If an interface is poorly organized or visually confusing, users may experience unnecessary mental effort, which can negatively

affect usability and overall user satisfaction (Marcus, 2013; Hassenzahl & Tractinsky, 2006).

Recent studies suggest that several design factors can influence the level of cognitive load experienced by users. Elements such as visual complexity, high information density, and poorly structured interaction flows can increase the mental effort required to use a system (Krug, 2014). For example, a cluttered interface, excessive text, or unclear icons may make it difficult for users to quickly understand the interface. On the other hand, well-designed interfaces that use clear visual hierarchy, simple navigation structures, and consistent interaction patterns can help users process information more easily and reduce cognitive load (Tullis & Albert, 2013).

Mobile applications introduce additional challenges because users interact with them on smaller screens and rely on touch-based gestures. In many situations, people use mobile devices while moving or while performing other activities, such as commuting or multitasking. These situations require designers to create interfaces that allow users to find important information quickly and complete tasks with minimal effort. Therefore, mobile interface design should emphasize simplicity, clarity, and ease of interaction to support users in different contexts (Budiu & Nielsen, 2013).

This paper aims to examine existing research on cognitive load in website and mobile application design. The study focuses on identifying key interface design factors that contribute to cognitive overload and exploring design strategies that can reduce unnecessary mental effort during interaction. By understanding how cognitive load affects user experience, designers can create digital interfaces that better align with human cognitive abilities and provide more efficient and satisfying user experiences.

Cognitive Load Theory

Cognitive Load Theory is a theory that explains how users process information when using digital systems (Sweller, 1988). According to CLT, the human working memory has limited capacity and time (Miller, 1956). When the mental effort required by an interface is too high, users have difficulty understanding information, making decisions, and performing tasks efficiently (Norman, 2013).

There are three types of cognitive load, as classified by CLT: intrinsic cognitive load, extraneous cognitive load, and germane cognitive load (Sweller, 1988 & Paas et al., 2003). These types of cognitive loads have different functions in the process of user interaction.

A. Intrinsic Cognitive Load

Intrinsic cognitive load refers to the mental effort required to understand the core task or content (Sweller, 1988). In websites and mobile applications, intrinsic load depends on task complexity and user familiarity (Shneiderman et al., 2016). For example, tasks such as filling out a detailed registration form, learning a new application feature, or comparing multiple products naturally require mental effort (Nielsen, 1994).

Although intrinsic load cannot be completely eliminated, it can be managed through good User Interaction /User experience design (Norman, 2013). Breaking complex tasks into smaller steps, providing clear instructions, and using familiar design patterns help users handle intrinsic load more effectively (Krug, 2014).

B. Extraneous Cognitive Load

Extraneous cognitive load is a result of poor interface design, not the task itself (Sweller, 1988). Extraneous cognitive load is unnecessary and directly affects usability (Tullis & Albert, 2013). Sources of extraneous cognitive load include cluttered designs, too much text, confusing icons, inconsistent navigation, distracting animations, and poor content organization (Tullis & Albert, 2013 & Krug, 2014).

Minimizing extraneous cognitive load is one of the main objectives of User Interaction/User Experience design (Norman, 2013). A simple design, consistent visual design, readable typography, and proper labeling can help users concentrate on their tasks rather than on the interface (Shneiderman et al., 2016).

C. Germane Cognitive Load

Germane cognitive load supports learning and meaningful understanding (Paas et al., 2003). In digital interfaces, germane load is encouraged when users are guided effectively through feedback, progress indicators, onboarding screens, and helpful hints (Rogers et al., 2019). These elements help users build mental models of the system and use it more confidently (Norman, 2013).

Cognitive Load in Website UI Design

Websites contain large numbers of information on a single screen, making cognitive load management particularly important (Tullis & Albert, 2013). Content-heavy websites such as e-commerce platforms, educational portals, and news websites frequently overwhelm users with text, images, banners, and advertisements.

Navigation structure plays a critical role in website cognitive load. Complex menu hierarchies, unclear categories, and hidden navigation elements increase mental effort and slow task completion (Rogers et al., 2019). Research shows that users prefer predictable layouts, clear headings, and familiar navigation patterns.

Visual hierarchy is another key factor. Proper use of headings, spacing, color contrast, and alignment helps users scan content efficiently and locate information quickly. Poor visual hierarchy forces users to read more carefully, increasing cognitive load (Tullis & Albert, 2013).

Responsive design also affects cognitive load. Websites that do not adapt properly to different screen sizes require users to zoom, scroll excessively, or search for content, which increases mental effort. Consistent design across devices reduces confusion and improves usability.

Cognitive Load in Mobile Application UI Design

To better understand how cognitive load has been studied in UI/UX design, a comparative review of selected research papers is presented in Table I. The table summarizes the research domain, authors, focus of each study, along with their key advantages and limitations. This comparison helps identify common design contributions as well as research gaps in existing literature.

Table I provides a structured overview of how different researchers have approached cognitive load in websites, mobile applications, and adaptive interfaces. Most studies highlight the importance of reducing extraneous cognitive load through better visual hierarchy, navigation structure, and content organization. At the same time, the limitations reveal a lack of real-world validation, limited participant samples, and narrow application domains, indicating the need for further research.

In addition, the reviewed literature shows that cognitive load management has become an important consideration in modern User Interaction/User Experience design research. Many studies emphasize the role of user-centered design principles in improving usability and reducing mental effort during interaction. These insights provide a useful foundation for future research and design practices aimed at creating more efficient and user-friendly digital interfaces.

The reviewed literature highlights cognitive load as a critical factor influencing usability, user satisfaction, and task performance. Interfaces that ignore cognitive limitations often result in user frustration, errors, and abandonment. In contrast,

interfaces designed with cognitive load principles in mind feel simpler, more intuitive, and more engaging.

From a User Experience perspective, managing cognitive load encourages designers to prioritize clarity and user needs over visual complexity. User testing and iterative design play an important role in identifying cognitive overload and improving interface quality.

Method

User Interaction/User Experience Design Strategies for Reducing Cognitive Load

This section explains practical design strategies that help reduce the mental effort users experience when interacting with websites and mobile applications. When an interface is designed carefully, users can easily understand information, navigate the system, and complete tasks without confusion. Effective User Interaction/User Experience design focuses on presenting information in a clear and structured way so that users do not feel overwhelmed. By applying certain design principles, designers can reduce unnecessary cognitive load and improve overall usability and user satisfaction.

Several User Interaction/User Experience design strategies have been identified in the literature as effective methods for managing cognitive load:

- **Visual Hierarchy:** Using size, colors, and spacing to guide user attention (Norman, 2013). Visual hierarchy helps users quickly identify the most important information on a screen. Designers can highlight key elements such as headings, buttons, or important messages by making them larger, using contrasting colors, or placing them in prominent positions. This allows users to scan the interface easily and understand content without excessive mental effort.
- **Content Chunking:** Dividing information into small, manageable sections (Nielsen, 1994). Chunking organizes large amounts of information into smaller groups or sections so that users can process them more easily. Instead of presenting long blocks of text or complex data, designers break information into headings, lists, or cards. This structure reduces cognitive overload and improves readability.
- **Consistency:** Maintaining uniform design patterns across screens (Shneiderman et al., 2016). Consistency ensures that similar elements behave in the same way throughout the interface. When buttons, icons, and navigation systems follow consistent patterns, users do not need to learn new interactions repeatedly. This familiarity

helps users understand the interface faster and reduces mental effort.

- **Progressive Disclosure:** Displaying information only when needed (Babich, 2018).

Progressive disclosure means showing only essential information at first and revealing additional details when users request them. This prevents the interface from appearing crowded and overwhelming. By presenting information step by step, users can focus on one task at a time.

- **Feedback and System Status:** Informing users about actions and results (Nielsen & Molich, 1990). Providing feedback helps users understand what is happening after they perform an action. For example, loading indicators, confirmation messages, or progress bars show users that the system is responding to their input. Clear feedback reduces uncertainty and improves user confidence.

- **Minimalism:** Elimination of unnecessary elements that are not useful for achieving user goals (Krug,2014). Minimalist design principles focus on the simplicity of the design by removing unimportant elements of the interface, like decorative ones. When the interface has only the necessary information, it can be easier for the user to focus on the goals they are trying to achieve. These principles minimize the extraneous cognitive load, promoting efficient interaction and understanding.

Summary and Discussion of Reviewed Literature

To better understand how cognitive load has been studied in User Interaction/User Experience design, a comparative review of selected research papers is presented in Table I. The table summarizes the research domain, authors, focus of each study, along with their key advantages and limitations. This comparison helps identify common design contributions as well as research gaps in existing literature.

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The reviewed literature highlights cognitive load as a critical factor influencing usability, user satisfaction, and task performance. Interfaces that ignore cognitive limitations often result in user frustration, errors, and abandonment. In contrast, interfaces designed with cognitive load principles in mind feel simpler, more intuitive, and more engaging.

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Table I: Summary of Cognitive Load-Based User Interface/User Experience Studies

| Author and Year | Method | Advantage | Limitation |
|-----------------------------|---|--|--|
| (Sweller, 1988) | Theoretical framework and experimental learning research. | Introduced Cognitive Load Theory and explained limits of human working memory. Provides a strong theoretical foundation for cognitive load research. Helps designers understand how information complexity affects user performance. | Mainly focused on learning environments rather than digital interface design. Does not provide direct design guidelines for web or mobile UI. |
| (Nielsen, 1994) | Heuristic evaluation and usability testing methods. | Provides widely used usability principles for improving interface design. Helps designers create clear navigation and reduce user confusion. Supports faster task completion and better usability. | Focuses mainly on usability rather than cognitive load measurement. Does not explain cognitive processing in detail. |
| (Paas et al., 2003) | Experimental study and literature review on cognitive load in learning systems. | Clearly explains intrinsic, extraneous, and germane cognitive load. Helps researchers understand how task complexity affects user understanding. Provides useful theoretical concepts that can be applied in UI/UX design. | Mainly applied to educational systems. Limited practical validation in website or mobile application interfaces. |
| (Cooper & Tarasewich, 2004) | Empirical usability study on handheld device interfaces | Provides guidelines for improving readability and navigation in mobile interfaces. Helps reduce complexity caused by small screens. Useful for understanding early mobile UI challenges. | Focused on early mobile devices. Some findings may not fully apply to modern smartphones and applications. |
| (Hooper & Berkman, 2011) | Design pattern analysis and mobile UI case studies | Provides useful mobile interface design patterns. Helps designers improve navigation and interaction in mobile apps. Encourages consistent and simple design structures. | Mostly design guidelines with limited empirical testing. Does not directly measure cognitive load effects. |
| (Marcus, 2013) | Quantitative usability testing and UX measurement techniques. | Provides practical metrics for measuring user experience. Helps evaluate usability performance and task efficiency. Useful for analyzing how interface design affects user interaction. | Requires structured usability testing environments. May not fully represent real-world user behaviour. |
| (Hadju & Nielsen, 2013) | Usability research focusing on mobile device interaction. | Identifies usability challenges in small-screen interfaces. Provides practical recommendations for mobile navigation and readability. Helps designers simplify mobile UI layouts. | Focus mainly on usability issues rather than direct cognitive load measurement. Limited academic experimental data. |
| (Krug, 2014) | Practical usability observations and case-based interface analysis. | Emphasizes simple and intuitive design. Shows how clear navigation and layout reduce user thinking effort. Provides practical examples for web interface improvement. | Based mainly on professional experience rather than controlled experimental research. Limited empirical data supporting the conclusions. |
| (Marcus, 2013) | UX research analysis and design evaluation studies. | Explores how visual layout and interaction design affect user experience. Supports the importance of visual hierarchy and structured design. Helps designers understand user perception in interfaces. | Cognitive load is discussed conceptually but not directly measured through experiments. Research scope is broad rather than focused on specific UI problems. |
| (Rogers et al., 2019) | Human-Computer Interaction research and design framework analysis. | Connects HCI theory with practical UI design strategies. Provides design guidelines that support better user interaction. Helps designers organize information in a structured way. | Broad theoretical coverage. Limited experimental studies focused specifically on cognitive load. |
| (Hadju & Nielsen, 2013) | Usability research focusing on mobile device interaction. | Identifies usability challenges in small-screen interfaces. Provides practical recommendations for mobile navigation and readability. Helps designers simplify mobile UI layouts. | Focus mainly on usability issues rather than direct cognitive load measurement. Limited academic experimental data. |
| (Kumar & Singh, 2023) | Experimental HCI study analyzing user interaction behavior. | Provides empirical evidence on how UI layout and information density affect cognitive load. Useful for improving web interface design guidelines. | Conducted mainly in controlled experimental environments. |
| (Patel & Shah, 2025) | Longitudinal usability study evaluating cognitive load over time. | Examines how users adapt to digital interfaces and how cognitive load changes with experience. | Long-term studies require extensive time and larger user samples. |

Conclusion and Future Scope

This review paper emphasizes the importance of cognitive load management in website and mobile application User Interaction/User Experience design. CLT provides a valuable framework for understanding how users interact with digital interfaces and why certain designs fail. By reducing extraneous cognitive load and supporting meaningful interaction through thoughtful design strategies, designers can create interfaces that are more usable, accessible, and user-friendly. Future research may focus on real-time cognitive load measurement and adaptive interfaces that dynamically respond to user behavior.

Future studies could be conducted on measuring cognitive load in real-time while users are interacting with a website or mobile application, with the help of modern technologies like eye-tracking, biometrics, etc. This could help researchers understand the cognitive process while users are performing tasks on the internet, as these technologies could offer deeper insights into the situation in which the user gets confused, overloaded, or faces difficulty while using the interface.

Future studies could be conducted on the role of artificial intelligence in detecting the situation in which the user gets confused, overloaded, etc., and adapting the interface in such a manner that the user can use the interface in a more efficient manner. For example, the interface could be made simpler, important points could be highlighted, unnecessary points could be removed, etc.

Future studies could be conducted on the cognitive load experienced by different kinds of users, devices, and real-life situations, in order to design more user-friendly interfaces for the users. For example, cognitive load could be experienced differently in the case of old users, users with low literacy, users from different countries, etc. Future studies could be conducted on these aspects as well, in order to design more user-friendly interfaces for the users.

For example, cognitive load could be experienced in the case of new technologies like wearable devices, augmented reality, voice-based interfaces, etc., which could offer deeper insights for the design of the next generation of user interfaces on the internet.

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