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Interface Complexity and Cognitive Load During Multitasking

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***Abstract*— A person's ability to interact with the computer largely depends on how easily the interface can be understood and used. The more controls, information and ways of navigate are displayed on the screen the more mental effort is required to complete a certain task. It becomes especially significant during multitasking as the user continuously switches between different information and different actions. In this paper we compare two conceptual designs of the interface, one with low complexity and one with high complexity. Both design provides the same functions but they differ in the amount of information, its organization and control visibility. based on the principles of Cognitive Load Theory, we claim that removal of unnecessary complexity decreases the amount of too much information and the concept of personalization as a way of letting users make a choice. Lastly, we provide list of design recommendations for the interfaces designed for multitasking.**

Keywords—cognitive load, human-computer interaction, interface complexity, multitasking, usability, visual organization

I. Introduction

The concept of Cognitive Load Theory (CLT) can be considered a good approach to this issue. This theory divides the cognitive load into three components such as: intrinsic, extraneous and germane [4], [5]. Intrinsic load is determined by the level of difficulty of the task. Extraneous load is caused by the manner how the information is organized and presented. Germane effort is the mental work that is spent on understanding and memorizing new material. Clutter, confusing labels and other features of the interface design increase the amount of extraneous load and distract from the primary task.

For this study, we have not conducted any user experiments in a controlled environment. We compared two interface designs that are implemented in a conceptual way – low-complexity one and high-complexity one. These interfaces perform the same functions, however, they differ in the amount of information, its organization, navigation and control visibility. Thus, we were able not to change the functionality and see how the difference in interface influences the required mental effort for multitasking.

II. Background and Related Work

A. Cognitive Load and Interface Interaction

The cognitive load is the effort required from a person to acquire information and complete the particular task. In this case, the most important resource is the working memory that allow storing the information temporarily and use it while performing a certain task. The working memory capacity is quite small. For instance, according to Miller, a person can memorize only seven items [8], and these items disappear in 20 seconds unless there is any recall [7]. All three types of loads increases, the available space. That means that as one type of load grows, there is less space for other types of loads decreases [4], [5]. In this respect, if an interface produces extraneous cognitive load, it is spent on cleaning the mess rather than on doing the actual task.

In this way, the minimum amount of extraneous load allows a person to do the same task using less resources. In a well-designed interface, all the necessary information is provided to a user without any controls, unnecessary grouping, and steps. On the other hand, simplicity is not necessarily good. The exact amount of items to display depends on the task, the user's experience, and the system's capabilities.

B. Measurement of the Mental Workload

A number of different methods have been developed by researchers to estimate human workload in interaction with computers. The most common method is NASA-TLX, that is a subjective measure which estimates the workload according to the perception of mental, physical, and temporal demands, performance, effort, and frustration [6]. Other methods involve the Workload Profile, SWAT, eye-tracking, physiological and behavioral measures that give observable data [3]. In the combination, they prove that the human workload is both a subjective and a measurable phenomenon.

Furthermore, eye tracking helps to be find out the areas where efforts are put in. Specifically, the fixation duration and the number of fixation are evaluated by researchers – these are the points where the gaze focuses on certain words or objects and saccades, the jumps that occur between the fixations [11]. High fixation duration and saccade randomness mean that a person faces difficulties decoding the information displayed on the screen [7]. In context of the study of user interfaces, such metrics can help to detetmine the overloaded areas.

Also, physiological measures are able to trace the changes in the level of the load related to the nature of the load while multitasking. For example, a high level of the pupillary dilation is expected when the load level becomes too high; other measures include the usage of the EEG and fNIRS. Physiological measures are less biased compared to questionnaires; however, they request for measurement.

For this paper we haven't collected any workload related data. This approach allows for getting the reasons for importance of interface complexity. possible experiment in the future may use such metrics as task completion time, error rate,

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task success rate and workload estimation in order to confirm if our opposites actually exist.

C. Interface Organization and Usability

Interface organization influences on the ability to perceive and understand information presented on the interface. Visual hierarchy, grouping, clarity, and controls placement of controls affects the way how users navigate in the system [2], [3]. Grouping similar objects makes the structure of the interface more perceivable. In case the similar object seem equally important user should make extra efforts in order to understand them.

This problem becomes even more significant in the case of multitasking since users continuously switch attention and return to the same interface. Well organized layout decreses the efforts required to find necessary information for completing a task, while poorly organized interface requires scanning several areas of the scree to find a particular control.

Presentation of the text is also the component of extraneous load which can be controlled by desingers directly. Readability studies recommends to set large default font size, which can be increased by user, high contrast between text and background, and plain typefaces instead of decorated ones [7]. Spacing is also important. According to W3C accessibility guidelines the content must remain available when line height is at least 1.5 times the font size, paragraph spacing is at least 2 times, letter spacing is at least 0.12 times, and word spacing is at least 0.16 times [10]. There are less definite recommendations on some aspects. The Studies of dark mode and fonts for dyslexic people yield contradictory results depending on users habits and experinence [7]. This means that some aspects of interface need to be regulated by designers while others require personal user adjustment.

Some typography questions are less vague than others. Earlier studies preferred sans-serif fonts for better readability on the screen, but on modern high-resolution screen serif and sans-serif fonts perform approximately equally well [12], [13]. Letter spacing is better supported. It reduces the problem of crowding, interference between neighbouring letters, and one study showed that wider spacing increases readability for dyslexic children by 13% and for ordinary people by 5%[14], [15].

In addition to that, colors applied in an app's design may also influence the legibility of texts. A too large difference between the colors (such as black texts against bright white background) will lead to strain for the eyes, whereas cream and warm-colored backgrounds will be helpful for dyslexics [16], [17]. Dark mode is one of the most popular modes which positive impact has not been confirmed yet. Though the dark mode is popular among the users, it has been shown that it leads to higher cognitive load and affects text perception negatively [18].

There is nothing about the interface itself that makes the application complex. The complexity of an application relies on On the basis of a combination of several aspects, for instance, number of controls, amount of data that is being presented, number of navigation steps, and complexity of perception of relationships between interface elements. There are mutual dependencies between these aspects since the presence of many controls does not necessarily mean a complex interface.

III. Comparative Interface Analysis

In this section, there will be an analysis of two interfaces that provide the same information and functionalities but use different ways to display and control them. These interfaces will be compared on the basis of information density, controls visibility, visual grouping, navigation, information retrieval and extraneous load. In this case, "low-complexity" and "high-complexity" just refer to the presentation of objects and do not define what interface is better to use in each particular situation.

A. Low-Complexity Interface

In the case of the low-complexity interface, the relevant data appears with the aid of fewer visible components. The associated information is arranged in distinct regions while unnecessary controls are segregated from the primary display. Navigation is straightforward, hence making it possible to access common actions directly, without having to navigate through various menu levels.

- Some few controls and options are available.
- The associated information is presented together.
- The primary workspace displays very little visual clutter.
- Fewer alternatives make it easier to navigate the interface.
- The primary data is distinct from the secondary data.

The interface allows multitasking since users are able to return to their tasks and see where they stopped easily. With fewer components, there is less visual data to process.

B. High-Complexity Interface

A high complexity user interface will display multiple controls and data in one visible area. The interface will normally contain several panels, menus, indicators, and navigation aids all at once. While the same data may be accessed, it is hard to spot the grouping of data with so many elements displayed together.

- There is more data present in the workspace.
- There are more navigation tools available.
- There are many visual elements competing for the user's attention.
- There are data elements that are not clearly grouped.
- It becomes harder to find the specific element..

C. Comparative Analysis of the Two Designs

Table I contains those differences which we would be able to find between these two designs. They have been identified after analysis of the designs. What we want to state here is that both these designs should not vary in terms of capacity but rather in usability.

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TABLE I
EXPECTED DIFFERENCES BETWEEN THE TWO INTERFACE DESIGNS

Factor	Low Complexity	High Complexity
Information density	Lower	Higher
Visible controls	Limited	Numerous
Visual grouping	Clear	More crowded
Navigation	Simpler	More choices
Information search	Expected to be easier	Expected to require more searching
Visual clutter	Low	Higher
Extraneous load	Expected to be lower	Expected to be higher
Multitasking support	More focused	More demanding

D. Analytical Criteria

Comparison is done according to the presentation criteria, but not according to the measured impact on the outcomes of the users. Information density is defined by the number of information units presented simultaneously, while control visibility refers to the number of control units that can be seen without additional effort. The other criteria used are visual proximity, which reflects proximity of the visually related information units, and navigation complexity, which reflects the number of decisions and actions needed to reach the desired functionality.

The criteria relate to elements of the user interface which can be modified without changing the functionality of the system. This is because one task can be displayed using different interface designs, grouping of controls and navigation schemes such that the analysis examines the influence of presentation rather than difficulty of the task.

IV. MULTITASKING AND COGNITIVE EFFORT

A. Task Switching

When multitasking, users have to split their attention between different activities or switch between them quickly. Every switch means working out where they were, finding the relevant information, and deciding what to do next. A complex interface adds to this, because the user has to find their way to the screen while trying to remember the state where they left.

A low-complexity interface makes the recovery easy by keeping important information visible and in groups that are easy to recognise. A high-complexity interface may need more scanning to find the same information, and this becomes more noticeable when users switch tasks often.

Research on task switching suggest that what people call multitasking is usually fast switching between their tasks, not doing them at the same time [22]. Each switch has a cost: the person needs time to set up for the new task, and accuracy often drops just after a switch [22]. Switching between very different types of tasks costs more than switching between similar ones. In a team simulation study, participants who switched between different task sets less often keep more working-memory capacity free and achieved higher scores [23].

B. Information Density and Search

The density of information in itself is not an adverse thing. For example, some monitoring systems, programs for engineers and workstations require a lot of information to be provided in order to be used. What matters here is whether the presented information is appropriate and structured in such a way that allows establishing connections between different pieces of information. When there are no connections between pieces of information but they are presented in an equally prominent way, users have to put extra effort into finding what they are looking for.

Speaking about Cognitive Load Theory, the extraneous load is primarily associated with the effort required to search and process information due to presentation. Though the task remains the same, the difficulty of its implementation increases greatly because of the interface. This needs to be considered since simplifying the presentation does not mean losing the necessary functionality.

C. Visual Hierarchy and Task State Recovery

In multitasking interface design, the location and representation of frequently accessed data can be important. In the case of having to access a menu or panel every time one has to know the state of a task, each such search imposes cognitive workload. A constant structure helps in reducing such repetitive searches.

D. Interruptions and Notifications

Interruptions increase these costs. Email, instant messaging, and other forms of notification disrupt the flow of the user's work and cause an unanticipated switch [24]. In one widely cited experiment, those users who experienced interruptions completed tasks faster but felt more stressed, frustrated, and pressed for time, suggesting that they compensated for their interruptions by working harder [25]. Digital work tools may also foster a culture of availability in which the user feels obligated to react to several stimuli simultaneously [24]. From the perspective of interface design, this implies that the application's method of providing notification counts as part of its cognitive load.

E. Task Complexity and Element Interactivity

Moreover, the extent of the effect is determined by the nature of tasks since the greater effect was found in relation to complicated tasks. The task complexity is measured by means of element interactivity that is defined as the number of information elements to process simultaneously according to Cognitive Load theory [26]. There are findings of an empirical study conducted with the participation of 300 managers involved in multitasking with several projects in which multitasking was positively correlated with high levels of cognitive load, higher levels of cognitive load were negatively correlated with inefficient decision-making and poor performance of projects, and the correlation between multitasking and cognitive load has been more influential on task complexity [24]. The research is based on self-reports using questionnaires; thus, only association and not causation is

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indicated but the results are consistent with the assumptions of Table I.

V. Design Considerations

A. Information Hierarchy

A good interface should show clearly which information is the most important for the particular task. Major items may be emphasized, whereas secondary items may be included in groups or panels that are available upon request. Thus, the system retains all its functionality but does not clutter everything with equal importance.

B. Progressive Disclosure

It is a useful method for systems that have many features. Rather than displaying all controls in one place at once, secondary features are kept in menus or other views. Thus, fewer controls compete for users' attention in the main work area. Advanced controls remain accessible when needed.

C. Hidden Cognitive Load

On the other hand, making the screen simple by hiding the functions has its price. As Sarkar writes, an excessive emphasis on simplicity may lead to limiting the capabilities provided by the program [9]. Hiding any function simply to make the interface simple will force users to search for the needed function. This problem is called hidden cognitive load [7]. Functional minimalism is more suitable in this situation since the simplification process is achieved through removal of the unnecessary elements rather than by hiding necessary functions [7], [9].

The use of the collapsing navigation panels is a good example of such tradeoff. It is possible to find web-based applications where the size of the side navigation menu is reduced to only icons without names. The applications based on artificial intelligence hide the navigation menu completely and users have to call it each time they need to switch to another section of the program [7]. Such solution works fine in case of one-action scenario but not when several actions should be performed simultaneously.

D. Consistency and Navigation

Keeping controls and navigation paths in the same place makes functions easier to find. If the same action appears in different places on different screens, users have to reorient themselves every time. A consistent structure helps users get used to repeated interactions and reduces the effort needed to read the interface.

E. User Experience Level

The user's experience will determine the way complexity can be approached. While an experienced user may require an interface that is full of options which can be accessed very quickly, a novice user may get confused with the interface. Thus, simplification is not only about removing features but it is more about determining what information to display and how to arrange it.

F. Personalisation and Adaptive Interfaces

Since no single level of complexity suits everyone, one practical answer is to let users set it themselves. Professional tools often let users move, pin, hide, and collapse panels, change the interface scale, and save their own workspace layouts [7]. Some communication apps offer a simplified layout mode that removes distracting elements and gives the desktop version a cleaner, mobile-like look [7]. Features like these let beginners keep a simple view while experienced users open up more functions, which directly addresses the conflict between simplicity and control discussed above.

Artificial intelligence may take this further. Tools built on large language models can already shorten text, simplify wording, or summarise a page when the user asks for it [7]. A possible next step is an interface that adjusts itself to the user's experience level, current task, and screen size, changing how dense the information is and how technical the wording is [7]. Such adaptive behaviour would need careful design, since an interface that keeps changing on its own could also make it harder for users to find things during multitasking.

Font choice shows why personalisation is useful. Fonts made for readers with dyslexia, such as OpenDyslexic, helped some readers in eye-tracking studies but showed no gain in reading speed or accuracy in others [19], [20]. Since the same font can help one group and slow down another, it makes more sense to let users choose their font than to pick one for everyone [7]. Some messaging apps already allow this, and browser extensions go further by letting users reflow a page into columns, change fonts and colours, or add a reading guide that highlights one line at a time [7].

G. Clear Interface Text

The Short texts within the interface, such as button labels, error messages, and hints, may have an impact on the cognitive load as well. Complex and lengthy sentences make a user hold multiple ideas in mind at once. Sentences that are around 7-14 words are easy to comprehend instantly, while comprehension becomes significantly harder if the sentences are way longer [7]. Short and clear labels will be particularly beneficial for interfaces which are used while multitasking and the user is merely glancing at the screen.

It should be noted that not all text in the interface can be designed and controlled by the designers. Label, error messages, and hints could be crafted carefully by UX writers; however, posts, messages, and other user-generated content cannot be of the same length and complexity [7]. The role of AI-powered summaries becomes more and more significant today. Today many searches end up without a visit to any website, since there appears to be a short answer from the AI [21], [7]. Such approach will help reduce cognitive load for the user while multitasking. However, it involves reliance on the summary's accuracy.

H. Managing Interruptions

Switching costs may also be minimized through direct interventions on the part of designers. Design elements that include group notifications, non-disruptive functions, dashboards indicating the state of multiple activities together, and simple priority setting mechanisms all serve to lower switching costs by reducing the amount of switching done [24].

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All of these design elements accomplish the same thing as low-complexity design: less demand for attention at once.

VI. Discussion

This comparison points to a basic idea in HCI: complexity comes from both the task and the way it is presented. Two systems with the same functions can place very different visual and navigation demands on the user. Earlier work on workload and usability supports this by looking at how interface organisation relates to mental effort and task performance [1]–[3].

The low-complexity design groups related information and cuts down visual noise, which makes key data easier to spot. The high-complexity design needs more scanning, since many control areas and information fields compete for attention. This difference matters most during multitasking, when switching between activities already adds to the mental load.

Still, complexity on its own does not tell us whether a design is good or bad. Some tasks are complex by nature and need many controls, and removing them could break the functionality or slow down experienced users. The aim is to get rid of complexity that is not needed while keeping the functions the task really depends on.

This is why cognitive load should be considered together with usability. Showing fewer elements can make the screen clearer, but it can also make important functions harder to find. On the other hand, showing more information is sometimes necessary when users need certain data in view all the time. Good interface design comes down to balancing how much information is available with how clearly it is organised.

The effect is not limited to speed. Under high cognitive load, people tend to fall back on shortcuts or rules of thumb when making decisions, which can lower the quality of their choices [24]. An interface that adds unnecessary load during multitasking may therefore affect not only how fast users work, but also how well they decide.

VII. Limitations and Future Work

The current study should be treated as a comparative analysis but not as a controlled user test since participants' reaction times, task errors, and workloads have not been obtained in this study. Consequently, the differences presented in Table I are expected effects based on HCI and cognitive load theories, and not proved findings of the test.

The complexity can be limited to two levels only in this study whereas in practice it can be many degrees in each of the aspects of the interface. Also, efficiency of interface usage depends on the task and user's previous experience.

Certainly, the first step in development of this analysis is its transformation into a controlled user test when users will perform the same tasks for both versions of the interface, and their reaction times, task errors, success rates, and subjective workloads will be measured. The latter could be assessed with standard measures using the well-known NASA-TLX method [6].

Eye-tracking can also be applied as a measure in the experiment. By comparing the measures of fixation and saccade in regard to both variants of the interface, it will be possible to identify areas which require additional visual effort and, hence, either confirm or refute assumptions made in Table I [11].

It would be interesting to investigate a variety of tasks. Maybe, looking-up task is influenced differently by interface density than the task of monitoring which presupposes displaying of a large amount of information simultaneously. Different kinds of tasks will help to define whether the relationship between the complexity of interface and the workload of users is conditioned by the task itself.

Finally, the research conducted over long periods of time would be useful in the course of further investigations. Cognitive load investigation of the interface is usually conducted during short-time sessions when people read continuous text, while real users interact with the interface for weeks or even months and perform their tasks using fragments of texts in visually complicated environment [7].

VIII. Conclusion

Complexity of the interface plays an important role in human-computer interaction especially in those scenarios where several tasks are being done simultaneously. This paper attempts to compare two interfaces that have different levels of complexity but do the same job. The first interface is a low-complexity conceptual interface while the second interface is a high-complexity conceptual interface. Both interfaces are meant to achieve similar objectives.

Simplification of the interface by removing unnecessary parts and providing information in a clear form will reduce cognitive load and make task switching easier. However, simplicity of the interface should not result in reduction of functions that are required in some situations. This is because simplicity will simply shift the load from one task to another. It is possible to make the user control simplification level.

In light of the fact that this study takes place with regard to analysis and not with user testing, the differences should be taken into consideration as design criteria and not as outcomes of any measurement. This could be checked through additional research involving user testing that combines objective and subjective measurements.

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