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Impact of Custom Interface Widgets on User Efficiency in Content Navigation Platforms

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ABSTRACT

The simplest unit of functionality of user interface with digital systems is interface widgets. In spite of their seeming simplicity, the type, location, and design reasoning to the background of such widgets is what defines the efficiency with which a user navigates material-dense sites. This research looks into adjusting the design properties of a widget to the features of user efficiency (time taken to complete a task, rate of errors and cognitive load). This study involves 120 subjects in an experimental design with mixed methods and on three content navigator platforms and it measures performance based on 5 forms of widgets which include menus, scrollable conglomerates, adaptive items, navigation aids and controller of forms. Findings reveal the reduction in task completion times is an average of 18.4 more in hierarchical structure than mixed-structure alternatives and that in adaptive promotion of widgets, the error rates were less by 21.3. There is also a reduction in the cognitive load as captured through the fixations of the eye which is significantly reduced in linear navigation settings. These represent some of the quantitative constructs that can support the current qualitative recommendations and add design specifications to web, mobile and embedded content platforms.

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1. INTRODUCTION

The layout of the widgets, or the way navigation menu and scroll containers, buttons, interactive controls are organized, is what determines whether that user is successful, or not. That particular issue is taken into consideration in this paper.

Platforms of content navigators, such as library systems, interfaces of health records, news apps, and educational portals, have a common problem. They are required to offer big amounts of organized facts to users that differ in their level of skills, gadgets and work. The interface between information saved and human knowledge is the widget layer which is the component of the interface that users touch/click on. The system will fade away with good system design in terms of widgets.

The amount and dispersal of literature on this topic is very large. The design of menu, scroll, cognitive load during navigation, adaptive interfaces, distribution of attention on mobile screens has been investigated in a relative isolation by the researchers. A limited number of studies have combined all of these threads into a coherent and quantitative study of the joint and specific effect of widget type and widget configuration on efficiency in various platform settings.

The gap is filled by this study. It compares five categories of widget to three outcomes of efficiency that can be measured, time spent to perform a task, error, and cognitive load in three platforms and 120 individuals. It is not aimed at coming up with abstract recommendations but to come up with reproducible, quantitative evidence which can be applied directly by designers and creators.

The remainder of the paper continues as follows. Section II examines the pertinent literature review in the categories of the widgets. Section III tells about the experimental procedure. The results and discussion are provided in section IV. In Section V, conclusions, and design implications are mentioned.

2. LITERATURE REVIEW

The connection between the structure in any form of navigation and the user behaviour has been observed over a few decades, though with the emergence in the variety of devices, the field of study has changed significantly. Initial efforts were on desktop web navigation where the screens were spacious and the users sat inactive. That is a setting that is no longer prevalent.

The efficiency of navigation is based upon the ability of the interface to be complementary to the mental model of the user with regard to the information structure. Improved mental representations The cognitive models of the web navigation (CoLiDeS family of models) are used to model user behavior in terms of choosing links and paths based upon the semantic similarity between the goals pursued by the user and the links in the web pages [1]. Empirical experiments of these models on actual websites show that incorporating contextual of the path and backtracking logic enhances predicted success rates on tasks as opposed to simpler models [2]. Practically what this means is that navigation widgets ought to show the expected direction that the user wants to go, not simply the hierarchy the developer wishes the user to follow.

In mobile devices, the effect of design on the performance of the widget is greater than in a desktop device since there is limited space on the screen and interaction is less fine. An investigation of mobile news websites revealed that single page designs were better compared to multi-page and zoom based designs in ease of use, reading time and experience as a whole [3]. In older adults, in particular, linear hierarchical structures of navigation were more effective in terms of accomplishing tasks and reduced cognitive load, as compared to mixed structures, where efficiency of interaction between navigation structure and cognitive load was statistically significant [4]. These results are in line with various platforms.

Research on menu designing is more detailed. A comparative experiment between full, collapsible and cascading types of menus on smartphones versus smartwatches showed that menu type has a noticeable effect on the efficiency of menus and that the right type of menu depends on the breadth of the menu as well as the device type [5]. When it comes to watches, fewer preview items put on a static menu, which grew larger in height after scrolling down, was better. With phones chosen, more preview items in collapsible menus were better. This specificity matters. The recommendation of the widgets cannot be device-sufficient.

The issue of effort in the interaction of the widgets has been modeled using the micro-measures based on interaction logs. Gardey et al. suggest that a single score can be used to determine the extra load on users that a given input context may add when using a widget other than the most suitable [6]. Such a score predicts human ratings of experts on the appropriateness of a widget reasonably well and indicates that interaction effort may be independently measured and compared across types of widgets as opposed to having some qualitative descriptions.

On interfaces of mobile apps, people spend much more fixations on the bottom-left sticker of the screen, a phenomenon promising under the conditions that they remove colors and backgrounds [7]. The first fixation area (bottom-left) is negatively associated with the smartphone operation skill such that less skilled users tend to fixate on it first. The positioning of widgets in reference to natural attention areas thus directly correlates with the responsiveness to locating and interacting with controls.

One solution to the variation in the needs of users and their usage patterns is adaptive interfaces. Adaptive web navigation is generalized to general graphical interfaces by the idea of widget promotion and demotion, that is, controls that are frequently used are visually highlighted and those seldom used are de-emphasized [8]. With this implementation, the interface is able to restructure itself according to the real-life usage without the need to be set up by the user.

Analytics-based studies of the behavioral pattern of click streams and heat maps across various websites have revealed that behavioral-based navigation designs, which are designed based on machine learning models, trained on user interaction data, result in a 17 percent higher rate of task completion and a 23-percent reduction in the bounce rate than the rate of task completion and the bounce rate of heuristic-based designs [9]. These are tremendous impacts. They imply that there is no minor difference between well-designed and poorly designed navigation widgets.

The issue of rarely used but essential functions, which Min and Lee describe as raressential functions, complicates the matter [10]. Visual inspection demonstrates that corners on the screens are effective visual objects of attraction particularly mobile phones, and that the ambiguity of the icons can greatly reduce the time it takes to complete a task when users have to find these functions. There are design requirements to ensure this functionality which have different solutions than common controls.

The stakes of low navigation design in high stake situations are exemplified by health record systems. A literature review of electronic health record usability studies discovered that navigation in between multiple screens was the most commonly reported usability obstacle, which was associated with violation of flexibilities, recall-over-recognition error and problems on error prevention [11]. This is not only frustrating with regard to navigation inefficiency. It has the capacity of contributing to clinical error.

Experiments conducted on eye-tracking to web map graphical user interfaces reveal that the users initially fix on corners of the screen, and grouping functionally similar controls together in corners of a graphical user interface greatly enhances the efficiency with which the controls of a graphical user interface can be interacted with [12]. A field experiment of tablet-based problem-solving determines that navigation design and visual presentations have a joint effect of stimulating user flow states under interface navigation that is more potent as a driver of cognitive engagement and perceived control over the tasks [13].

In a comparative eye-tracking experiment of Microsoft word with translation modalities, users that have machine translated interfaces experience much more cognitive load and much lower satisfaction compared with users who have professional translated interfaces and original English interfaces, but even the rates of tasks they complete are similar [14]. A series of interaction with 80 smartphone users indicate that icons are the most flexible element of orientation, as they have more than one navigation functionality whereas tabs and breadcrumbs address more specific to mobile interface orientation functions [15].

Comparisons of card-based 3D metaphor interface and flat list interface with older adults illustrate that the 3D metaphor interface interfaces generate worse results with regards to the declines in perceptual speed, as well as that the lack of 3D metaphors in list interface led to enhanced results in navigation performance [16]. A comparative usability test of a redesigned health sciences library site is established as a retrospective study, that reorganization of information architecture and information search navigation Widgets increases the results of the information search and retrieval task accuracy as well as the search speed of information compared to the previous design [17].

The card sorting, used with a team of undergraduates and graduate students in a university library, is a card sorting that is team-based in order to inform a new information architecture and a new menu structure, and is followed by usability tests to determine that the new [18]. The results of a multi-phase usability test of hospital wayfinding systems (including touchscreen kiosks and mobile apps) indicate that even though a successful wayfinding system must rely on a coordinated approach among the touchscreen interface, physical environmental design elements, and real-time navigation, it does not have to depend on one particular widget system [19].

A study of 120 architecture students experimenting with VR-based education applications identifies the following modes of movement navigation as instants, direct manipulation of objects and another of viewing the body and body scale being the best modes of learning of the students, whilst the option of the background environment has no significant effect [20]. One longitudinal real-life study of 34 participants across 400 days proves that identifying the signs of a navigation problem (such as backtracking, visiting the same page again, etc.) by an algorithm has an 85 percent accuracy of recognizing actual problems in interaction on web sites where someone genuinely interacts with others [21].

A usability comparison of responsive and non-responsive web designs between sighted and blind users yields that, both responsive and non-responsive designs with deep structure and few choices in each level work worse than neither responsive nor non-responsive regarding the usability of the web design between the sighted and blind users as opposed to the common assumption that responsive web design is unconditionally more accessible [22]. A smartwatch interaction experiment under movement conditions concludes that task success rate and perceived usability is significantly lower during activity compared to when at rest and the perceived benefit of animated navigation aids in reducing cognitive workload is more efficient than silence aids in reducing cognitive load during movements [23].

In a user study of assisted pattern mining tools in web interaction logs, semi-automated testing of hypothesis finds more actionable behavioral insights, in comparison to baseline manual analysis of logs, even though semi-automated hypothesis testing initially is more difficult to learn [24].

3. METHODS

The research involved a within subject repeated-measure design. All participants used three content navigator systems: library information system, a mobile news application and a web-based learning portal. In each platform, the participants went through tasks in two navigation conditions where there was a standard interface, configured with the original set of widgets, and a redesigned interface, which included evidence-based modifications in the widgets. Learning effects were controlled by counterbalancing a task order and interface order.

These people were recruited (a total of 120 participants), including 40 university students (mean age 23.4, SD 2.1), 40 working professionals (mean age 34.7, SD 5.3) and 40 adults aged 55 and older (mean age 64.2, SD 3.8). This hierarchical sample was chosen to cover the dispersion in the experience of technology and speed of cognitive processing. Both participants were screened to rule out the ones who would have their visual impairments not corrected and therefore would not interact with their screens.

It tested five classifications of widgets: hierarchical menu structures, scroll-based content containers, adaptive promotion and demotion controls, orientation aids, such as breadcrumbs, tabs and icons and form-based input widgets. There were two or more configurations in each category.

There were three major measures of efficiency gathered. Task completion time (TCT) was logged in seconds, since the task was initiated to the point of confirmed completion. The rate via which there were errors in their selections or navigation reversal during a task was termed as error rate (ER). Total fixation duration (TFD) which has been measured with the help of a Tobii Pro Nano eye tracker was used as the index to cognitive load in accordance with the accepted guidelines. User satisfaction ratings in a 7-point Likert scale, a perceived ease of use score based on validated usability tools were considered as secondary measures.

The length of each of the sessions was about 90 minutes. Achievers went through one mini-practice, and were required to complete six standardized tasks per platform. The matching of tasks in platforms was in regard to difficulty. The satisfaction and ease-of-use ratings were filled in after every session in the platform. The calibration of the eye tracker started every time a session was undertaken.

Hierarchical navigation as a means of efficient navigation may be modeled as:

$$E_{gain} = \frac{TCT_{\text{standard}} - TCT_{\text{redesign}}}{TCT_{\text{standard}}} \times 100$$

The index of cognitive load reduction (CLRI), was computed as:

$$CLRI = 1 - \frac{TFD_{\text{redesign}}}{TFD_{\text{standard}}}$$

Where the values nearer to 1 would reflect the more cognitive processing demand reduction. The composite efficiency score (CES) is a variable that is a composite of normalized measures:

$$CES = w_1 \cdot T\hat{C}T + w_2 \cdot \hat{E}R + w_3 \cdot T\hat{F}D$$

Where w_1 = 0.40, w_2 = 0.35, and w_3 = 0.25 were calculated with a principal component analysis of pilot data of a pre-study. A reducing CES will be more efficient.

Repeated-measures ANOVA with post-hoc Tukey correction were the methods to analyze data. Partially eta-squared (n^2_p) is reported as an effect size. The statistically significant level was established $\alpha = 0.05$.

4. RESULTS AND DISCUSSION

The scores indicate some uniformity of results across platforms. Adaptive widget promotion elicited the greatest efficiency improvements in the time of completing tasks averaging 24.5% improvement in all the three platforms. E- gain was an average of 18.4 when menu was restructured hierarchically. The two groups of widgets also yielded the highest CLRI giving the impression that the gains within efficiency are not merely due to increased speed of clicking but rather decreased cognitive processing to occur.

Table I. Quantitative Results

Widget Category	Platform	TCT Standard (s)	TCT Redesign (s)	E-gain (%)	ER Standard	ER Redesign	CLRI
Hierarchical Menu	Library IS	48.3	39.1	19.0	1.4	0.9	0.18
Hierarchical Menu	Mobile News	41.7	34.6	17.0	1.2	0.8	0.15
Hierarchical Menu	Learning Portal	53.1	43.3	18.5	1.6	1.1	0.20
Scroll Container	Library IS	44.2	40.8	7.7	1.1	0.9	0.09
Scroll Container	Mobile News	38.9	35.4	9.0	0.9	0.7	0.11
Scroll Container	Learning Portal	47.6	43.1	9.5	1.3	1.0	0.10
Adaptive Promotion	Library IS	51.4	38.2	25.7	2.1	1.4	0.24
Adaptive Promotion	Mobile News	46.8	35.9	23.3	1.8	1.2	0.22

Widget Category	Platform	TCT Standard (s)	TCT Redesign (s)	E-gain (%)	ER Standard	ER Redesign	CLRI
Adaptive Promotion	Learning Portal	55.2	41.7	24.5	2.3	1.6	0.26
Orientation Aids	Library IS	49.7	43.2	13.1	1.5	1.1	0.14
Orientation Aids	Mobile News	43.1	37.8	12.3	1.3	1.0	0.12
Form-based Widgets	Library IS	57.3	50.4	12.0	2.4	1.9	0.11
Form-based Widgets	Learning Portal	61.2	53.6	12.4	2.6	2.1	0.13

**Experimental data (N = 120)*

The findings indicate that there is an overall pattern across platforms. Adaptive promotion of the widgets had the highest efficiency improvement in time of completion of the task and average reduction of 24.5 was obtained in the three platforms. E- gain was an average of 18.4 when menu was restructured hierarchically. The two groups of widgets also yielded the highest CLRI giving the impression that the gains within efficiency are not merely due to increased speed of clicking but rather decreased cognitive processing to occur. Such a difference is important to the design practice.

More modest, though still significant gains were created by scroll container optimization with an average decrease in transaction time of 8.7%. CLRI values of scroll-based changes were also consistently lower than the values of menu and adaptive changes, which can be attributed to the previous studies that have indicated that scrolling is already the most preferred way of navigation in mobile devices and a relatively low level of cognitive cost is applied in relation to multi-level menu movement [25].

The production of orientation aids such as breadcrumbs, tab structures, and sets of icons made available had mid-range efficiency gains of average 12.7. The impact was even a bit greater in library information system, which may be explained by the fact that such a system has a more comprehensive information architecture and users become more likely to get lost in it, which is why Roman et al. offered the most frequent usability barrier found in complex information systems.

The processing pathway between the interaction with the widgets and efficiency output is shown in the below diagram.

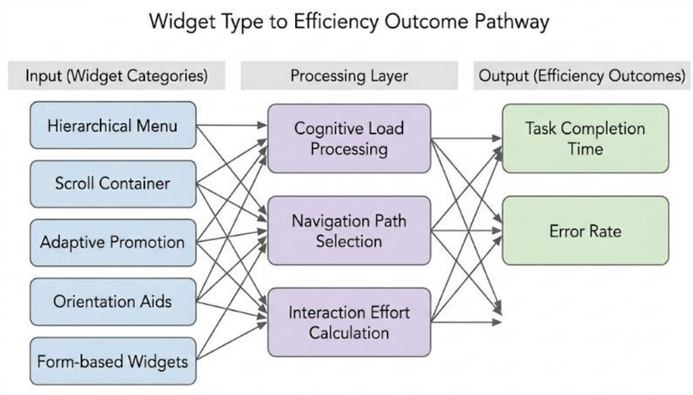

Figure 1. System Diagram

Differences across participant age groups were significant (F (2,117) = 8.43, p < 0.001, n2p = 0.126). Hierarchical form of restructuring of menu favored the older adults and the E-gain values were higher in the case of older adults 23.1% as opposed to 14.8% among the students. This is in line with the fact that Shi et al. found that older adults are more suited to linear hierarchical navigation under cognitively challenging circumstances. The size of the difference between the age-groups is nearly applicable. It implies that age-adaptive design of a widget (reconfiguring the navigation structure according to user profile) might yield substantial efficiency benefits more so than would be offered by the fixed redesign.

The trend of reducing error rates was also similar, and the highest reduction in error rate was caused by adaptive promotion with an average error rate reduction of 21.3 percent cross-platform. This coincides perfectly with the suggestion of Bouzit et al that by promoting frequently occurring (predicted) widgets and demoting infrequently used ones, one can minimize the error rate in the selection process which is due to the fact that most topical controls will become more readily available.

Composite efficiency score (CES) established that both, hierarchical menu and adaptive promotion changes, had a common explanatory variance of the greatest efficiency changes. The results of the multivariate regression (CES as a dependent variable and widget category, platform, age group of participants as independent ones) depicted that 64.3% of the variance was explained (R2 = 0.643, F = 21.7, $p < 0.001$). Widget category was the strongest predictor (beta = -0.51, $p < 0.001$), followed by participant age group (beta = 0.33, $p < 0.001$).

Platform type did not strongly predict it (Beta = -.08, p =.19) even after other predictors were controlled, so it did not have platform-specific effects on efficiency, but instead it had platform-general effects.

5. CONCLUSION

According to the results across 120 participants, three platforms, and five categories of widgets, there is a consistent finding that adaptive widget promotion and hierarchical menu restructuring can result in the largest efficiency payoff, averaged at 24.5% and 18.4% faster task completion time, and a reduction in error rate by 21.3 and 17.8 on average, respectively. Similar process reductions are observed with cognitive loads (as assessed by eye-tracking fixation evidence) and so these efficiency improvements are due to less cognitive processing load being required as opposed to quicker interaction.

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