The Usability of Hidden Functional Elements in Mobile User Interfaces

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Abstract: The trend of maximizing mobile screen real estate by hiding user interface features has been in use for some time. However, there is a lack of empirical knowledge concerning the real usability issues of using this strategy. In this paper, we present novel and statistically significant evidence to suggest that hiding user interface elements decreases usability in terms of performance and user experience. We conducted a within-users experiment comparing identical user interfaces, where the only differences between them were that one version hid the user interface elements and the other version had all the user interface elements visible to the user. We recorded task times, errors and user satisfaction for a series of tasks. We also discuss our results in light of existing user interface design guidelines and show that our results are in harmony with existing guidelines.

1 INTRODUCTION

In this paper we present the results of an investigation into the common trend of hiding functional elements at the user interface for increasing screen real estate on mobile devices such as smartphones and tablets. Such hidden elements are typically accessed from within an app by swiping one of the sides of the mobile device and then the extra features available in an app appear on the screen. When not in use, or if one swipes in the opposite direction of access, these disappear again from the user interface.

While this solution typically maximises the screen real estate available, it reduces the overall usability of an app, because users need to remember where the features are and are required to make more interaction touches to interact with the app. Frequent use of such apps will likely ensure users can remember how to access such features in the future. However, this may not be the case for infrequent use of such an app. Also, forcing users to swipe from a side in order to access other app features could increase task times and errors while also reducing user satisfaction.

Therefore, the authors of this paper investigated the issue of hiding features within an app with a view to maximizing screen real estate. This was done specifically in relation to effects on task time, errors and user satisfaction. To our knowledge this direct and specific investigation has not been done before and closes an important gap in knowledge.

In the following sections we discuss some background literature related to this investigation. Then our experiment and results are presented. Finally, some discussions and conclusions conclude the paper.

2 BACKGROUND

The issue of screen real estate available on a mobile device has been studied for some time. Clearly, smaller screens incur interaction challenges and therefore researchers have tried many strategies to overcome the issue of small screens or less screen real estate.

Gomes, Priyadarshana, Visser, Carrascal and Vertegaal (2018) explored the area of using flexible displays that are held in a roll shape, but which can then be unrolled to reveal a tablet-sized screen, thus giving more screen-real estate than with most conventional smartphones. The authors concluded that tasks involving navigation were intuitive with their prototype device. Their set of participants seemed to indicate that the shape of their device could improve grasping when compared with a telephone shape.

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Concerning small screens and touch interaction, Butler, Izadi and Hodges (2008) tried to look at the issue of the fingers potentially occluding some of the already small screen area on most mobile devices during an interaction. Their approach was to trial 'infra-red proximity sensors embedded along each side' (Butler et al, 2008) of the mobile device. This enabled detection and positioning of the fingers in nearby areas of the screen, effectively increasing the interaction zone size. Although rigorous evaluation was not reported by the authors, the concept is interesting.

Further, Song, Sörös, Pece, Fanello, Izadi, Keskin and Hilliges (2014) developed an algorithm which would recognize in-air gestures using only the standard camera found on a mobile device. The idea was to maximise the screen real estate available by including the possibility of in-air gestures in the proximity of the mobile device. This would also somewhat alleviate issues of finger occlusion during interaction. Their comparative evaluation consisting of touch interaction only versus touch and in-air gestures, suggested that interacting with a mobile device where touch and in-air gestures were available simultaneously is statistically significantly faster. Informal evaluation with a few individuals also suggested that users were mostly positive towards using in-air gestures for interaction.

Byrd and Caldwell (2009) compared 2.8", 3.5" and 7" screen sizes. While not all results produced significant outcomes, the overall trend showed that larger screen sizes produced faster task times and shorter screen access times. Differences in errors for each screen size were not statistically significant. This gave users a larger input area, particularly if the device rested on a surface.

Also, Wang, Hsieh and Paepcke (2009) investigated the option of deliberately hiding files (or content) out of sight on a small screen device. Content, such as photographs, etc. could be placed in virtual 'piles' away from the main screen real estate, but available by accessing the sides of the screen, through small visual cues located at the sides of the screen. These represented distinct 'piles' of content, e.g. photographs or categories of photographs, etc. Although the concept suggested is interesting, it forces users to rely on their memory. It also raises doubts concerning the length of time it would take users to forget (or partially forget) what each 'pile' contains. There is also lack of evidence concerning the optimum amount of 'piles' a user should use, before increased quantities of 'piles' would become easier to forget.

This brief consideration of previous works shows that a lot of effort has been expended over the years in trying to deal with the basic issue of mobile devices having very limited screen real estate.

However, the main solution that has been adopted in recent years is to hide as many of the user interface elements as possible so as to maximise the use of the physical dimensions available of mobile devices. However, as will be seen from the evidence presented below, this is not the best option in terms of usability. Therefore, in the next section we present detailed information on the experiment we conducted in relation to hidden user interface elements.

3 EXPERIMENT

3.1 Experiment Introduction

In order to evaluate the usability of hiding functional elements on a mobile user interface it was decided to use a mobile camera-type application as the main context. The mobile camera was chosen for several reasons. (1) As far as we know all new or not so old smartphones include one or more cameras. (2) The camera application on a smartphone is one which often contains several functionalities that can be tailored or adopted by users and is therefore suitable for an experiment and a series of realistic tasks which would be ecologically valid. (3) Camera usage on smartphones is very common amongst users. Already in 2017, one survey indicated that 85% of all digital photographs were taken with a smartphone (Richter, 2017).

We chose to use an empirical experiment with hypotheses (Lazar, Feng and Hochheiser, 2017), rooted in the hypothetico-deductive approach. However, our experiment also contained a more qualitative side to it, by using a questionnaire, with a Likert-type scale (Likert, 1932) to elicit participant opinions. The main reasons for this, were that we wanted to conduct the study in controlled conditions in order to collect precise numerical data, whilst at the same time collecting some qualitative data. We felt this approach was more useful than having a completely quantitative or completely qualitative approach. Furthermore, this is an approach that has been used in previous research to good effect (e.g. Shrestha and Murano (2022), Keya and Murano (2022) and Shrestha and Murano (2016)).

3.2 Experiment Hypotheses

In our design of the experiment, we devised a series of two-tailed hypotheses. These are as follows:

H1 - There will be a statistically significant difference between the two developed prototypes in terms of task times.

$H1_0$ – There will be no statistically significant difference between the two developed prototypes in terms of task times.

H2 - There will be a statistically significant difference between the two developed prototypes in terms of user errors.

$H2_0$ - There will be no statistically significant difference between the two developed prototypes in terms of user errors.

H3 - There will be a statistically significant difference between the two developed prototypes in terms of user satisfaction.

$H3_0$ - There will be no statistically significant difference between the two developed prototypes in terms of user satisfaction.

3.3 Users

In this experiment 20 participants were recruited within varied age ranges (21-30 years – 9 participants, 31-40 years – 6 participants, 41-50 years – 3 participants, 51-60 years – 2 participants). Our sample of participants consisted of 10 males and 10 females.

All the participants had in common that they were familiar in advance in using a camera application. Overall, all participants were competent in the use of mobile devices/computers.

These common aspects of knowledge amongst the sample ensured that the overall sample was relatively homogeneous. This was important especially as some of the data collected could have been biased by overly novice or overly experienced participants, e.g. the timings and errors recorded.

All ethical considerations concerning human participants were implemented in line with Norwegian guidelines for such research.

3.4 Design

For this experiment, a within-users experimental design was chosen. The main reason for this choice was that it allowed each participant to experience both user interface types and thus evaluate their experiences based on having interacted with two different user interfaces.

3.5 Variables

The independent variables were the two user interfaces being evaluated and the specific tasks used in connection with the user interfaces.

The dependent variables were in connection with performance and user satisfaction.

The dependent measures were the time to complete a task and the number of errors. Errors were simply defined as a participant not completing a task. A post-experiment questionnaire with six specific user experience-type questions was used to reveal some details on user satisfaction.

3.6 Tasks

The tasks were designed to be as realistic as possible within a camera application. The five tasks we designed were: To capture a picture, To adjust the "Zoom Level", To turn off the "Flash", To open the "Settings" and To adjust the "Auto White Balance" AWB. Therefore, each prototype had five working options – one for each task. During the experiment the tasks were executed by participants in the same order as listed here.

The appearance of the two prototypes used is shown in Figure 1.

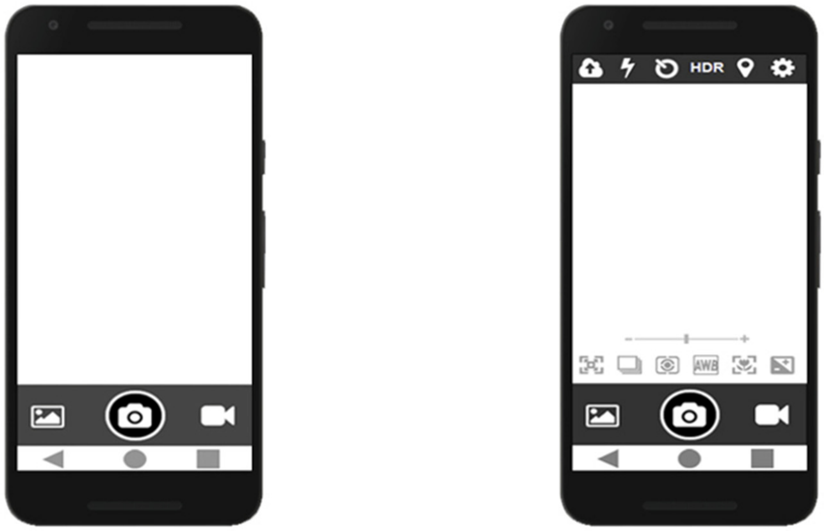
3.7 Procedure

The experiment was conducted in three main stages. The first stage welcomed the participants and at this point participants signed a consent form (Note: the experiment met ethical standards for Norway) in relation to having read an information sheet concerning the research.

The second stage consisted of carrying out the tasks, as described in the previous section. During this stage the participants were observed for their interactions and the results of each task were recorded on a spreadsheet.

The third and final stage involved the participants completing a post-experiment questionnaire, which elicited opinions concerning the experiences they had had in using the two different prototypes.

The next section will present the results of the statistical analysis on the collected data.



(a) Prototype 1 with hidden elements

(b) Prototype 2 with visible elements

Figure 1: The Final Design of the Prototypes.

4 RESULTS

In this section we present the results of a statistical analysis on the data collected and described earlier in this paper. The main aim was to determine the presence of any statistical significance.

The data was initially analysed using the Shapiro-Wilk test, which indicated that the data was parametric in nature and therefore suitable to be analysed further with a parametric significance test. For the data we chose a t-test. We have chosen to show in this section the precise figures for the means, standard deviations, t-tests and p values for readers interested in the details. However, we also present the means and standard deviations in graphical format to allow readers who wish only a quick overview to achieve this.

Task Time: Overall task time (minutes and seconds) was recorded as the total time taken for all tasks on each prototype by a participant.

Descriptive statistics show that the Mean (M) task time in using Prototype 1 with the hidden elements is M = 1.1470, Standard Deviation (SD) = .2215 and the Mean task time in using Prototype 2 with the visible elements is M = .3095, SD = .0697. The t-test result is $t = 18.142$, $p < .001$. This shows a highly significant difference in the overall task times, where the prototype with visible elements was significantly faster to use to complete the designated tasks. Figure 2 displays the means and standard deviations for the task times.

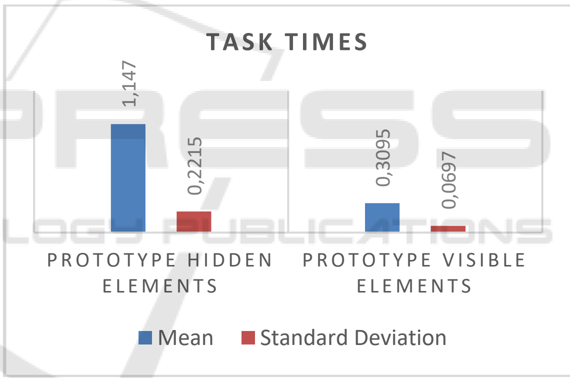


Figure 2: Means and Standard Deviations for Task Times.

Number of Errors: As discussed above, errors were defined as a failure to complete a task. One error in performing a task was counted as a failure. A total of 15 errors were observed for prototype 1 with hidden elements, and there were no errors observed for prototype 2 with visible elements.

Descriptive statistics show that the Mean (M) number of errors incurred in using Prototype 1 with the hidden elements is M = .75, SD = .550 and the Mean number of errors incurred in using Prototype 2 with the visible elements is M = 0, SD = 0. The t-test result is $t = 6.097$, $p < .001$. This shows a highly significant difference in the overall error rate, where the prototype with visible elements was significantly better at helping users avoid making errors. Figure 3 displays the means and standard deviations for the errors made during the tasks.

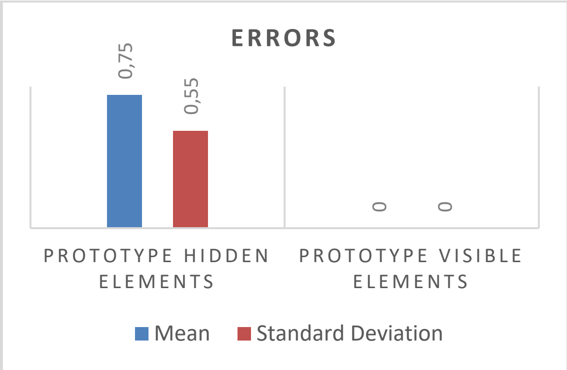


Figure 3: Means and Standard Deviations for the Errors Made During the Tasks.

User Satisfaction: In order to find out participants' opinions regarding user satisfaction, a seven-question questionnaire was designed. Each question was asked for each user interface version and the scores for each pair were statistically analysed for significant differences. Each question in the questionnaire used a Likert-type scale ranging from 1 to 5 (Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5). Higher scores indicated higher user satisfaction.

Question 1 concerned the user interface being easy to interact with. Descriptive statistics show that the Mean (M) response for Prototype 1 with the hidden elements is M = 2.60, SD = 1.353 and the Mean response for Prototype 2 with the visible elements is M = 4.40, SD = 1.273. The t-test result is t = -3.488, p = .002. This shows a statistically significant difference in overall opinions, where the prototype with visible elements was rated significantly easier to interact with. Figure 4 displays the means and standard deviations for the user interface being easy to interact with.

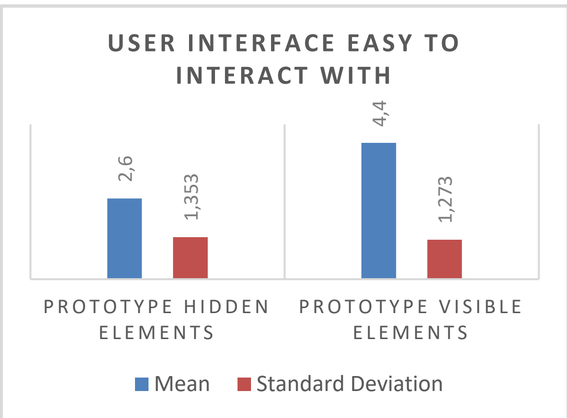


Figure 4: Means and Standard Deviations for the User Interface Being Easy to Interact With.

Question 2 concerned how easy it was to remember the commands. Descriptive statistics show that the Mean (M) response for Prototype 1 with the hidden elements is M = 2.45, SD = 1.356 and the Mean response for Prototype 2 with the visible elements is M = 3.85, SD = 1.226. The t-test result is t = -2.692, p = .01. This shows a statistically significant difference in overall opinions, where the prototype with visible elements was rated significantly easier for one to remember the commands. Figure 5 displays the means and standard deviations for the ease of remembering the commands.

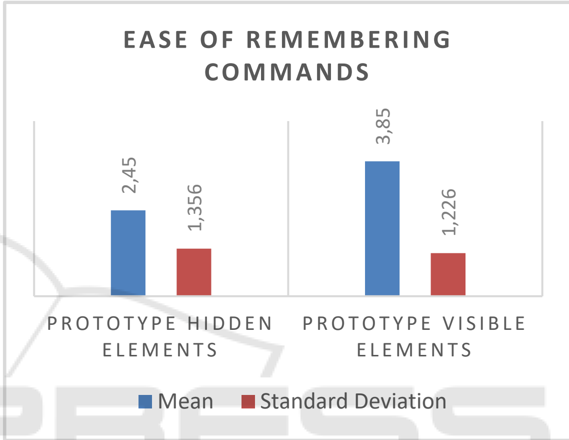


Figure 5: Means and Standard Deviations for the Ease of Remembering the Commands.

Question 3 concerned the tasks being easy to complete on the interface. Descriptive statistics show that the Mean (M) response for Prototype 1 with the hidden elements is M = 3.25, SD = 1.209 and the Mean response for Prototype 2 with the visible elements is M = 4.50, SD = 1.147. The t-test result is

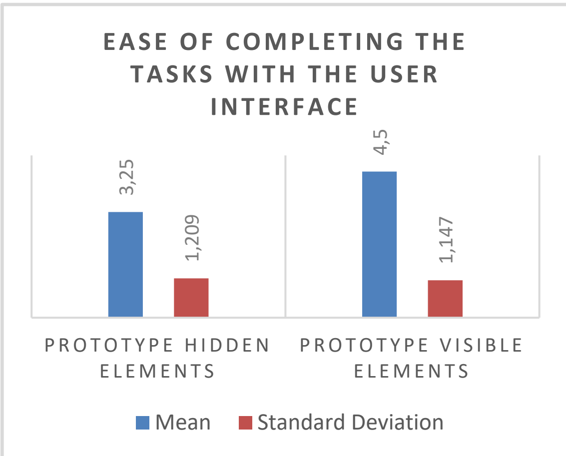


Figure 6: Means and Standard Deviations for the Ease of Completing the Tasks at the User Interface.

t = -3.101, p = .006. This shows a statistically significant difference in overall opinions, where the prototype with visible elements was rated significantly easier for the tasks used in the evaluation. Figure 6 displays the means and standard deviations for the ease of completing the tasks at the user interface.

Question 4 concerned the clarity of one finding a desired option/command. Descriptive statistics show that the Mean (M) response for Prototype 1 with the hidden elements is M = 2.30, SD = 1.302 and the Mean response for Prototype 2 with the visible elements is M = 4.10, SD = 1.447. The t-test result is t = -3.214, p = .005. This shows a statistically significant difference in overall opinions, where the prototype with visible elements was rated significantly clearer in terms of finding a particular option or command. Figure 7 displays the means and standard deviations for the clarity in finding a desired option/command.

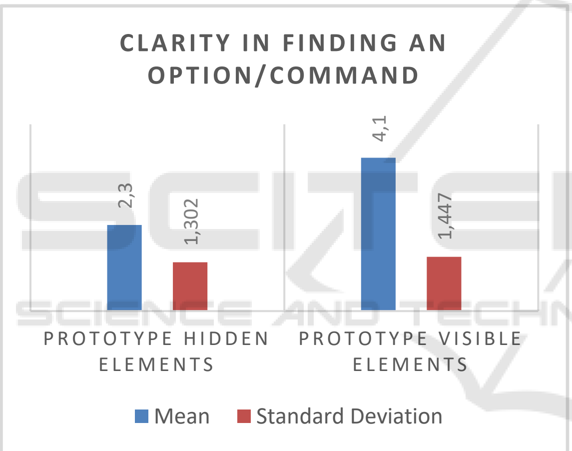


Figure 7: Means and Standard Deviations for the Clarity in Finding a Desired Option/Command.

Question 5 concerned feelings of comfort with hidden elements or visible elements. Descriptive statistics show that the Mean (M) response for Prototype 1 with the hidden elements is M = 2.75, SD = 1.164 and the Mean response for Prototype 2 with the visible elements is M = 3.85, SD = 1.089. The t-test result is t = -2.463, p = .02. This shows a statistically significant difference in overall opinions, where the prototype with visible elements was rated as significantly more comfortable in featuring visible user interface elements. Figure 8 displays the means and standard deviations for the feelings of comfort with hidden elements or visible elements.

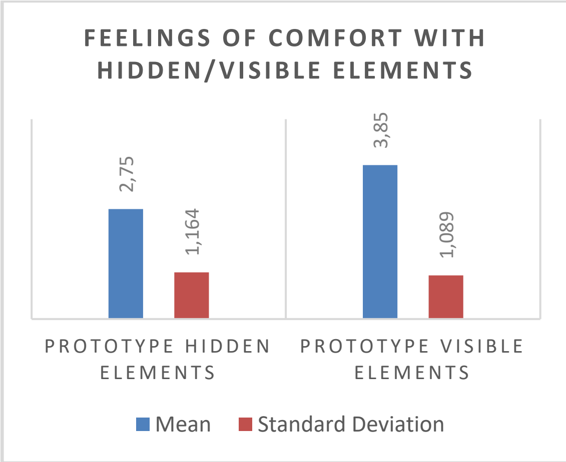


Figure 8: Means and Standard Deviations for the Feelings of Comfort With Hidden Elements or Visible Elements.

Question 6 concerned feelings of comfort with the app interface using maximum screen space by hiding elements or the app interface occupying more screen space for displaying commands/options. Descriptive statistics show that the Mean (M) response for Prototype 1 with the hidden elements is M = 2.75, SD = 1.070 and the Mean response for Prototype 2 with the visible elements is M = 3.55, SD = .999. The t-test result is t = -2.270, p = .03. This shows a statistically significant difference in overall opinions, where the prototype with visible elements was rated as significantly more comfortable despite having less screen real estate available due to displaying options/commands (rather than hiding them). Figure 9 displays the means and standard deviations for the feelings of comfort with the app interface screen space.

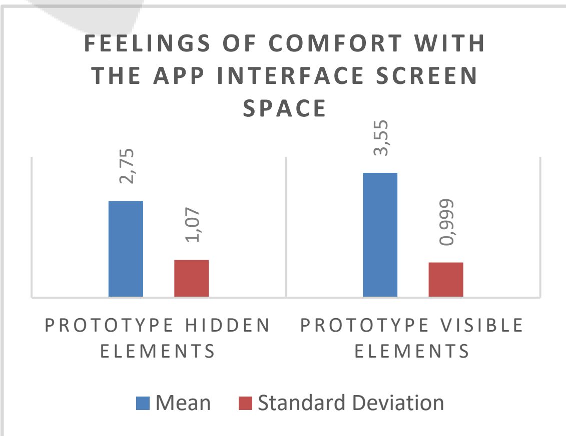


Figure 9: Means and Standard Deviations for the Feelings of Comfort With the App Interface Screen Space.

Question 7 asked participants to make one choice regarding which of the two user interface types they would prefer to use. In line with the responses of the previous six questions participants overwhelmingly (80%) responded that they would choose the user interface where the user interface elements were displayed (not hidden). The other 20% of the sample would choose the user interface where the elements were hidden from view.

This section has presented detailed results in terms of performance in carrying out representative tasks and user opinions. In the next section we discuss how real-world use of our findings would improve the usability of mobile interaction.

5 DISCUSSION

The results detailed in the previous section are quite clear and categorical. We have novel and significant results. All the performance and user perception aspects we investigated show clearly that hidden user interface elements perform much more poorly and are strongly disliked when compared with an equivalent counterpart that does not hide any of the elements. To our knowledge no other studies have directly and specifically investigated by direct empirical comparison the hiding of user interface elements for increasing screen real estate. Further, the results should be a clear signal to all user interface designers that hiding user interface elements is not the best way forward.

Therefore, our three positive hypotheses (see Experiment Hypotheses section above) which related to task times, user errors and user satisfaction are all accepted. In each of the three cases we observed, categorically statistically significant figures to suggest that in all three areas under investigation the visible elements perform significantly better and are significantly preferred over a version of a user interface designed to have invisible elements.

The results of this investigation are also very much in line with current knowledge of user interface design. For example, Nielsen's Heuristics (Nielsen, 2020), which can be used in an evaluative process and/or a design process suggest in Heuristic 6 to use 'Recognition rather than recall' (Nielsen, 2020). In further explaining this, we are encouraged to 'Minimize the user's memory load by making elements, actions, and options visible. The user should not have to remember information from one part of the interface to another. Information required to use the design (e.g. field labels or menu items) should be visible or easily retrievable when needed. (Nielsen, 2020) (see also Budiu, (2014))' This suggests that hiding necessary elements of an app in order to have more screen real estate is not the best option as it forces users to remember where everything is.

Furthermore, the International Organization for Standardization (ISO) provides support for the findings in this investigation and Nielsen's Heuristics. The ISO 9241-110:2021 (International Organization for Standardization, 2021) concerns Interaction Principles. Sub-section 5.4.1 under the Learnability section outlines various principles related to Discovery. One of these is that 'the interactive system supports discovery of its capabilities and how to use them, allows exploration of the interactive system, minimizes the need for learning and provides support when learning is needed. (International Organization for Standardization, 2021)'. We would suggest that hiding user interface features, etc. does not support discovery or learning.

6 CONCLUSIONS

The trend over recent years to maximise at all costs the screen real estate for mobile devices is probably unnecessary, as suggested by our investigation and well-established guidelines and principles. Even though human users are generally good at adapting to different modes of interaction, e.g. in remembering where hidden options are within an app, we would argue that this does not justify bad usability practices and bad user interface design.

It is acknowledged that there needs to be a trade-off between screen real estate and making all elements (e.g. app features, settings and/or navigation etc.) visible. However, the trend to hide everything is not the best option given our investigation results and the well-established user interface design principles. However, more and better design decisions should lead designers to not hiding everything, but to making at least the most important aspects visible. This clearly suggests that some elements would continue to be hidden. If that would be the case, better user interface cues that do not use much screen space could be adopted to let users know there are other options available.

Future work in this area would benefit by investigating the option of using user interface cues to inform a user that other elements are available. However, our suggestion is that if the number of elements are not too numerous, these should always be visible by default, with perhaps an easy option to make them invisible for experienced users. Further, this investigation did not specifically look at the effects on human memory (short or long term memory) in relation to hiding/making visible user interface elements. Future work could also focus on this aspect and provide useful insights into these approaches.

REFERENCES

Budiu, R. (2014) Memory Recognition and Recall in User Interfaces, https://www.nngroup.com/articles/recognition-and-recall/

Butler, A., Izadi, S. and Hodges, S. (2008) SideSight: Multi-“touch” Interaction Around Small Devices, UIST '08: Proceedings of the 21st annual ACM symposium on User interface software and technology, October 2008, P. 201–204.

Byrd, K.S and Caldwell, B.S. (2009) From UMPCs to Cell Phones: How Does Diminishing Screen Real Estate Affect Screen Access and Working Memory?, Proceedings of the Human Factors and Ergonomics Society 53rd Annual Meeting.

Gomes, A., Priyadarshana, L.L., Visser, A., Carrascal, J.P. and Vertegaal, R. (2018) MagicScroll: A Rollable Display Device With Flexible Screen Real Estate and Gestural Input, MobileHCI'18, September 3-6, Barcelona, Spain, ACM.

International Organization for Standardization (2021) Ergonomics of Human-System Interaction - Part 110: Interaction Principles (ISO 9241-110:2021).

Keya, R. T. and Murano, P. (2022) Is Carousel Interaction Really Usable?, First Monday, Volume 27, Issue 1, January 2022.

Lazar, J., Feng, J. H. and Hochheiser, H. (2017). Research Methods in Human-Computer Interaction, Morgan Kaufmann.

Likert, R. (1932) A technique for the measurement of attitudes. Archives of psychology, number 140. New York: Science Press.

Nielsen, J. (2020) 10 Usability Heuristics for User Interface Design, https://www.nngroup.com/articles/ten-usability-heuristics/

Richter, F. (2017) Smartphones Cause Photography Boom, Statista, Aug 31, https://www.statista.com/chart/10913/number-of-photos-taken-worldwide/

Shrestha, S. L and Murano. (2022) The Design and Evaluation of an Online Dictionary User Interface - PDF, International Journal of Computing and Digital Systems, Volume 1, March 2022.

Shrestha, S. and Murano, P. (2016). A Universally Designed and Usable Data Visualization for A Mobile Application in the Context of Rheumatoid Arthritis. International Journal of Advanced Computer Science and Applications, Vol. 7, Issue 12, December.

Song, J., Sörös, G., Pece, F., Fanello, S.R., Izadi, S., Keskin, C. and Hilliges, O. (2014) In-air Gestures Around Unmodified Mobile Devices, UIST '14: Proceedings of the 27th annual ACM symposium on User interface software and technology, October 2014, P. 319–329.

Wang, Q.Y., Hsieh, T. and Paepcke, A. (2009) Piles Across Space: Breaking the Real-Estate Barrier on Small-Display Devices, International Journal of Human-Computer Studies 67 (2009) 349–365.