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Comparison of hamburger and bottom bar menu on mobile devices for three level navigation

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ABSTRACT

Mobile websites and application are used daily by millions of people as a way of communication and entertainment as well as a professional tool. Content rich apps with multiple levels of content hierarchy face challenges due to the limited space of the user interface. It is important that the application has excellent navigation features along with help and search capabilities [1], as navigation of the user interface is one vital aspect for such web and native apps offering to the user a way to explore its content, understand its structure and use the services that they offer. The efficient identification of the navigation pattern and its usability is a key element of the user experience. This paper compares two different mobile navigation patterns: One of the most common navigation patterns known as *hamburger* menu, and a *bottom bar* menu. In order to compare the two navigation patterns a usability evaluation, using a demo application that was developed for this purpose, was conducted. Twenty participants took part in the test where their performance along with their subjective feedback was collected. The analysis of the evaluation suggests that *bottom bar* menu is more efficient than *hamburger* menu in terms of total completion time. The qualitative feedback of the participants also suggests that they perceive *bottom bar* menu better than the *hamburger* menu one. In addition to their contribution for future research, the study results can help professionals choose what mobile navigation pattern to use as well as better know the benefits and drawbacks of their choice.

Author Keywords

Navigation, mobile application, usability, mobile interaction, mobile evaluation

INTRODUCTION

Mobile devices play an increasing role in our daily life with the smartphone devices becoming more advanced every day. Smartphones nowadays offer new interaction options allowing applications to use several different ways of navigating the applications content. Users can navigate by searching for content (type or voice), by using a navigational menu or by utilizing a gesture that has been designed for the specific application.

Menu navigation is very common in desktop application as well as content rich mobile applications. While it allows the user to navigate, in the same time it provides a structural

representation of the application [2]. On desktop navigation, users interact with the website by using their keyboard or mouse. The use of hover effect in order to show a desktop navigation menu element is very common and something that is not available for mobile devices. The limited user interface space, the fact that we cannot use hover effects as well as the unique interaction methods that mobile devices offer, have contributed to the development of several mobile specific navigation patterns.

The icon consisting of three vertically aligned bars known as *hamburger* icon was first introduced at the Xerox start workstation and it can be seen in Figure 1. Two decades later, in 2010, Facebook used the *hamburger* icon both in their mobile and native mobile applications contributing to its spread. The menu worked by clicking the *hamburger* icon, which revealed a tray that slides in from the left and moves the main content to the right.

Hamburger menu quickly became one of the most commonly used navigation patterns on mobile devices as well as websites and Google is currently suggesting it as a navigation option. Google's Material Design guidelines mention that *when there is insufficient space to support tabs, side navigation is a good alternative. Side navigation can display many navigation targets at once. A drawer remains hidden until invoked by the user* [3]. With the support of Google, the *hamburger* menu has gained popularity and currently is being used in all Google products, a big number of mobile apps as well as desktop websites. One of the main reasons that *hamburger* menu became so popular is that it can scale to a big number of menu items.

Despite of the popularity of the *hamburger* navigation pattern, there have been several reports and industry studies on how poor it performs in terms of user experience and conversions. Specifically it is mentioned that *hamburger* menu has lower discoverability, it is less efficient, hard to recognize as a navigation pattern and comes in clash with platform navigation patterns [4, 5, 6].

This raises the need for further research on how users perceive the *hamburger* menu as well as how it performs in comparison with other navigation patterns. In order to evaluate the *hamburger* menu an evaluation was done where participants were asked to complete the same tasks using two different menu systems. The second navigation system needed to be different from *hamburger* menu in the

most basic features. It needed to be easy to discover, easily recognizable as a navigation element and always visible. For this purpose the *bottom bar* navigation proposed in iOS Human Interface Guidelines was selected [7].

The rest of the paper is structured as follows. The next section is a literature review on related work on menu navigation on desktop and mobile interfaces. The third section introduces the study and explains the method: how the evaluation was designed, the prototype developed as well as the procedure that was used to conduct the usability test. Also a brief introduction of the participants is given. The fourth section presents the results along with interesting remarks and incidents mentioned by the participants. At the final section, reasons that lead to the result as well as limitations and future work are discussed.



Figure 1. The *hamburger* icon designed by Norm Cox for the Xerox Star personal workstation [8]

RELATED WORK

Navigation and menu structure are a very important aspect of user interface design for both mobile and desktop applications. The balance of depth and breadth of the hierarchy is particularly important for the usability of an information structure [9].

As far as desktop applications and websites are concerned, there has been a lot of research on novel menu system and how we could make the selection more efficient as well as comparison between different navigation methods [10, 11, 12].

Following the rise in usage of mobile applications and websites, the research on menu navigation for mobile and touch devices has increased as well. Researchers have been focusing on how we could take advantage of the new features that this medium offers, how we could deal with the limited user interface space but also what navigation pattern is more appropriate for different use cases. The related work shown below focuses on evaluation tests as well as novel navigation methods for mobile devices.

In the early days of mobile browsing, the placement of navigating element in applications developed for mobile banking was the topic of the study made by Tuuli Hyvärinen et al [13]. The focus was the comparison two different navigation versions of the same application. One of them provided a system where the user was required to use specific menu pages for navigation and where there

were no cross-navigation enabling links on content pages. The other application had cross-navigation enabling links on content pages. The study results indicated that the participants considered the application with links hierarchically beneath each other on menu pages and having no cross-navigating links on content pages better.

Kyungdoh Kim et al [14] compared 3D and 2D menus for smartphones. Tasks of different complexity were tested as well as menus of different breadth. The study results indicated that users preferred the 3D revolving stage menu to the 2D overview menu when the menu had higher breadth while the 2D menu showed better performance in menus with lower memory load and complexity. Breadth is an important factor when discussing menus and mobile navigation and is one of the key decisions that need to be taken into account during the evaluation.

Schröder and Ziefle [15] compared developed and compared a completely icon based menu with a traditional one. The results showed that the icon-based menu produced higher learnability outweighing initial differences and prove that it can be viable and successfully applicable.

A lot of research has been done also in novel interactions ways and how the new interactions methods that mobile devices offer can be utilized. One area of focus has been the interaction with the mobile device in situations where the user is not able to have eye contact with the screen. The use of the phone's bezel was proven to help the user interact without and eye contact. PocketMenu that Martin Pielot et al [16] evaluated outperformed iPhones VoiceOver in terms of completion time, selection errors, and subjective usability. Jain and Balakrishnan [17] tested a similar concept of Bezel menu with the results indicating a fast transition of the participants from novice to expert users.

Colley and Häkkinä [18] investigated another novel interaction concept for mobile phone touch screen input by distinguishing between different fingers. The results showed that users could see value in real life implementations while there were considerations about comfort and perceived speed when using different fingers to interact with the device.

Bonnet and Appert [19] propose a radial menu that enables a very large number of functions on a single small tactile screen. Their target was to offer a set of functions in a single viewport. They manage to do so by using a radial menu with a puck in the middle. The puck can be used to select a menu item but also as an input field by stretching it to one direction. The Swiss Army Menu is an interesting approach of the unique input possibilities that touch interfaces create.

The related work showed the various novel ways of interacting with mobile while navigating. It also indicated several points and conclusions that other researchers made while running evaluation on mobile devices. These

considerations were taken in account during the experiment design phase that follows in the next section.

EVALUATION DESIGN

ISO 9241 defines usability as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [20]

In order to compare the *hamburger* menu navigation in contrast to the *bottom bar* one, a usability evaluation was contacted where effectiveness, efficient and user satisfaction were measured. Twenty participants took part in the evaluation where they were asked to perform three tasks using two different version of the same application. Qualitative data analysis techniques were used to focus on the participants’ subjective experience while quantitative methods and tools were used to collect data from the participants’ interaction with the prototype applications.

Participants

Twenty participants took part in the evaluation and they were invited for voluntary participation via social media. The participants’ age varied from 17 to 62 years old. All the test sessions were done with the observer and the participant at the same location. Prior to the session, participants were informed about the data recorded, how it will be used and were asked to agree for voluntary participation. Demographic information about the participants was collected and stored online using a demographic questionnaire that asked for their age, gender, primary hand as well as smartphone usage frequency and operating system.

Thirteen participants were male and seven were female with the average age being 29.95 years old. Eighteen participants were right handed, one left-handed and one ambidextrous. All the participants had smartphones that they used in a daily basis, several times a day.

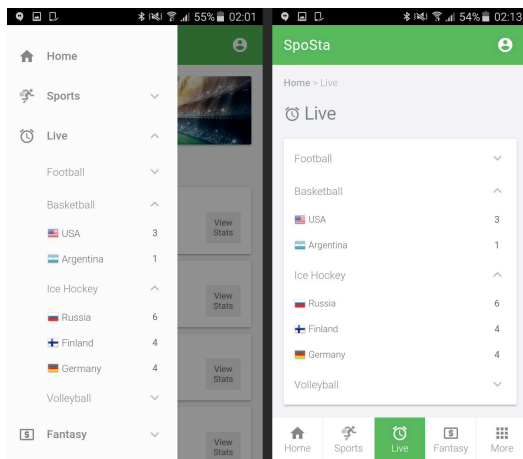


Figure 2. Both version of the menu with two submenus with a three level navigation expanded

Equipment

The evaluation was carried out using a Samsung Galaxy J5 phone. The phone has a 5" inch screen with a resolution of 1280 x 720 pixels. Android Chrome browser was used with the web app launched in full screen mode and was launched using a home screen icon. This gave the feeling of a native app to the participants.

Each user evaluation was recorded with the following ways:

- The time between each user interaction (tap, launch of a new page) was recorded using a JavaScript script that was running on the browser. The time between each interaction was stored in milliseconds and the time started counting from the moment that the page was fully loaded. Once the evaluation session had ended, the results were stored with the participants’ details on a remote server database using a PHP-script.
- The screens as well as all the interactions were recorded on a remote server. A video with the mobile user interface and a timeline of all the interactions was stored on a remote server.
- All participant comments and remarks during the experiment were recorder with a microphone. The most important findings are presented at the results section.

Applications

In order to evaluate the two navigation patterns a sample application was created. The name of the application was *SpoSta* standing for sports statistics. The app content featured sports statistics (league rankings, team points, feature games etc.) for eight sports as well as live game results. It also had a fantasy competition section (a competition between the website users). Only the parts needed for the evaluation tasks were implemented and presented to the participants with demo content.

One of the main reasons that *hamburger* menu is popular is the ability it has to scale to many items. This is the reason the evaluation was done using a menu having a large dataset. Sports statistics is a good test case as it features multiple sports and multiple countries for each sport. As we can see on Figure 2, the application features a three level navigation with a total of 106 navigation items. Five of them were first level; twenty-four were second level and seventy-seven third level navigation items.

During the design phase of the application several iterations were done with paper and low fidelity prototypes. Table 1 shows the data collected from the analysis of the top news websites according to Alexa ranking [21]. The analysis helped the reach of a decision for the menu location and icon.

Website	Menu effect	Menu position	Menu trigger icon
Reddit	Overlay	Right, top	
Yahoo	Slide (left)	Left, top	
CNN	Overlay	Right, top	
New York Times	Overlay	Left, top	
Huffington Post	Overlay	Right, top	
The Guardian	Overlay	Right, top	
Google News	Overlay	Left, top	
Forbes	Slide (left)	Left, top	
IndianTimes	Slide (left)	Left, top	
BBC	Slide (bottom)	Middle, top	
Foxnews	Slide (left)	Left, top	
USAToday	Overlay	Left, top	

Table 1. Analysis of the top 12 news websites according to Alexa. Menu effect refers to the effect used when the menu is expanded. Overlay menu expands on top of the applications content when activated. Slide menu pushes the content either from right/left or top/bottom when it is activated. Once disabled the content slides back.

As we can see from Table 1, ten out of the twelve tested websites chose a variation of the three horizontal lines known as menu while seven out of twelve positioned the icon on the left side of the page. Last, seven out of twelve tested websites used an overlay menu instead of a slide left/right one.

Considering also the fact that the material design guidelines [3] position the navigation to the top left using an overlay effect, we decided the final prototypes to follow these guidelines as well.

The main characteristics of *hamburger* navigation pattern are:

- It has ability to scale to a big number of items.
- It takes limited space, as only the icon is visible.

Since we wanted a navigation pattern with diverse characteristics, *bottom bar* was chosen with its main characteristics being:

- It displays the navigation elements as an icon followed by a text explaining the element
- Always appears at the bottom edge of the screen
- Displays no more than five tabs at one time in a horizontally compact environment

One Figure 3 we can see the first version of the navigation with the *hamburger* menu expanded and collapsed. Figure 5 shows the *bottom bar* version design. It is important to mention that both versions had the exact same design and structure with only difference being the navigation pattern used.

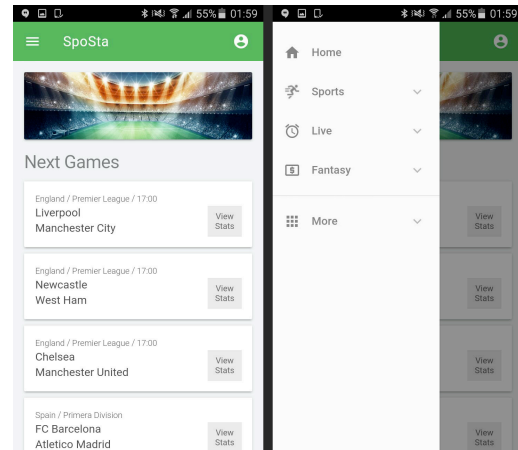


Figure 3. *Hamburger* menu design

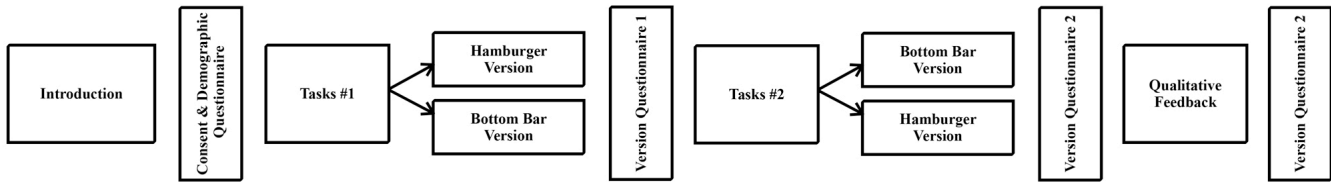


Figure 4. Study design

Tasks

The participants were asked to perform three tasks. Participants were expected to complete the tasks without any major issue while the time taken and taps needed to archive them may vary.

All the tasks were presented to the user in a way that encouraged navigation through the application's menu. The wording of the questions is very important and influences the user's behavior [22]. Considering the objective of the experiment, the tasks were expressed as "Please navigate to the test page" instead of "Open/go to the test page" or "Find/search the test page" that would encourage the use of the search functionality.

Task 1

Please navigate to the Fantasy Homepage page.

The first task is simple. The main target is to evaluate whether the user is able to identify how the site navigation is triggered and how it works without any help from the instructor. The user should not have an issue navigating to the selected page.

Task 2

Navigate to the sport Handball, Denmark and find which is the last team in the ranking table.

The task here is slightly more complicated as the user has to find a certain country that is in the third level of navigation. The first level category is sports (second in the list of first level menus) while the specific sport is in the middle of the list of selections in the second level of navigation.

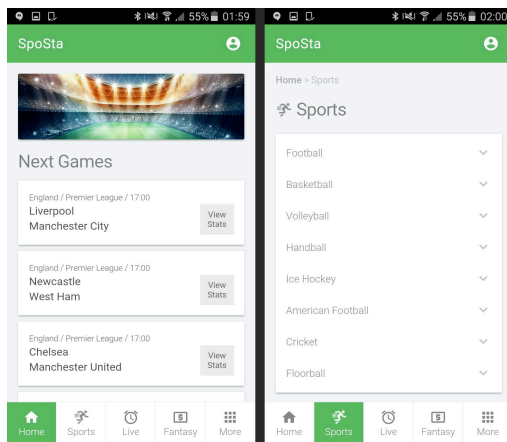


Figure 5. Bottom bar menu design

Task 3

Click on next task and navigate to the same sports as before, handball, and find the first/leading team in Germany ranking table.

The third and last task is very similar to the second one. The user is asked to navigate to another third level category that is part of the same second level one. So the user has to navigate to the same sport but to a different country. Here the user has the option to navigate through other navigation options such as the breadcrumbs and the device back button.

Evaluation process

The evaluation had a within-subjects setup. All participants were asked to evaluation both application versions. The tasks performed were the same having the same order. In order to minimize order effects, ten participants were presented with *hamburger* version first followed by the *bottom bar* version and the other ten with the inverse order.

The evaluation started with an introduction of the purpose of the study and a presentation of the application. Participants were informed that this is a test application, were asked to think aloud while doing the tasks. It is important to mention that they were not reminded to do so till the end of the two evaluations as it is possible that thinking aloud has a negative effect on the task completion speed [23]. While performing the tasks participants were anxious thinking that they are being under evaluation, something that influenced the results of the first two participants. The results of the first two participants were discarded. So after the first two participants, a few changes were made to the application technical implementation. Also it was clearly explained to the participants that they are not being tested and they should rather use the application at the normal speed they use any other application with their smartphones. This seemed to help the participants relax and carry out the evaluation more smoothly.

After each version evaluation the participants were answering to a questionnaire with three 7-point Likert scale [24] questions. At the end of the evaluation the user filled a comparative questionnaire as well. The data that was created after each evaluation was:

- A recorder voice of the evaluation session (audio)

- The exact interactions saved in a database (javascript/php scripts)
- User interface recording at a remote server
- Demographic questionnaire
- Questionnaire for each version
- Comparative questionnaire

The rich data that was collected gave the possibility to replay the whole user session and better analyze the results.

RESULTS

The usability of the two navigation patterns was evaluated using the demo applications that were developed. Below we can see the results of the evaluation concerning the three aspects that define usability: efficiency, effectiveness and perceived satisfaction.

Effectiveness

The effectiveness of the two applications was measured to the number of completed tasks. Each evaluation had six tasks, three for each version. All the participants completed all the tasks. Only one user was close to quitting after searching for the navigation for a long time. Participant 5 found the navigation in 21.9 seconds, which was the highest value among the participants. Participant 5 was an Android user and expressed that:

Usually I am familiar when I visit a page. I did not know the page and it was hard to find the navigation. I scrolled to see the structure of the page. Only later I thought to check on top and then I thought it might be the navigation. Participant 5

We can conclude that in terms of effectiveness there was no difference between the two applications.

Efficiency

All the values were recording using a JavaScript script that was developed for this purpose. All the clicks of each evaluation session were recorded using a unique id. Using the audio and screen recording the appropriate data was collected.

Based on the data collected ANOVA (analysis of variance) tests were calculated with the navigation menu as independent fixed factor and task completion time, time until the first tasks starts and number of clicks as dependent variables.

Total task completion time

As we can see in Figure 6, the mean task completion time for *bottom bar* navigation was 28.26 s. This was 22.3% less than the mean of 36.39 s observed for *hamburger* navigation with the difference being statistically significant ($p = 0.006$).

Further analyzing the completion time we tested each individual task completion time. Users were faster with *bottom bar* navigation for all tasks but only at task 2 the difference was significant (32.8% faster, $p = 0.001$). In general, according to the evaluation results and the variance analysis, *bottom bar* navigation is considered faster as far as total completion time is concerned.

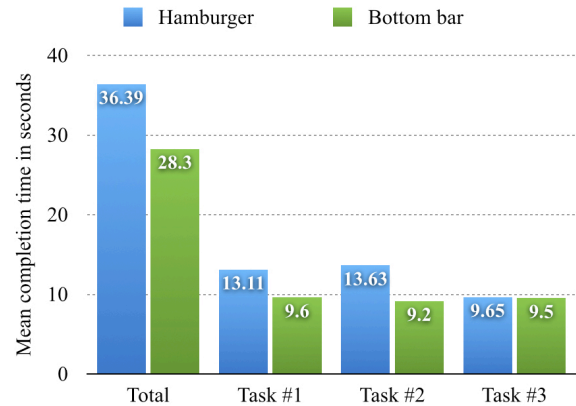


Figure 6. Total and individual task completion time in seconds.

Time until first task start

The time until the user interacts for first time with the navigation was calculated, as we wanted to see how fast the two navigation patterns are recognized as navigation elements. Both navigations had similar first interaction time with *bottom bar* method being 7.1% faster (6.27 seconds against 6.75 of the *hamburger* navigation) which was not a significant difference ($p = 0.69$).

Number of clicks for each evaluation

The number of clicks needed for each evaluation was tracked. The minimum number of clicks without the use of back button or breadcrumbs link that *hamburger* navigation would need is 11 clicks with seven participants achieving it. One user completed the evaluation with *hamburger* navigation with just 9 clicks as he used the breadcrumb shortcut that saved the need of two clicks for task #3. For *bottom bar* navigation, the minimum number of clicks needed is 8 with eight participants achieving it. Two participants completed the evaluation with 7 clicks as they used the breadcrumbs, which save one click in task #3. Comparing the two navigation patterns, the average for *hamburger* navigation was 12.2 clicks and for *bottom bar* navigation 8.7 clicks, which are 3.5 or 28.6% clicks less but the statistical analysis showed that this is not a significant difference ($p = 4.32$).

Perceived user satisfaction

After each evaluation session, participants were asked to fill in a questionnaire evaluating the application that they had just used on a 7-point Likert scale. After the evaluation of both applications, participants were asked to fill in a

comparative questionnaire. Qualitative data and notes were collected during that process as well.

The data collected was analyzed using ANOVA test with the navigation menu as independent variable and the user rating as dependent one.

Likert scale version questionnaires

In Figure 7 we can see the mean of the participants feedback after evaluating each application. The statistical analysis showed no significant difference between the ratings of the two versions. This can be partially explained by the fact that all the participants were able to complete all the tasks with both applications.

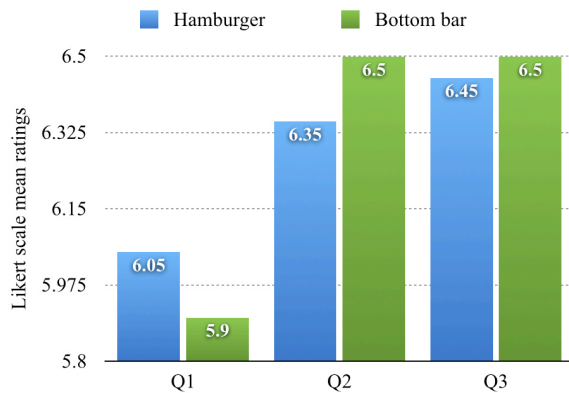


Figure 7. Likert scale mean ratings for the questions:
Q1: It was easy to find the app navigation
Q2: The app navigation was easy to use
Q3: I felt I could navigate at any point or given time

Comparative questionnaire

Last, participants were asked to provide comparative feedback. In many cases, the comparative feedback questionnaire also initiated the qualitative feedback from the participants. As we can see in Table 2, participants showed a preference for *bottom bar* navigation with 12 of them (60%) choosing it as their preferred application version in general. From the rest of the participants 7 chose *hamburger* as their preferred application and one user did not have any special preference. Big difference in the participants' choice there is also at the question "Which application version felt faster/more efficient" with 14 participants (70%) voting for *bottom bar* and the rest of them split between no preference and *bottom bar*. The efficiency of the *bottom bar* navigation was also shown by the quantitative calculation as we mentioned earlier.

Concerning to the feedback that the participants provided, half of the participants did not seem to have strong opinion towards one or the other navigation while the rest of the participants had certain arguments to reason their choice. Participants who liked the *bottom bar* navigation focused on the fact that it was always visible.

	Hamburger navigation	Bottom bar navigation	Not sure/No preference
Preferred application version in general	7 (35%)	12 (60%)	1 (5%)
Which application version was easier to use	8 (40%)	9 (45%)	3 (15%)
Which application version felt faster/more efficient	3 (15%)	14 (70%)	3 (15%)
Which application version you knew better where you are	5 (25%)	5 (25%)	10 (50%)
Which application was more aesthetically pleasant	6 (30%)	10 (50%)	4 (20%)

Table 2. Comparative questionnaire results

Second version (bottom bar) was easier. It helped that I had already done the first test but it also helped that the navigation was always visible. Participant 5

The other app (bottom bar) had the navigation at the bottom so I could always see it. I have seen the hamburger icon before but did not recognize it straightaway. Participant 13

I prefer the bottom bar because usually you go to bottom for navigation. Even in a book we have footnotes to explain what we read in the text above. Participant 14

On the other hand, participants who preferred the *hamburger* navigation mentioned that fact that it was a familiar pattern as the primary reason of their choice.

Bottom Bar is different from what I have used. I am used to navigation on top. After the first time I used the bottom bar version it was easy to use it though. Participant 10

Hamburger menu was easier as I had seen it before. I did not have to change page to navigate which is a plus. Participant 16

I am more used to the navigation being on top left. Bottom bar was not harder but I have seen it in less apps. Participant 17

The preference of navigation does not seem to occur based on the operating system that the participants had. The operating system that participants are familiar with did not seem to play an important role in user preferences as we noticed big diversity in participants who have the same operating system.

DISCUSSION

The purpose of this study was to compare the *hamburger* navigation pattern with the *bottom bar* one. This was done by running a usability evaluation with twenty participants. The results indicated that the participants prefer the *bottom bar* version in the comparative questionnaire while the statistical analysis showed that *bottom bar* menu was faster in total completion time than the *hamburger* menu.

Problems and limitations

During the evaluation pilot test with the prototype application, valuable feedback was gathered which altered some details of the initial usability evaluation process.

User feedback and Likert Scale

After the evaluation of each version, participants were asked to fill answer a questionnaire that included three questions. All answers used a 7-point Likert scale. The participants, knowing that the app was developed by the observer for the specific case of this experiment, were reluctant to give low scores possible thinking that this would insult the observer even after the encouragement for such feedback. For example, Participant 1 had the second slowest time in identifying the *hamburger* navigation as a navigation element. At the relevant question he filled 6 out of 7 Likert points, 7 being the maximum. This was just below the average rating for the question that was 6.05 Likert points. The Likert questions served as a beginning for conversation with the participant and input of feedback. The use of open-end questions would have possible served the purpose of the survey better.

Electronic questionnaires vs paper ones

For the first two participants, questionnaires were filled electronically after each evaluation session. This seemed to create several issues with the evaluation itself. Participants were distracted during the session from the laptop computer that was being used. Also while writing notes on the session and audio recording it via the laptop's software, participants were able to see the exact comments and thus be influenced and get the feeling of being interviewed. Last, as we needed to be physically next to a desk, the participant 2 was using the smartphone by placing it on the table and not holding it with his hand. The recordings of the first two participants were discarded from the final results.

For all the following evaluation sessions we replaced the electronic forms with a print version and we recorded the session using a smartphone. Notes were done on the questionnaire papers using pen. These changes created the

overhead of having to digitalize all user input but added the benefit of a distraction-free and more fluid evaluation process.

Future research

During the evaluation all participants used the same smartphone. It was a Samsung J5 with a 5" inch screen. This was done to eliminate differences between participants and the display of the two applications on their devices. But as Participant 5 noted while using the *hamburger* version, it introduced some issues.

This is a 5" inch phone. It is hard to reach top left corner and imagine that I have quite big fingers. I was afraid the phone would slip, as I like using the phone with one hand. It was challenging to reach top left side. Participant 5

Testing with different screen sizes and the impact it has on the usability of each navigation patterns is a future research that could add to the work done during this evaluation.

Future work with focus on the exact interaction context while the participant was doing the test could also contribute to the finding of this evaluation. Participants were free to use the mobile in any way they wanted and whether they used both hands or not were not tracked nor recorded. After a number of evaluations, three patterns on the way participants were interacting with the test device were noticed.

The participants either used the phone with one hand, either with two (primary hand using it and secondary holding the device) or they placed it on a stable interface (table or desk if nearby). Participants did the evaluation both standing and sitting on a chair. Collecting the contextual data and the way participants physically interacted with the device could possibly lead to improved results and is a recommendation that future researches should take into consideration.

CONCLUSION

The goal of this study was to compare the *hamburger* menu and *bottom bar* navigation patterns. This was achieved by conducting a usability evaluation with two test applications that were developed for this purpose. The evaluation results showed a better efficiency using the *bottom bar* menu when it comes to tasks completion time. No significant difference was found in terms of the time it takes to identify each of the patterns as navigation element, an important finding as low discoverability was considered to be one of the key drawbacks of *hamburger* navigation. On the other hand, the qualitative analysis of the participants' feedback showed that participants who are used to the *hamburger* navigation menu have more positive opinion towards it. The preference of the participants during the evaluation was irrelevant to the operating system that the participants were using at their personal smartphones. The findings of this study as well as the comments and remarks on the usability evaluation process can contribute to future research of mobile interface usability.

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