

ANALYSIS OF REACTIONS OF MOBILE PHONE USERS

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ABSTRACT

In this work, we analyze the aspects of user reactions during their work with a mobile phone. We tried to find the most crucial positions within the mobile screen, which provide essential information and stimulus. One of the main factors is to know which part of the screen is the first interest of the user and which part the user reacts to the fastest. Sixty-four persons participated in an experiment. We used the gamification approach to motivate users for the best results and created a game. Users competed with each other during the game, and they tried to react to the new point of the screen as soon as possible. The experiment showed that about a quarter of the screen below the centre was an area where users react the fastest. There were interesting differences between men and women and signs of background impact.

Keywords: mobile devices, smart devices, user experience, user interface, user reactions

1. INTRODUCTION

Mobile devices are one of the most frequently used devices. According to Zalani R., the average time that US adults spent daily on a mobile device in 2021 was 3:54 compared to 3:22 hours spent watching TV. The long-term trend of increasing screen time can be proven by comparing data from 2021 and 2014 when the average time spent on a mobile device was 2:32 and 4:20 as for the TV [1]. This makes mobile devices an important target platform for business. To design successful and user-friendly applications, graphic designers must take care of the correct positioning of all graphic elements.

It could be assumed that user reactions may be different on different parts of the screen, which is important to improve the user experience with mobile applications. Touch reaction will be faster in a location that could be easier to hit by a finger. To overcome this limitation and measure the real time in which the user is aware of the information displayed in various places of the screen, the point of the game is to hit anywhere on the screen as soon as possible after the user realizes a new point is displayed on the screen. Because the user can hit anywhere on the screen (usually he hits the same place), we eliminated differences in time of finger movement. We used the gamification approach to achieve the best results and created a game focusing on reactions.

2. SUBJECT

As more and more mobile applications are being developed, the concurrency between them is increasing. Nowadays, creating only functional applications is not enough. The user experience is an important feature to produce a successful mobile-based application. Many types of research have been done for web pages to improve the user experience and business profit [2]. Same as in web page development, mobile application design is also important. It is essential to know where to place controls or information we want the user to see first. The speed of user

reaction and user attention is the primary goal of graphic designers when designing commercial mobile applications. However, reaction speed is also important in industrial applications, displaying data from the manufacturing processes [3].

As mobile phones came with touch screens in 2008, the application control became simpler. Users change from indirect control using a keyboard to direct tapping and moving objects on the device screen, allowing users to control the application in a more natural way [4]. Mira et al. use an emotional recognition framework to optimize the touch interface on a mobile device [5]. They created a framework that tries to reorganize the user interface by user preferences. It can enlarge icons for social networking service applications and hide or shrink the finance and task-oriented applications according to recognized users' preferences. Nowadays, many researchers try to find the best practices to create a user interface for special groups of people like older or sightless people [6, 7, 9]. Barros et al. provide useful recommendations like [6]:

- Use the home screen menu as a safe point of return
- Use the back button as a safeguard for older adults
- Take advantage of scrolling if the application requires it
- Use icons along with the text when designing buttons
- The use of the keyboard should be minimized
- Provide generous spacing between items
- Be cautious about the positioning of interactive elements towards the edge of the screen

Especially the last three may relate to the physical position in the screen, what can suggest that the physical position of control or graphics element can affect users' reaction, and there can be differences between various user groups.

Mentioned works use various ways to measure users' reactions. Some works use emotion recognition,

questionnaires, or video analysis [5, 6] to get users' feedback.

Another work uses smart glasses to create a variant of an eye-tracking solution [8]. However, this solution detects only if the user looks at the phone, and it does not detect the position where he looks on the screen. The solution is based on accelerometer and gyroscope data to detect head movement (turn down) and camera information to detect if the user is looking on the phone. Authors mention that this detection often fails and detects pie as a mobile. The sample recognition same as gyroscope sensor data are illustrated in the following Figure 1:

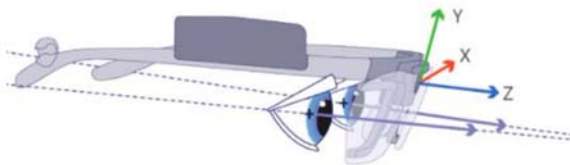


Fig. 1 Glasses parameterization and examples of identification as a cellphone

The last-mentioned method was also used by Jin et al. to measure user reaction time. In their case, users click on the button, which appears in various positions on the screen. The work does not focus on the button's position, and it tests various dimensions of a button [9]. However, this solution brings complications, that hitting the point further from the users' base finger position takes more time than hitting the point closer to the finger position.

To achieve the goal of our work, we created a solution similar to the solution used by Jin et al. [9]. We decided to display a symbol at the various position of the screen and measure the time of the user reaction.

3. METHODS

To measure user response, we created a reaction game. The goal of the game is to tap the screen immediately when the user sees a symbol on the screen. As Figure 2 shows, the symbol consists of a few circles with black and white colour.



Fig. 2 Symbol used to measure a user reaction

Users can tap anywhere on the screen to eliminate the longer times needed to move fingers to tap on farther parts of the screen. The symbol appears in random time intervals (between 0 – 1.5s) and is visible for one second. If the user does not react in one second, it is marked as a failure. The mobile application measures the time between the symbol is displayed to user reaction. If a user tries to cheat by regular taping without reaction to the symbol, the app location adds 2 seconds to the next symbol time.

The symbol is displayed twelve times for three different backgrounds, visible in Figure 3.

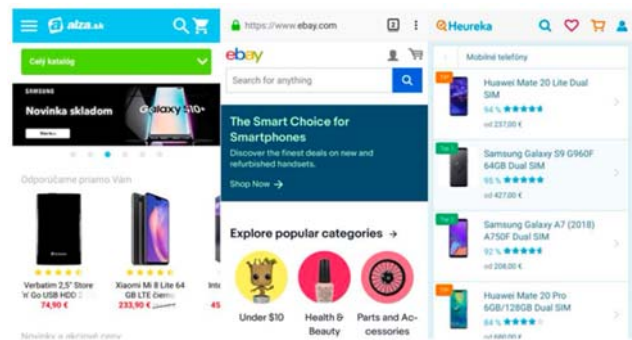


Fig. 3 Game backgrounds

The backgrounds are marked by numbers 1, 2, and 3 (left to right). The backgrounds are screenshots from three various e-shop applications. The first background is a screenshot from one of the Slovak Republic's leading e-shops. The second screenshot has been taken from e-commerce consumer-to-consumer and business-to-consumer sales website. The last one presents the Slovak most popular price comparison portal.

We used some parts of the gamification approach to motivate the users to do their best score [10]. The application has a leader board, which shows the best tries, and all players try to achieve first place on the leader board.

3.1. Experiment

Before the experiment, all participants were informed about the game and how to play it as well as their agreed with participation in the experiment. Next, they were asked to do their best. Sixty-four participants, 25 women, and 39 men took part in the experiment. The average age of participants was 24,7 years with a minimum of 18 years and a maximum of 88 years.

All users play the game inside a rooms with adequate lighting conditions. Screen brightness has been set to the maximum value. To achieve the best result, users put the phone on the table and moves only one finger around the screen.

3.2. Data processing

Data are recorded and exported to CSV and JSON format. As a first step, we normalized data from various screen resolutions to the same resolution 674 x 1092 pixels. To eliminate various motor abilities and muscular speed of tested subjects we do not work with absolute time, but we sorted all user's tries from fastest to slowest. In next analysis, we work only with the order of touches, not its time. It means we know which try was the user's fastest, second, third, etc. The next step was to split the screen into 8 columns and 13 rows. Next, all tries were split into this 104 squares and the average rank for the square. Finally, we created heatmaps to visualize the results. The lower square rank means the average faster reaction in the square.

4. RESULTS

General results show that the average number of missed reactions per user was 2.17, and the average reaction time

(without missed tries) was 541.71ms. Then the reaction data has been processed according to the approach described in section 3.2, and the heatmap in Figure 4 displays the average rank of reactions in specific parts of the screen.



Fig. 4 Heatmap of average reaction ranks in various parts of the screen

The heatmap indicates that the fastest user reaction appears on the stimulus in the middle and on the bottom half of the screen. In opposite, the worst reaction appears on the bottom 15% of the screen height. However, this area of the worst reaction is placed immediately next to the zone of the best reactions. This idea corresponds with the heatmap of total missed tries in Figure 5.

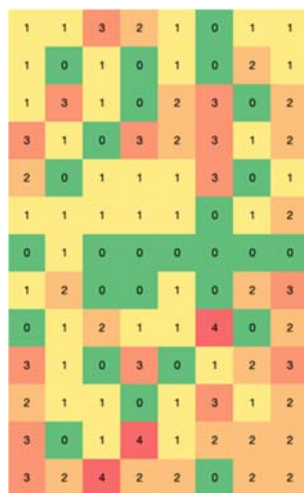


Fig. 5 Total number of missed tries

4.1. Gender-specific results

Our measurements also show interesting differences between men and women. Twenty-five women miss 80

tries, which means 8,89% of all tries. The average reaction speed was 583ms. On the other hand, 39 men missed 58 tries – 4,13% with an average reaction time of 517ms. We can also see small differences in the reaction rank heatmap in Figure 6.

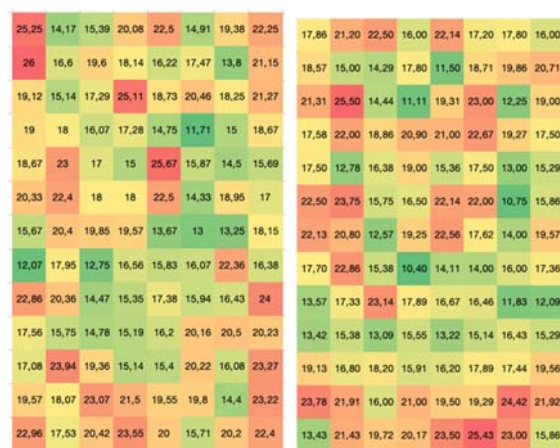


Fig. 6 Gender specific heatmap of average reaction ranks (men on the left)

The heatmap indicates that the fastest user reaction appears on stimulus in the middle and on the bottom half of the screen. In opposite the worst reaction appears on the bottom 15% of the screen height. However, this area of the worst reaction is placed immediately next to the zone of the best reactions. This idea corresponds with the heatmap of total missed tries in Figure 5.

4.2. Background specific results

As it was mentioned in the third paragraph, the application uses three different backgrounds to evaluate the impact of various shapes and graphics on user reaction.

The first background is a screenshot from one of the largest e-shops in the Slovak republic. The second one is a screenshot from one of the largest American e-commerce portals. The last one is a screenshot from the Slovak price comparison portal, which is designed as a long list of the same elements. The detailed results are shown in Table 1.

Table 1 Detail comparison of background effect on user reactions

Background	Missed values	Average time (ms)
1	83	551
2	42	549
3	14	523

Heatmaps of reactions rank, compared to background image can be seen in Figure 7.

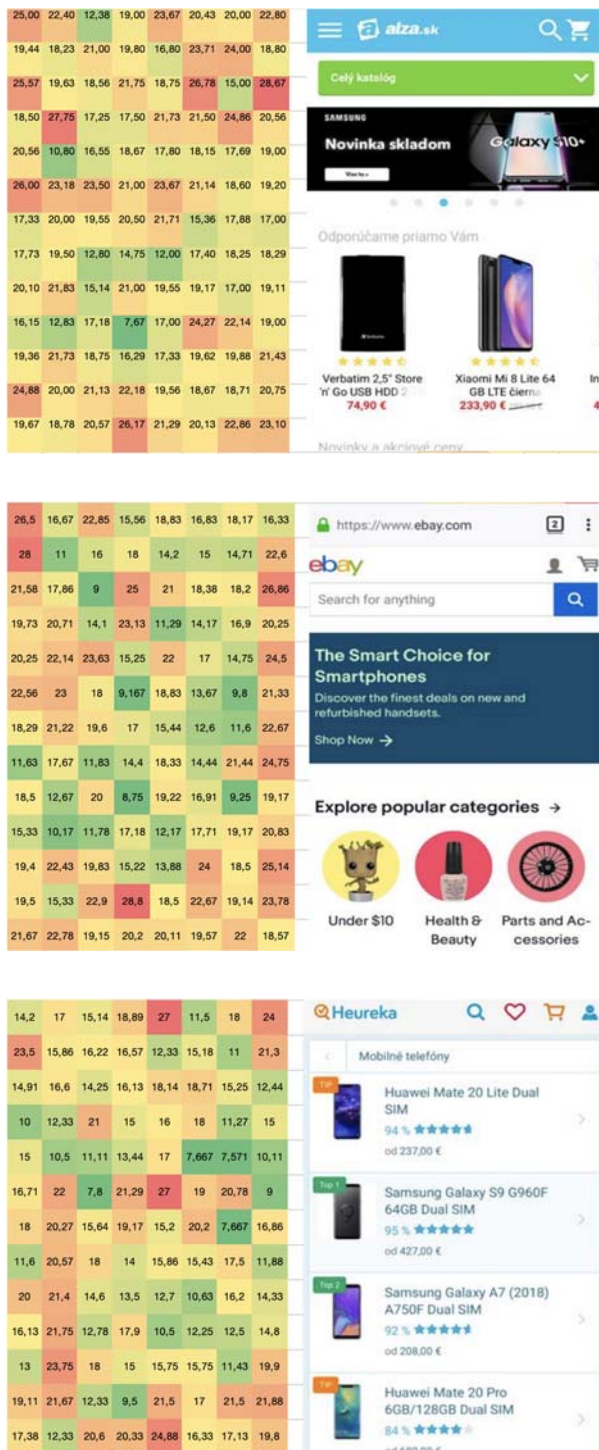


Fig. 7 Comparison of user reactions up to the various background images

5. CONCLUSIONS

The results acquired from 64 persons show that the fastest awareness of new information is connected with points displayed a few dozens of % below the center of the screen, which contrasts with displaying information in the navigation bar and push notifications on the top of the screen. The difference in average reaction time was below 0.1s. However, the difference between men and women is interesting in some missed tries. Women missed 8,89%

from all tries, compared to 4,13% missed by men. with an average reaction time of 517ms. Results also suggest the effect of various backgrounds on users reactions, but this needs more investigation.

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BIOGRAPHIES

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Juliana Ivančáková was born in 1993. In 2017 she graduated at the department of Cybernetics and Artificial Intelligence of the Faculty of Electrical Engineering and Informatics at Technical University in Košice. Her thesis was focused on data mining research in the medical domain. After that, she continues at the department as a PhD student and she is focuses on semantic modelling and data mining, with the title of the thesis Models and methods of data analysis for extraction of semantic representation of data sources.

David Trella was a student at the Department of Cybernetics and Artificial Intelligence of the Faculty of Electrical Engineering and Informatics at Technical

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Peter Butka received his MSc degree in 2003 and PhD degree in 2010, both at the Department of Cybernetics and Artificial Intelligence, Faculty of Electrical Engineering and Informatics at Technical University in Košice. From 2014 he is an associate professor at the same department in the branch of business information systems. His research interests include data/text mining, knowledge management, semantic technologies, and information retrieval.

František Babič graduated (MSc.) at the Department of Cybernetics and Artificial Intelligence of the Faculty of Electrical Engineering and Informatics at the Technical University of Košice in 2005. In the same year, he began his doctoral study in the same department and successfully finished in 2009. In 2018 he became an associate professor. He has been participating in several international and national research projects, such as FP6 IST, COST, Central Europe, APVV, VEGA, KEGA. His scientific research is focusing on data analytics, knowledge processes, and project management. He is the author of over 170 scientific publications (more than 50 indexed in the WoS database).