Comparison of Smartphone Navigation Methods: Tap vs. Swipe

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ABSTRACT
A user study was conducted to compare the accuracy and speed of two navigation methods for touchscreen mobile devices: button-based input and swipe-based input. The study involved eight participants and a Samsung *Galaxy A71* mobile phone. To conduct the study, a mobile game was created which requires users to enter a specified door. The game can be played using touch buttons or swipe gestures. The results for effectiveness indicated that playing using button-based input was 2.84% faster than playing using swipe gestures. The accuracy results show that games played using button presses caused 51.43% more incorrect door entries than games played using swipe gestures. Seven of the eight participants indicated a preference for the button-based input method.

Keywords
Swipe, Tap, Navigation, Speed, Error Rate.

INTRODUCTION
When interacting with smartphones, users often need to navigate through various screens and menus. Two common interaction methods that are used when navigating on smartphone devices are swipes and taps.

Some smartphone applications confine users to a single method of interaction, while others give users the choice of using either the tap or swipe gesture. An example of an app that provides the two interaction methods is Tinder. A dating application that lets users choose whether or not they are interested in the person that is currently being presented to them. As seen in Figure 1, users can either tap the green heart to indicate that they "like" someone or they can tap the red "X" to indicate that they "dislike" someone. Alternatively, users can also use swipe gestures to perform the same actions. Users may swipe right on the screen to indicate that they "like" someone or swipe left on the screen to indicate that they "dislike" someone. Similarly, in Spotify, an audio streaming application, users can navigate between songs by swiping right or left to listen to the song that is queued before or after the song that they are currently listening to, as seen in Figure 2. Alternatively, users can also tap on the forward or backward buttons to go to the next or previous song respectively.

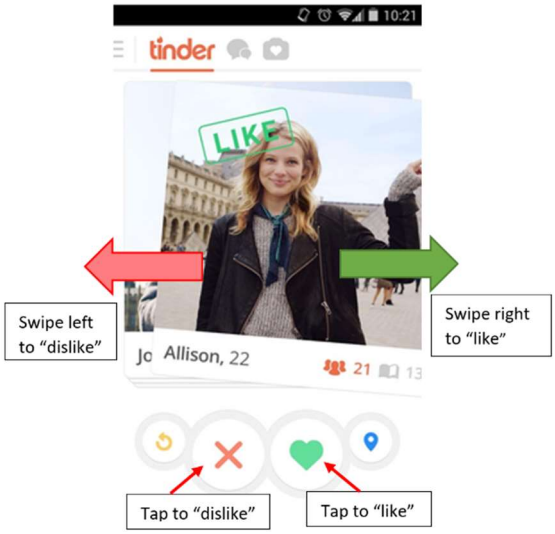

Figure 1. Screenshot of *Tinder's* user interface.[1]

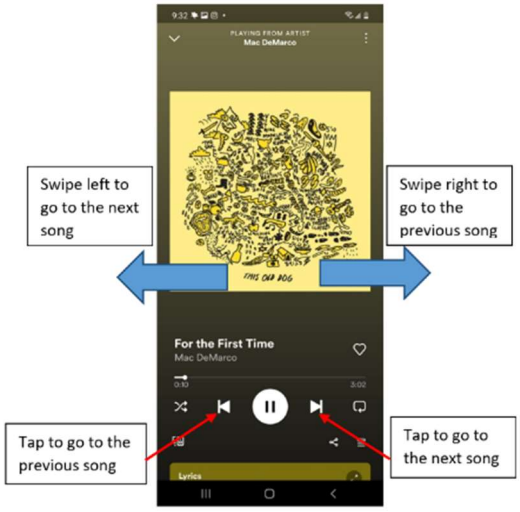

Figure 2. Screenshot of *Spotify's* user interface

Restricting users to one interaction method of navigation can hinder their experience if the interaction method presented to them is less effective than the one that is not presented to them. Alternatively, if both interaction methods are presented to the user, navigation may be confusing as different actions can cause the same end result. Furthermore, if the swipe interaction method is more

[1] https://en.wikipedia.org/wiki/Tinder_(app)

effective than the tap interaction method, then by presenting buttons to perform tap navigations, developers would be giving screen space to a less effective interaction method and also making the UI feel more cluttered. Similarly, if the tap method is more effective, then including the swipe method may confuse users as they might accidentally swipe and be unaware of what caused a navigation action. The two variables the team used to measure effectiveness are speed and error rate. Having this information can be extremely useful to developers as it allows them to know which navigation method is more effective than the other and consequently only presents the user with the more effective navigation method.

In this paper, user performance of the tap interaction method is compared to the swipe interaction method. The goal of the user study is to determine which interaction method, swipe or tap, is more effective when users are trying to navigate through options presented to them on a smartphone device.

RELATED WORK

A study investigated the speed and accuracy of interacting with a touch screen device using double-tap and swipe gestures while holding a device with a single hand and using a thumb [2]. Lai et al. [2] found that single-handed swipe interactions outperformed double tap in both speed and accuracy [2]. A target selection game was used to carry out the study, a game with 8 dots in a circle, in which a dot became a target and turned red. To select the target using the swipe mechanism, users can swipe anywhere on the screen in the direction of the dot. The angle of the swipe is tracked; the goal is to get an angle as close as to the red dot from the center of the circle. To select the target using the double-tap mechanism, users must first tap anywhere on the screen to set a reference point, then tap again to where the red dot should be in reference to that point. The angle between the two taps was tracked. The results from the experiment showed that the swipe interaction method is significantly faster than double-tap because swiping is continuous whereas double-tap requires more cognitive effort.

A study conducted by Bai et al. [1] analyzed interaction techniques used in handheld mobile Augmented Reality (AR) systems. The paper analyzed methods that can overcome the issue of users having a difficult time interacting with virtual objects in mobile AR scenes while using one hand to hold a device, their other hand to touch the device's screen, and at the same time maintaining visual tracking of an AR marker. The researchers investigated two different interaction methods: freeze view touch and finger gesture-based interaction. From the studies conducted, the research team found that the freeze view touch method was more effective in comparison to the gesture-based interaction method. However, they did state that although users found the gesture input method enjoyable, it needed to be further developed so that it could be more accurate.

Negulescu et al. [3] examined the relative cognitive demands of three smartphone input techniques (Tap, Swipe and Move) in two specific scenarios in which the user is distracted. The first scenario being walking and the second being an eyes-free seated scenario. Through conducting experiments, the researchers found that there was no significant difference in reaction time for taps, surface gestures or motion gestures when using a smartphone. Additionally, the researchers also found that when walking and interacting with a smartphone, users spend significantly less time looking at their smartphone when using motion gestures in comparison to when they use the tapping technique, even with interfaces that have been optimised for eyes-free input. The researchers concluded that there could be benefits to using motion gestures as a modality for smartphone input while distracted.

Research conducted by Dou et al. [4] studied whether the addition of horizontal swiping interaction techniques on mobile websites could influence user engagement, enjoyment, and motivational factors that influence behavior when using a website. The method [4, p. 12] of this research involved using a group of 273 undergraduate student participants and requested users to complete various tasks. The tasks were completed on two different versions of the stimulus mobile website that differed in its number of interaction techniques. Research findings suggest that users tend to display higher levels of enjoyment when using the horizontal swiping technique [4]. This variable is imperative in its ability to highly engage users, as it results in users visiting the website more frequently due to increased interest and curiosity surrounding the interface. In addition, the flexibility of adding the swiping interaction technique has led to users feeling a sense of control, which also contributes to their perceived enjoyment [4]. However, the article findings did state that using only one interaction method opposed to the two techniques used in the study may not have led to the same level of control among participants. In addition, there have been no significant differences observed when comparing the time transformation aspect of user engagement among the two interaction techniques [4, p. 23].

METHOD

The method of evaluation chosen by the team corresponds to an observational form of research. The team created an application which offers users two types of modes of interaction with the user interface. One of the modes of interaction relies upon key buttons used to navigate the position of the user's focus on the screen, whilst the other mode of interaction uses swiping motions across the device screen to perform the same tasks. The application was designed to collect data regarding the effectiveness of each

mode of interaction. Such data was collected without making the performance results of each task apparent to the user themselves, to minimize the potential bias and external influence the users experience when performing the given tasks. Due to this lack of external influence and the qualitative nature of the data collected, the team believes that the method of evaluation used here will be of an observational nature.

Participants

The participants chosen for this study were university students selected from an age range of 18-25. These participants were volunteers who are well-versed in modern Android devices and are familiar with the use of such devices on a day-to-day basis. An equal number of participants of each gender, with a total of eight participants were involved in the study.

Apparatus

The experiments were conducted on a Samsung *Galaxy A71* running the Android (11.0) operating system. The device had a 6.7-inch display with a resolution of 1080 × 2400 pixels and a density of 393 pixels/inch. See Figure 3.

Figure 3. Samsung *Galaxy A71*.

The application used in the experiment was developed in Java using Android Studio. The application was developed specifically for this research.

In terms of design, the team implemented a simplistic layout to make things as easy to manage for users as possible. The application screen was divided into a set of sections. The top-most section was reserved for the prompt that dictates the user task. As shown in Figure 4, the prompt was a clear and straightforward indication of the specific numbered door the user had to enter. In addition to this, the section below the prompt was reserved for the doors themselves, which were represented by simple rectangles with numbers present within as labels. The team implemented a total of five doors, numbered appropriately from 1 to 5. Lastly, the section right below these doors was an indicator used to show the door that held focus at any given time, represented as a red square, as seen in Figure 4.

When it came to the button-based system, there was an additional section below the indicator where the buttons were positioned. In the case of the swipe-based system, there was no explicitly defined section for input. Rather, the entire screen was available to receive swipe inputs. In the case of both systems, the indicator used to show the currently selected door always started in the centre of the doors presented at the start of a test, i.e. door number 3.

As shown in Figure 4, one of the modes of interaction offered by the application involve simulated buttons on screen. In this mode, the user was able to interact with the assigned task by clicking one of three buttons. The ‘Right’ button to move the focus to the right, the ‘Left’ button to move the focus to the left and the ‘Enter’ button to enter the appropriately selected door. The door that is being focused on is indicated by a red square at the bottom of the door, as seen in Figure 4.

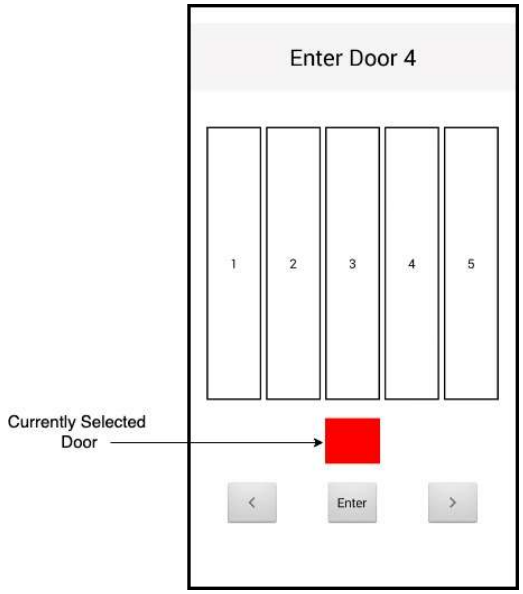

Figure 4. Button-based input method of the application employed in the study.

As can be seen in Figure 5, the other mode offered by the application involved a swipe-based system. In this mode, the focus was moved left and right using swipes on the screen, a rightward swipe and a leftward swipe to move in the corresponding direction. Then, an upward swipe to enter the currently selected door.

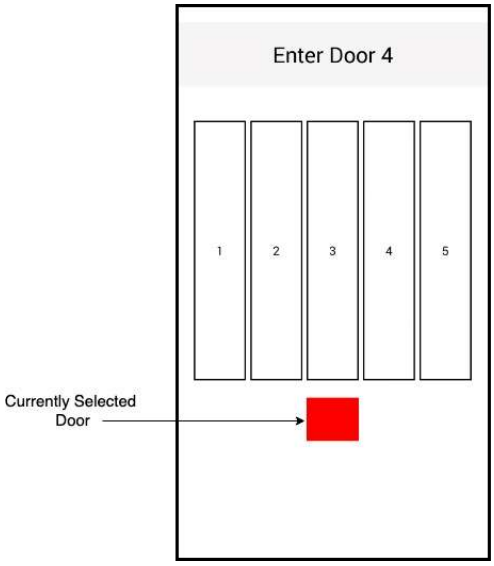

Figure 5. Swipe-based input method of the application employed in the study.

In both modes, the user was prompted to enter a specific doorway as indicated by the statement at the top of the screen. The doorway specified at each level was random. Users were meant to navigate to the corresponding door using a given mode of interaction, before entering said door to complete the given task.

Procedure

The selected participants were provided with the application and asked to complete the tasks assigned by it. The team had two overarching groups, one of which attempted the provided tasks using the button-based mode of interaction first, followed by the swipe-based system. The second group did the same, only in the converse order to compensate for the learning effects.

The participants were given the following instructions: "Please press the 'OK' button to begin the game. You will then enter the first level in which you will be presented with a prompt indicating which door you must select. Use the given interaction method to focus on and select the indicated door. Please play the game quickly and accurately, at a steady yet comfortable pace. Once you have completed all 10 levels the game will automatically end, and a researcher will meet with you shortly." They were also allowed to watch a short demo to explain the functioning of each input mode.

Participants were not allowed to practice prior to starting the experiment. Each participant spent approximately 1 minute on each input method, thus approximately 2 minutes in total.

The participants played the game sitting down with the device held in their hands, as they like, when performing the task. An example is seen in Figure 6.

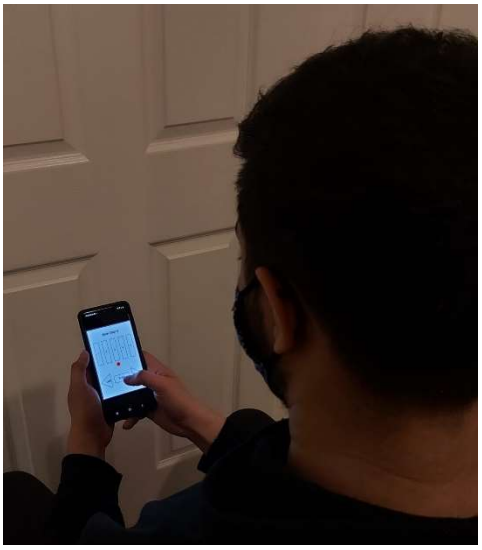

Figure 6. Participant performing the experiment.

The application itself offered ten tasks in the form of prompts which required users to select a door based on their numbered labels in accordance with the prompt present at the top of the screen, as can be seen in Figures 4 and 5. Unbeknownst to the users, the team implemented code in the application which collects data behind the scenes as the user completed their assigned tasks. This data included speed of completion and rate of errors based on the mode of interaction.

Once this data was collected, the team used it to compare and contrast the two chosen methods of input to distinguish between the strengths, weaknesses and overall effectiveness of these methods.

Design

For the purposes of this study, the independent variables chosen by the team are the type of tasks being provided to the users and the overall number of tasks being completed per user per testing session.

The user study employed a 2 × 10 within-subjects design. The independent variables (and levels) are as follows:

- Navigation method: tap, swipe
- Game levels: 1, 2, 3 … 10

The dependent variables that the team has chosen to study for the purpose of this project are as follows:

- Speed of Responses, which is measured by an internal timer, not visible to the user, that measures how long it takes for each individual task to be completed.
- Accuracy of Responses, which is measured by an internal counter not visible to the user that measures how many out of the given tasks are completed correctly and how many are completed incorrectly.

Lastly, the team conducted research using this methodology over a number of testing sessions. Each user was asked to complete 10 tasks per session of testing. And each user was given five sessions to complete per mode of

interaction. This means that each research subject was asked to complete 10 sessions of testing, with five of these sessions being used to gather data for the button-based system and five being used for the swipe-based system. Each of these sessions consisted of ten tasks.
In total, there were 8 participants × 2 navigation methods × 10 game levels × 5 sessions per navigation method = 800 trials.

RESULTS AND DISCUSSION

Speed

The mean time to complete a game was 10.70 seconds. The mean time using button touches was 10.55 seconds, whereas the mean time using swiping gestures was 10.85 seconds. Games completed using button touches were 2.84% faster than games completed using swiping gestures. See Figure 7.

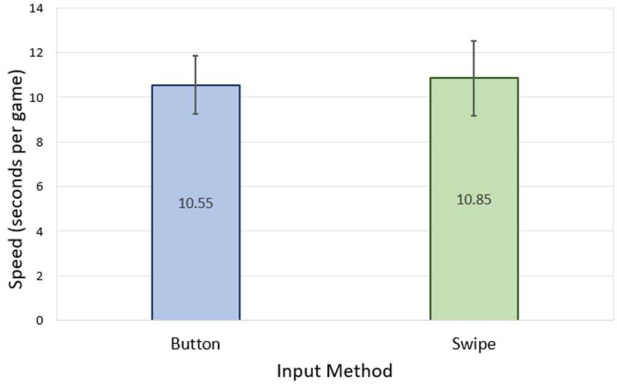

Figure 7. Seconds taken to complete a game by button and swipe input methods.

Reducing the time spent navigating through menus on a device is extremely useful as it means that users will get to their desired location faster and with more ease. The difference in speed could possibly be due to the fact that a swipe gesture requires more movement than a tap gesture. A tap gesture only requires a user to move their finger down to touch the screen and then move their finger up to leave the screen. A swipe gesture on the other hand, requires the user to do both the up and down finger motions required in a tap gesture and an additional finger sweep gesture across the device surface. The added gesture likely causes the user to spend more time on the swipe gesture in comparison to a single tap gesture needed for a button press.

A comparison of the mean times per game between the input methods is presented in Figure 8. Of the five games, the highest mean completion time for button-based input was 11.47 s thus making the first game the slowest for button input. Similarly, the slowest mean completion time for swipe-based input was also in the first game, with a completion time of 11.73 s. It can be observed that the highest mean completion time for the swipe-based input method in trial 1 was 0.26 s or 2.27% slower than the highest time button-based input experienced in game 1. The data shows that users were consistently faster with the button-based input method, with the grand mean completion time for button input being 10.55 s and the grand mean completion time for swipe-based input being 2.84% slower at 10.85 s.

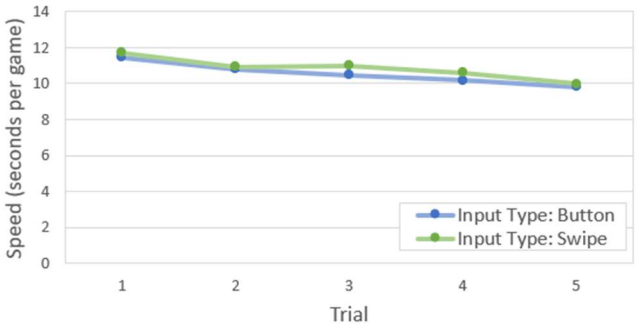

Figure 8. Completion time (s) by input method and trial.

Accuracy

When it comes to accuracy, the team found that the number of errors that users made whilst completing the provided tasks remained fairly consistent for each type of input in terms of any kind of drastic increase or decrease in value. The grand mean for error rate is 0.26 per trial. The average error rate for the swipe-based method was 0.18 errors per trial, while the overall average for button-based method was 0.35 errors per trial. The difference demonstrates higher rate of accuracy for swipe-based interfaces showcasing 51.43% less error rate than the button-based interface, which can be seen below in Figure 9.

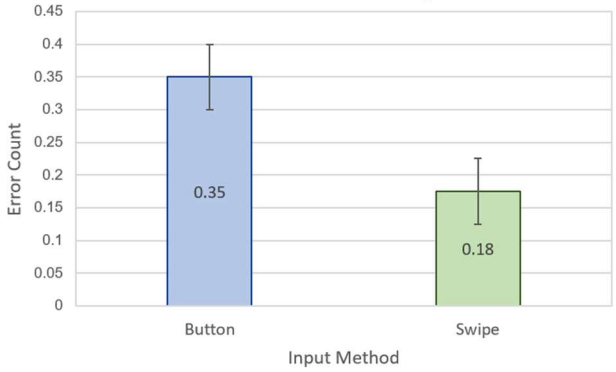

Figure 9. Errors made when using the button and swipe input methods.

As shown in Figure 10, when using the button-based input method, users displayed an overall higher average error rate with a mean average value of 0.35 over the five trials, which is 51.43% more than the swipe-based method, which amounted to 0.18.The average error rate does equalise at 0.38 over trial two, however, even as it shifts over the next three trials the error rate of the swipe-based method remains distinctly lower than its button-based counterpart.

The swipe-based input method both showcased a lower average error rate, but also showed a distinctly steep

change in errors made between trials as shown in Figure 10, which may be indicative of a more accurate system of input once users become accustomed to using the system. As can be seen in the graph in Figure 10, users showed an overall increase in errors made between their first two trials for the swipe-based method, going from 0.25 to 0.38 average errors, before the number of errors dropped down to zero and remained so until the very last trial.

On the contrasting side of things, the button-based method showed a consistent error rate of 0.38 over its first two trials before decreasing and then increasing again, much the same as the swipe-based method, which once more implies the notion of users growing accustomed to a given method of input. However, the button-based system never showcased an average error rate of zero, despite following a similar trend in changes to the swipe-based system. This implies that despite the users growing accustomed to this method, the potential for errors remains present, even if it does decrease. Especially when taking into account the fact that the average error rate of the button-based method never falls below 0.1.

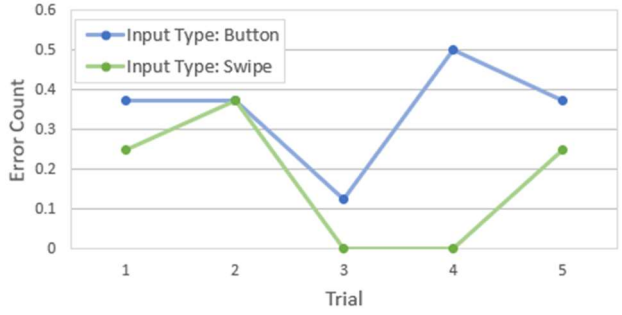

Figure 10. Error count (s) by input method and trial.

Overall, the swipe-based method was shown to be at least 51.43% more accurate than the button-based method, in the cases where errors were present, since trials 3 and 4 showcased an average error rate value of zero for the swipe-based method.

Participants might have made more errors with the button-based interaction method because the buttons are not very big, and participants might have accidentally missed them. Another factor that may have caused participants to make more errors with the button-based input system is that buttons only require a tap, and users might accidentally tap a button. Participants were highly unlikely to perform a swiping motion accidentally.

Participants found neither of the input methods confusing or hard to learn. This is likely because these are interaction methods that they use daily on their smartphone devices. Participants also did not face any fatigue or discomfort.

Participant Feedback

Based on the questionnaire given to participants after they completed the experiment, participants stated that they were able to learn both methods quickly. Seven of the eight participants indicated that they prefer the button method over the swiping method as the button method was more comfortable for how they naturally hold their phones.

CONCLUSION

An experiment was conducted comparing user performance of the tap and swipe interaction methods. A game was created to carry out this experiment which required users to enter a specified door either by a swiping or button-based input method. Users were required to enter one of five doors, whose numbers were randomly generated and displayed on top of the mobile screen. The speed and accuracy in which users completed the given tasks were tracked. In terms of speed, games completed in button mode performed 2.84% faster than games completed in swipe mode. Furthermore, in terms of accuracy, the swipe method was revealed to be more promising as games played using this method caused 51.43% fewer incorrect door entries than games played with the button method. Overall, participants indicated that they preferred the button-based input method over the swipe-based input method. Further work can be conducted by comparing the two input methods while users are using a mobile device and not looking down at the screen.

ACKNOWLEDGMENT

We thank the eight participants for their involvement in the experiment.

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