# An Evaluation of Direct Scrolling and Button Scrolling

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**ABSTRACT**
We conducted a user study examining the accuracy and task completion time of three scrolling methods for touch-screen mobile devices. The scrolling methods included direct scrolling with simulated physics, direct scrolling without simulated physics, and scrolling with buttons. The performance of nine participants was examined through a set of 5 trials for each scrolling methods. The experiment concluded that the task completion time of direct scrolling with simulated physics was about 13% lower than the other two scrolling methods. The direct scrolling with simulated physics was the most accurate method with a 0% error rate, while the error rate for the other two scrolling methods was 1.11%. Most participants chose direct scrolling with simulated physics as their preferred method of scrolling and the most convenient scrolling method. Direct scrolling without simulated physics was the least preferred scrolling method and the least convenient method among the participants.

**Keywords**
Android development, Scroll, Buttons, Gestures, Touch-Input, Visual Search

**INTRODUCTION**
Mobile Computing has come a long way over these past few decades. The mobile devices first introduced were cellular devices that were being solely utilized for communicating with one another. However, mobile phones have been converted into portable mini-computers that did not require physical keyboards through technological advances. Touch features became popular amongst users immediately by improving the user experience. For example, the touch feature facilitated the type action by allowing users to tap on the screen on a virtual keyboard rather than pressing physical keys. Additional touch gestures were introduced for improving usability, including swiping on the screen to attend a call instead of pressing the button, zooming on an image with a tap or pinch gesture rather than mouse clicks, key presses, etc. Another common feature that facilitates mobile interaction is the scroll gesture.
The scrolling gesture proves to be practical for completing many tasks on a smartphone. Whether it is to view posts on a social media application or read books on a device, the scrolling feature has high usage. This paper evaluates three scrolling methods based on their accuracy and task completion time. The evaluation is done using a visual search that requires scrolling to identify a number target. Even though the current scrolling feature is efficient in many ways, some applications utilize other touch gestures to implement scrolling.

**Direct Scroll with Simulated Physics**
The standard way of scrolling a list on mobile devices is by tapping and moving items. This can be done by a swipe gesture which sets the items in a state of motion and is called direct scrolling. Figure 1 shows how users can use their thumbs to scroll through the content by swiping in the orange arrow's direction [5].
Another feature of the commonly used scrolling method is that the list continues to scroll with a continually decreasing speed after the finger has left the surface of the touch screen. The scrolling speed decreases till it reduces to zero and stops the scrolling. The physics used for slowing the scrolling and turning the state of motion to a complete stop is called the simulated physics for scrolling [1]. The simulated physics allows scrolling through long lists with fewer interactions; however, the user must actively stop the motion when approaching the desired item on the list. This requires accurate monitoring and quick reaction. Additionally, the possibility to pass the target item, also known as overshooting, can be a source of longer task completion and lower accuracy, especially in large lists.

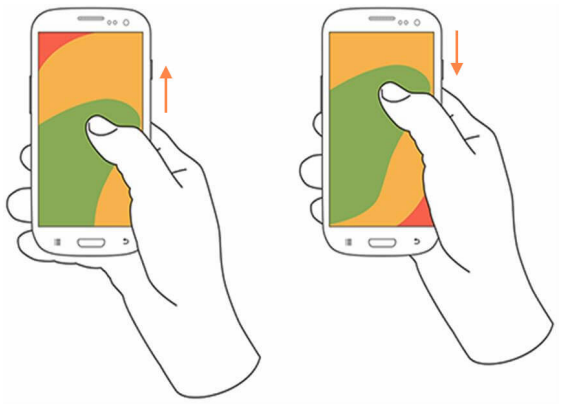

Figure 1. Gesture for performing a direct scroll [5]

**Direct Scroll Without Simulated Physics**
One of the drawbacks of using the direct scroll with simulated physics is that the user could go rapidly through a list and miss the target object. This is caused by the simulated physics that can lead to scrolling past the target

object. Removing the simulated physics will reduce or prevent overshooting. In direct scroll without simulated physics, when the user's finger leaves the touch screen, the list immediately stops at its current position. Although this method requires more interactions with the interface than direct scroll with physics, it was expected to reduce the number of overshoots and lead to lower task completion time and better accuracy.

### Button Scroll

Since users can scroll applications for hours, it is understandable the hand can get tired of swiping on a screen for too long. Scrolling with buttons is a variant to direct scrolling. The user can press a button for as long as they want to scroll, which prevents the continuous swipe gesture. Since the button scroll requires fewer finger movements, the aim was to observe if it can provide a convenient user experience compared to the direct scrolling methods. Theoretically, the button scroll requires less effort as the only action required is the button press where the user can apply pressure to the button to scroll and lift the pointer to stop.

## RELATED WORK

A study done by Breuninger et al. [1] examines seven different types of scrolling a list on a touch screen device and compares the speed, error rate, and subjective rating associated with each one of them. Throughout a series of trials, the participants had to find and select items on lists of different lengths. The participants demonstrated equal speed using direct scrolling and buttons to scroll. The number of overshoots causing error was higher in direct scrolling than in using buttons; however, this difference was insignificant. Direct manipulation without simulated physics performed significantly worse than all other scrolling methods in terms of input speed and error rate. Overall, participants favored direct scrolling along with an alphabetical index bar that allows fast jumps in the list.

In a study conducted by Brewster et al. [4], three scrollingtechniques were tested for in-car touchscreens: direct scrolling, pressure-based scrolling and scrolling using onscreen buttons on a touchscreen. 18 participants recruited for this study had to scroll through and browse an alphabetically ordered list of songs and select 15 songs. The results showed that direct scrolling was significantly less accurate than using onscreen buttons but took almost half the time to complete compared to the onscreen buttons.

A paper written by Miyaki et al. [3] proposes a scrolling model for single-handed mobile interaction. Their proposed method enables a user to scroll continuously using a single long pushing operation while the position of pushing determines the direction of the scroll. They claim that conventional procedures (e.g., flicking) require multiple time operations relative to demanded scrolling, and their proposed method makes a significant difference in usability for single-handed user operation.

A similar study done by Kujala et al. [2] evaluated the effects of three alternative touch screen scrolling methods for searching music tracks on a mobile device. The participants had to perform scrolling tasks while driving. They had to maintain a specified speed as well as staying in the lane. This study concluded that Kinetic scrolling decreased visual sampling efficiency and increased visual load compared with Swipe, increased experienced workload compared with both Buttons and Swipe, and decreased lane-keeping accuracy compared with baseline. However, Buttons did not significantly excel Kinetic with any metric but on subjective ratings.

## METHOD

An experimental user study was conducted to evaluate participants' performance using different scrolling methods on a mobile interface. The scrolling methods consisted of direct scrolling with simulated physics, direct scrolling without simulated physics, and scrolling using buttons. The experiment's purpose was to determine which scrolling method has a lower error rate and task completion time. Additionally, the user study intended to determine which scrolling method was preferred by the users.

### Participants

Nine close family members volunteered to participate in this experiment. Five of them were female, and the other four were male. The participants' age ranged from 22 to 55.

### Apparatus

The experiment ran on a Google Pixel 4a mobile device with Android 10 as its operating system. The device had a 5.8" display. The name of the Android experiment software is *Scroll Option Tester* and is used for scrolling through a list using different scrolling methods. The following scrolling methods are supported:

- Direct scrolling with simulated physics
- Direct scrolling without simulated physics
- Scrolling using buttons

Upon launching, the program presents a setup dialog. See Figure 2. The setup parameters are scrolling method and group number. The group number identifies the group to which the participant was assigned. The scrolling method is used to select the method to scroll. Different scrolling methods are defined in the application.

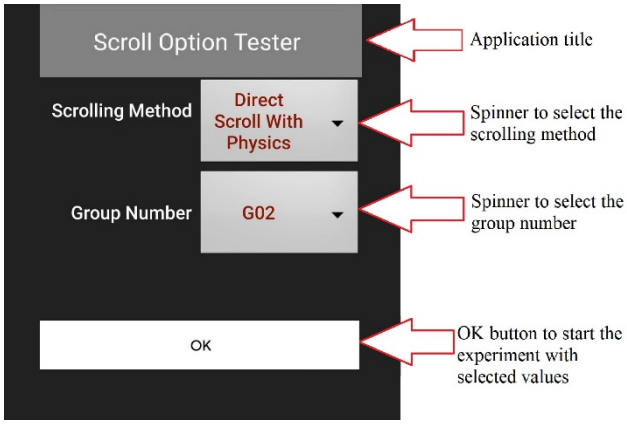


Figure 2. Screenshot of the setup dialog.

Timing and data collection begin when the experiment launches. The experiment launches with the selected scrolling method applied to a vertical list of numbers. The list is implemented using a ListView class, where each row is populated with a toggle button and a TextView using a custom Adapter. The TextView contains a random number[1]. The toggle buttons are set to off upon launching and can be switched on by a single tap with a finger on the button. A number is selected at random from the numbers in the vertical list. The randomly selected number is displayed above the vertical list. The randomly selected number displayed above the list should be found in the vertical list of numbers, and the toggle button assigned to it has to be switched on. Switching on a wrong toggle button counts as an error. Figure 3 shows how the experiment looks with direct scrolling with simulated physics and direct scrolling without simulated physics. Figure 4 shows how the experiment looks with scrolling with buttons.

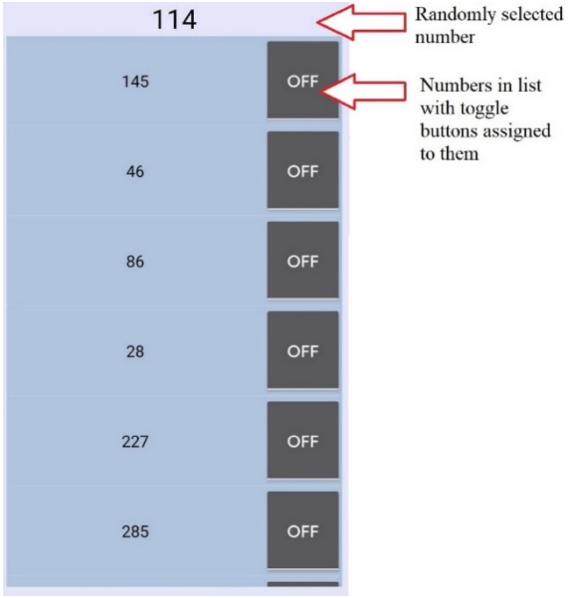


Figure 3. Screenshot of the experiment with directed scrolling with and without simulated physics.

When the number is found in the list and is switched on, timing and data collection end. A results popup shows the task completion time (in seconds) and the error rate (%). When the user taps "Okay," the next vertical list of numbers appears with another randomly selected number to be found in the list (i.e., the next trial). After 5 trials, the application goes back to the setup dialog.

When the 5 trials finish, user performance data are written to "txt" files. The files are stored into a directory called "TrialFolder" – a sub-directory within the device's public external storage directory. The output files use the name of the scrolling method as the base filename. This is followed by group number and timestamp. An example might be ButtonScroll-G02-210047.txt.

The output files' data are comma-delimited and contain:

- Group numbers
- Scrolling method
- Task completion time per trial (in seconds)
- Average of error rate per trial (%)

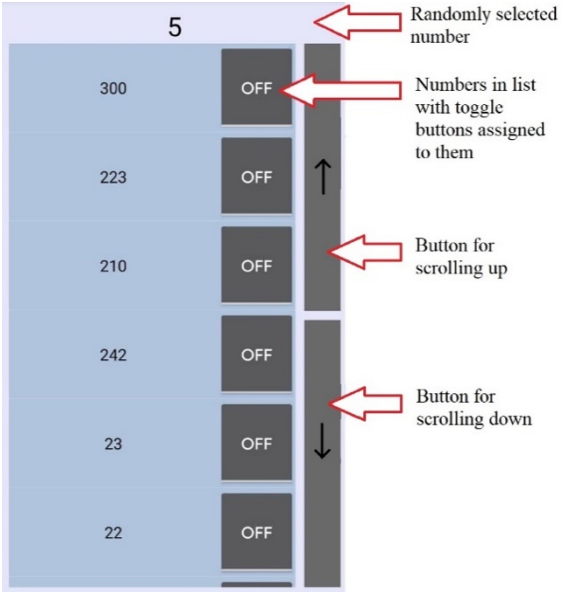


Figure 4. Screenshot of the experiment with scrolling with buttons.

**Procedure**

Nine participants were divided into three equal groups. Participants were informed of how the software operates, the task they had to complete, and the purpose of the experiment at the beginning of the experiment. There were no practice trials before the experiment. Participants were seated and used the software on their mobile android devices.

The participants completed five trials using each of the three scrolling methods. The experiment took approximately three to four minutes for each participant. The participants used scrolling methods in an order based on the groups they were in. The order they performed in is as followed:

- Group A: direct scrolling with simulated physics, direct scrolling without simulated physics, scrolling using buttons.
- Group B: direct scrolling without simulated physics, scrolling using buttons, direct scrolling with simulated physics.
- Group C: scrolling using buttons, direct scrolling with simulated physics, direct scrolling without simulated physics.

After the participants finished the experiment using all three scrolling methods, they were asked to complete a

[1] The Code for setting ListView was taken from Demo_ListView_1

questionnaire related to their experience from the experiment, their preferred method of scroll in terms of convenience, and some personal information.

### Design

The user study employed a single-factor within-subjects design. The independent variable consisted of three levels:

- Scrolling method (direct scrolling with simulated physics, direct scrolling without simulated physics, scrolling using buttons)

The dependent variables were task completion time and error rate. Participants were divided into three groups to counterbalance the order of testing and thereby cancel learning effects due to the sequence of testing. In addition, data were collected via the questionnaire administered after testing. The total number of trials was 9 participants x 3 scrolling methods x 5 trials = 135 trials.

## RESULTS AND DISCUSSION

Upon completing the user study, there were some interesting findings regarding three scroll methods on the task completion time and the error rate. Additionally, the qualitative analysis showed some intriguing results about the preference of the scroll methods amongst the users.

### Task Completion Time Per Trial

The task completion time was the main dependent variable in this experiment. Over a total of 135 trials, the mean task completion time was 7.33 seconds. The lowest mean task time was for the direct scrolling with simulated physics, which was 6.71 seconds, followed by scrolling with buttons with 7.63 seconds, and the highest mean was for direct scrolling without simulated physics of 7.65 seconds. See Fig. 5. In comparison, the mean task completion time for direct scrolling with simulated physics was 12.83% less than the mean for direct scrolling without simulated physics and 13.09% less than the mean for scrolling with buttons.

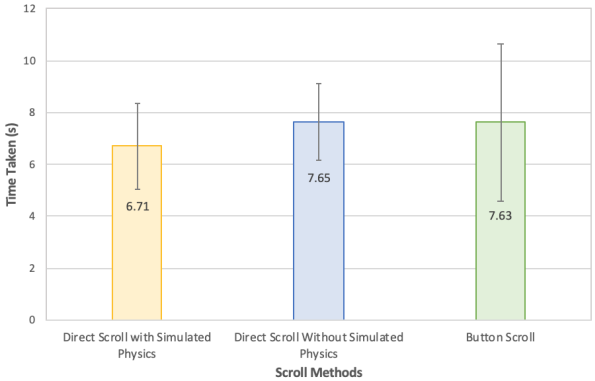


Figure 5. Bar chart displaying the mean task completion time of scrolling methods.

The results for task completion time were as expected because the users commonly use direct scrolling with simulated physics, and have adapted to it, while the users needed time to adjust to the other two scrolling methods. The output suggests that adaptability of the scrolling matters while performing a visual search. Additionally, we can observe that time recorded for beginning trials is higher than the ending trials as the mean for the first trial of all methods is 10.72 seconds, and for the last trial, it is 6.53. This is shown in Fig. 6. The time decreased by 48.6% in just 5 trials.

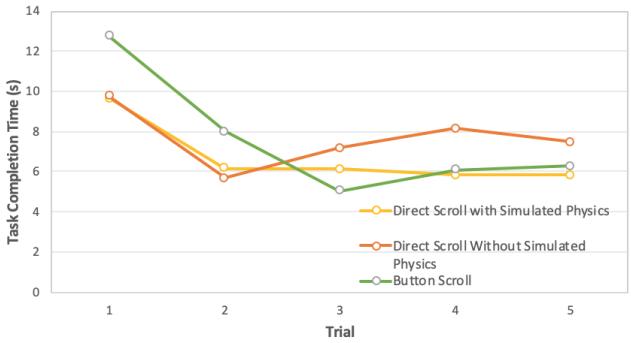


Figure 6. Line chart displaying the task completion time of scrolling methods per trial.

The reduction in task completion time suggests that some practice with the scroll methods can improve users' performance and help them adapt them to button scroll and direct scroll without simulated physics.

### Error Rate Per Trial

The error rate had minimal changes throughout the experiment. Out of 135 trials, 98.52% of the trials completed without errors. The direct scroll with simulated physics method had the lowest error rate of 0% by all users, while direct scroll without simulated physics scroll and button scroll each had an error rate of 1.11%. as shown in Fig. 7.

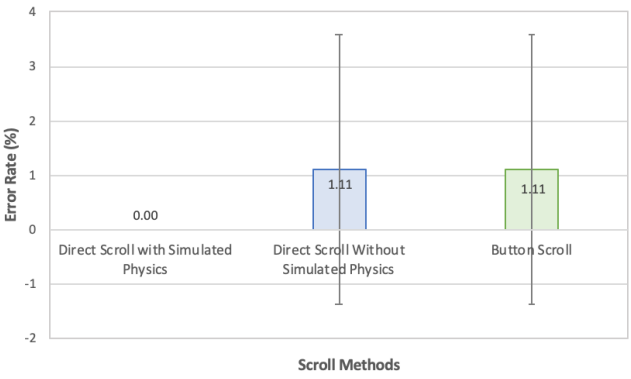


Figure 7. Bar chart displaying the mean error rate of scrolling methods.

Since the direct scroll with simulated physics scrolling method is common, it explains why users focused on the visual search rather than adapting to the new techniques. Users did not need to adjust to the scrolling technique while the users got used to the other two methods after the first trial.

### Qualitative Analysis

After finishing the activity, the users completed a survey where they picked the most convenient scrolling method for their use and provided an overall preference for all the scrolling methods. The direct scrolling with simulated physics and scrolling with buttons have an average

preference rate of 7.67 out of 10, while the direct scrolling without simulated physics has an average preference rate of 7.33 out of 10, as shown in Fig. 8. The direct scrolling without simulated physics was preferred 4.53% less than the other two scrolling methods.

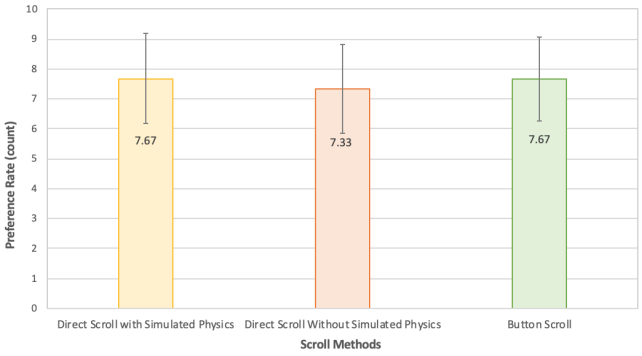


Figure 8. Bar chart displaying the mean user preference of scrolling methods.

Additionally, users chose their preferred method in terms of convenience where 44.4% of the users chose direct scroll with simulated physics, followed by button scroll with 33.3% of the user votes, and direct scroll without physics with 22.2%. This can be seen in Fig. 9.

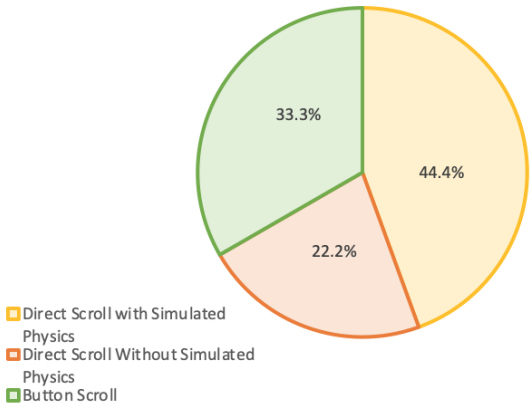


Figure 9. Pie chart displaying the user convenience in scrolling methods.

## CONCLUSION

This experiment compared the task completion time and accuracy of users using three scroll methods for touch screen mobile phone devices. The scrolling methods examined in the user study included direct scrolling with simulated physics, direct scrolling without simulated physics and scrolling with buttons. The time taken by users to complete the task using direct scrolling with simulated physics was the lowest among the three scrolling methods (6.71 seconds), followed by scrolling with buttons (7.63 seconds) and direct scrolling using without simulated physics (7.65 seconds). Participants made 0% error using direct scrolling with simulated physics and made 1.12% error using direct scrolling without simulated physics and scroll with button. As a result of the qualitative data regarding the participants' preferred scrolling method, participants proffered scrolling method without physics 4.53% less than the other two methods which had an average preference rate of 7.67 out of 10. The result for the qualitative data also shows that 44.4% of the participants chose direct scrolling with simulated physics as the most convenient scrolling method, while 33.3% of the participants chose scrolling with buttons and 22.2% of the participants chose direct scrolling without physics as the most convenient scrolling method. The study also shows that since participants were already familiar and had adapted to the direct scrolling with simulated physics, they performed better in terms of accuracy and task completion time in the experiment.

Our study is scalable for further research. The user study can be further improved by including more dependent variables such as missed target as a number of times users scroll past the target number.

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