

# Evaluation of Scrolling Techniques

## Report and Documentation

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PREPARED FOR

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## 1. DESCRIPTION OF TECHNIQUES

The pointing devices used in the test were chosen to represent some frequently-used devices, each with a different ideal usage. The devices used were an iPhone 6 (screen dimensions: 1334 x 750 at 326 ppi), a first-generation iPad Air (screen dimensions: 2048 x 1536 at 264 ppi), the trackpad of a Macbook Pro 15" laptop (screen dimensions: 2880 x 1800 at 227 ppi; tracking speed set to 33% of the maximum). The devices had a range of diagonal screen sizes, the iPhone measuring 4.7 inches (width: 6 cm, height: 10.5 cm), the iPad measuring 9.7 inches (width: 14.7, height: 19.7), and the Macbook measuring 15.4 inches (width: 36.4 cm, height: 24.9 cm). As for the All tests used Google Chrome (OSX version on the Macbook and iOS version on the two other devices) which fully maximized but not in "full screen mode."

It was difficult to access to more exotic devices, but the three pointing devices tested provide a good base of data with regard to general use cases. This is to say — data about popular devices is more applicable and telling with regard to general use at the expense of gaining understanding of edge cases (i.e. rare methods of pointing which may be significantly better or worse than more popular devices).

## 2. DESCRIPTION OF PARTICIPANTS

I was the first person to test all input devices, and I use all three devices in my personal life, giving me a good amount of experience with each. However, my most used device is my Macbook which I use mostly for software development, writing, video editing, and browsing the Internet. In close second is my phone,

which I use for more lightweight operations including for producing/consuming social media. I use my iPad less frequently than the other two devices, but when I do I'm usually reading, watching videos, or playing a game on it. I have had access to some kind of computer for the past eight years, and have used them frequently since then, so I believe I am proficient with technology. I conducted my tests in my room sitting on my couch. For both mobile devices, I held the device with my left hand and used my right index finger (my dominant hand) to point. For the Macbook, I rested it on my lap and used the trackpad with my right hand. I first tested the Macbook, followed by the iPhone, and then the iPad.

In addition to myself, I recruited a sophomore Design major (let's call him Noah) who uses a computer on a daily basis for his work but for different purposes than I do. Noah self-reported that he is proficient with technology, and has been using a computer since before middle school (a Sony Vaio). For the past five years, he has used a computer similar to the tested device (a Macbook Pro of a different size), giving him significant experience with the Apple trackpad. Noah has also owned an iPhone for the past six years, which he uses on a daily basis. While he has experience using an iPad, he does not own one and does not use it frequently. He said that his most-used devices are his Macbook and iPhone. All of his tests were conducted with his dominant hand (which is his right hand), and the tests were located at a table in a study area of the Gates Hillman Center on Carnegie Mellon's campus. During testing, both the iPad and Macbook rested on the table but he held the iPhone in his hand. The order of the testing was first with the iPhone, then the Macbook, then the iPad.

The final participant was a friend of mine studying art (let's call her Sarah) who does not use a computer often, and when she does it's usually to consume social media or watch videos (low-skill activities). She self-reported that she is neither proficient nor incompetent with technology, although leaning towards incompetent. Sarah has used an iPad a couple of times, but she did seem to be comfortable with the device. While she does have an iPhone, she uses it infrequently and does not treasure it like many people do their phone. As an example, Sarah lost her phone for the past week and a half and appeared unconcerned, making little effort to remedy the situation, leaving her unable to be reached easily. Sarah first tested with the iPad, followed by the Macbook, and finally the iPhone. These tests were conducted in a design studio in the Margret Morrison building on Carnegie Mellon's campus, at a large table. For all of the tests, Sarah placed the device on the table and pointed with her left hand. Sarah was the only left-handed participant.

### 3. RESULTS

After reviewing the data, it was immediately clear that each device had significantly different performance for each metric. As far as an overall average of how long it took to complete the test and how error prone each test was, the iPhone both took the least amount of time (123.8 seconds on average) but was the most error prone (26.7% of taps were errors, on average). On the opposite end of the spectrum, the Macbook performed in a way complimentary to the iPhone's performance; the Macbook test took the longest (529.4 seconds) but was by far the most precise (4.3% of clicks were errors). Coming in as the most "balanced" choice, the iPad tests were reasonably quick (352.7 seconds; almost halfway between the other two devices) but relatively error prone (25.7% of taps were errors, which is almost as bad as the iPhone).

As far as users are concerned, I ended up taking the least amount of time (256.4 seconds) but I was not the least accurate (nor the most), with a reasonable error rate of 19.7%. The slowest and most error prone person was the dissimilar participant, who took a time nearly double the best time (441.5 seconds) but an error rate in the same ballpark as the rest (25.6%). The similar participant had results similar to mine, taking 308.0 seconds to complete the test on average, and with an average error rate of 14.3%, the best of the group. When looking at how the error percentage and response time changed as a function of the bar size, each device had very different performance. In terms of error percentage, the iPad and iPhone both behaved similarly (although this conclusion is hard to make because the iPhone is too small for a few of the tests to be valid). Both touch screen devices showed that users tapped the bars more accurately when the bars were bigger, as one might expect. Somewhat surprisingly, the Macbook did not exhibit this performance, showing a consistently random error percentage for each test, with no clear trend.

As far as the response time varies as a function of the bar size, the results for each device appeared to trend in a similar manner but the effect was far less pronounced than the how the error percentage varied. This behavior suggests that perhaps users prioritized a quick response rather than an accurate one, which is why the accuracy varies more than the response time. Theoretically, if the participants had been instructed to prioritize accuracy, perhaps the response time would be a more valuable metric to measure the difference between different target sizes.

The significant accuracy difference between the trackpad and the touch enabled devices can be explained by the nature of the two different interactions, and the fundamental differences between them. Because a mouse can point to a single pixel, it is easy to get a score with a low error percentage as long as you take a little bit more time to position it correctly. Conversely, when the bars

are small, it can be impossible to select it because the selection area created by the finger is in some cases far bigger than the target area. As far as preferences go, all of the participants expressed frustration when using the small iPhone screen because the targets were often smaller than the size of a finger. One participant also described the task on the Macbook as "tedious" because of the relative difficulty of accurately aiming a mouse with a trackpad as opposed to simply tapping with a finger.

It is unclear how strong of a learning effect there is, but participants did seem to be more confident using the iPad after the iPhone or vice-versa. However, using the Macbook and the iPhone (or iPad) did not translate as directly, and as such users did not appear as confident using the Macbook before a touch device as they did when they used two touch devices in a row.

## 4. DISCUSSION

The main issue with the direct touch interaction is the large selection size inherent with using one's finger to select a target. However, this inconvenience is often outweighed by how intuitive simply tapping on something is — touching something directly is perhaps the most basic way for a human to interact with an object, so no one needs to be educated about how that interaction works. On the other hand, the trackpad was designed for accuracy before ease-of-use, which is reflected in the results: users were more frustrated using the trackpad but the accuracy of the device was better by an order of magnitude.

The different design principles behind each interaction reflect that each excel for different uses. The trackpad performs as a more professional "tool" — something that must be learned (albeit quickly) but that performs exactly as advertised. As long as you take your time, it's easy to pick a very precise spot and point to it.

The touchscreen, which seems like a modern invention, has its roots in 1965, when E.A. Johnson came up with the plans for the first finger-driven touchscreen. However, Johnson's touchscreen did not resemble the kind of touchscreen in a present-day iPhone (e.g. there was no multi-touch & it was not resistive), but the principle has its roots with Johnson. In 1983, after years of research across many institutions and companies, HP released the HP-150 as one of the first touchscreen computers ever. Just a year later, Bob Boie of Bell labs developed the world's first touchscreen that supported multiple fingers at a time. After this, many pen-based touchscreens flooded the market (e.g. Palm Pilot, Apple Newton). However, as far as society is concerned, this kind of interaction was made widespread in 2007 when the iPhone gained popularity (with Apple making it look like they invented multi-touch).

The trackpad developed around a similar time, when in 1982 Apollo computers shipped with a touchpad. However, in a similar fashion as they did with multi-touch, Apple Computer was the first to license the touchpad for laptops in 1994, and where it has since remained.