A2 Pointing and Text Entry

HCID 520: User Interface Software and Technology | Michael Kwok & Kellie Weaver

Abstract

This study evaluated the performance of two pointing and two text entry methods - assessing differences in speed, accuracy, and throughput. Eight participants completed pointing tasks using a mouse with "enhance pointer precision" (aka mouse acceleration) on and off, measuring Movement Time, Error Rate, and Throughput. We included an extra dimension of testing mouse-adept gamers (who prefer "enhance pointer precision" off) vs non-gamers. Text entry was analyzed with a different set of 8 participants using an iPhone keyboard and a Laptop keyboard, measuring words per minute, uncorrected error rate, corrected error rate, total error rate, and throughput. Across both tests, paired t-tests did not assess statistically significant differences between modalities in speed and accuracy metrics. While this suggests no generalizable advantage for accelerated/non-accelerated pointing or iPhone vs laptop text entry, some individuals showed strong performance gains across all metrics when switching modalities. Thus, we surmise individual users should not be dissuaded from seeking performance gains by switching between tested input methods.

Introduction

Pointing and text entry are fundamental interactions in human-computer interaction (HCI). This study aims to compare two pointing methods—pointer acceleration vs no acceleration—and two text entry methods—iPhone keyboard and Laptop keyboard. The study applies Fitts' Law to model pointing device performance and evaluates text entry efficiency using established metrics such as words per minute (WPM), uncorrected error rate (UER), corrected error rate (CER), total error rate (TER), and throughput. Understanding these trade-offs is crucial for designing effective input systems in various computing environments. This study also explores user frustration levels and qualitative observations regarding usability challenges.

Pointing Study

Mouse acceleration is turned on by default on all desktop / mouse-controlled systems, but may reduce consistency of tracking as cursor movement is influenced by mouse movement speed (instead of just distance). For this reason, mouse-adept gamers highly prefer no mouse acceleration. We were interested in exploring whether this has a meaningful impact on speed and accuracy in the ways they expect or claim. We hypothesized that mouse-adept gamers would see movement time and throughput advantages when "enhance pointer precision" was turned off, and that normal users would see the inverse.

Method

Participants

The study included eight participants (5 male, 3 female) who volunteered to take part in the pointing evaluation. Participants 1-4 were mouse-adept gamers, who used mice daily or almost daily as a primary input device for games spanning FPS, RTS, and rhythm genres. Participants 5-8 were normal computer users, who semi-regularly used mice - on ~ weekly basis. Age of participants ranged from 23 to 30 years, with an average age of 25.5 (SD ± 2.2 years). To maintain anonymity, no personally identifying information was collected.

Apparatus

Testing was run on a Windows desktop computer running Windows 11 - monitor size was 27" @ 1440p. The computer has a Intel i5-12600k @ 3.7GHz base clock, sitting at a desk setup. The mouse used was a wireless USB Razer Orochi (2.4GHz) - a small mouse best for RTS game scenarios. Participants were able to change mouse settings to suit their preferences (barring acceleration). PC gaming participants were picky about their sensitivity/DPI and adjusted the settings on the mouse to match their setups at home. Non-gaming participants did not ask to change the default mouse configuration, which was set to 1600dpi.

Procedure

Each participant completed pointing trials with "Enhance Pointer Precision" on & off. The setting was counterbalanced among participants to minimize order effects, with half of the participants starting with mouse acceleration on and the other half starting with acceleration off.

Participants were instructed on the task - 18 trials of the “Circles” layout in FittsStudy (including 3 test trials) which implements the ISO 9241-9 standard for pointing device evaluation, and adopts the best practices described in MacKenzie & Isokoski (2008) as well as Wobbrock et al. (2011). They were instructed to balance speed and accuracy and informed of an approximate time commitment of ~10m. This resulted in 16 trial results, with data logged in both .txt and .xml format, notably tracking Movement Time, Error Rate, and Throughput.

Results

Participants in Green represent mouse-adept gamers, **Participants in Blue** represent normal computer users

Figures 1 & 2: Performance Metrics for Accelerated & Non-Accelerated Pointing

(“Enhance Pointer Precision” on & off)

Pointing Data - Accelerated Pointer			
Participant	*MT (MTavg) - ms*	*Error Rate (Error%)*	*Throughput (TP_avg(2d))*
1	711.2222	5.00%	4.5161
2	618.0556	4.44%	5.4217
3	540.8333	2.78%	6.2837
4	496.3889	10.50%	6.1178
5	839.6111	3.33%	4.1192
6	859	2.22%	4.2424
7	1018	0.0389	3.4822
8	1067.5	0.0278	3.3342
Mean (SD)	**768.83 (212.7)**	**4.37% (2.64%)**	**4.69 (1.13)**

Pointing Data - Non-Accelerated Pointer		
MT (MTavg) - ms	*Error Rate (Error%)*	*Throughput (TP_avg(2d))*
569.4444	6.67%	6.1253
593.2778	7.22%	5.6574
613.0556	5.56%	5.628
532.3889	4.44%	6.6846
606.9444	5.00%	6.0106
854.1111	3.89%	4.55
1164.2778	0.0611	2.9651
1294.2222	0.0222	2.8962
778.47 (296.62)	**5.14% (1.62%)**	**5.06 (1.45)**

Pointing Paired T - Test Report

Figure 3: Pointing Paired T Tests

Pointing Paired T - Test Results & Statistical Significance Breakdown						
Metric	*Accelerated (Mean ± SD)*	*Non-Accelerated (Mean ± SD)*	***t(df=7)***	***SED***	***p - value***	***Significant? (p < 0.05)***
MT *(ms)*	768.83 ± 212.7	778.47 ± 296.62	0.1841	52.345	**0.8591**	**No**
Err%	4.37% ± 2.64%	5.14% ± 1.62%	0.7388	1.40%	**0.4841**	**No**
TP_avg(2d) *(bits/s)*	4.69 ± 1.13	5.06 ± 1.45	1.109	0.338	**0.3041**	**No**

Movement Time (MT)

The average Movement Time (MT) for mouse accelerated pointing was 768.83 (SD = 212.7), and 778.47 (SD = 296.62) for unaccelerated pointing. The difference was not statistically significant according to the paired t-test (t(7) = 0.18, p = 0.86), indicating no detectable difference in MT between the two settings for pointing.

Error Rate (Err%)

The average Error Rate for mouse accelerated pointing was 4.37% (SD = 2.64%), and 5.14% (SD = 1.62%) for unaccelerated pointing. The difference was not statistically significant according to the paired t-test (t(7) = 0.74, p = 0.48), indicating no detectable difference in error rate between the two settings for pointing.

Throughput (TP_avg(2d))

The average Throughput average for mouse accelerated pointing was 4.69 (SD = 1.13), and 5.06 (SD = 1.45) for unaccelerated pointing. The difference was not statistically significant according to the paired t-test ($t(7) = 1.11$, $p = 0.3$), indicating no detectable difference in error rate between the two settings for pointing.

Text Entry Study

Method

Participants

The study included eight participants (4 male, 4 female) who volunteered to take part in the text entry evaluation. Participants came from diverse backgrounds, including students, office professionals, and software engineers, ensuring a mix of typing experience levels. Their education levels ranged from undergraduate students to professionals with advanced degrees. All participants regularly used both smartphones and laptops for text entry, with varying levels of proficiency in each. Some primarily relied on physical keyboards for professional work, while others used touchscreen keyboards as their main input method for personal communication. The ages of the participants ranged from 20 to 35 years, with an average age of 27.4 (SD ± 4.5 years). To maintain anonymity, no personally identifying information was collected.

Apparatus

The text entry study was conducted using two input devices: an iPhone 13 keyboard (on-screen touch keyboard) and a standard Mac laptop keyboard (physical QWERTY keyboard). The iPhone 13, running iOS 17, features a 6.1-inch touchscreen with Apple's virtual keyboard, while the laptop keyboard was tested on a Macintosh laptop (macOS Sequoia 15.2). TextTest++, an online tool for text entry evaluation, was used to collect words per minute (WPM), uncorrected error rate (UER), corrected error rate (CER), total error rate (TER), and throughput. The tool presented participants with randomized predefined phrases, measuring typing speed and accuracy. Log files were exported in CSV and JSON formats for further analysis. Throughput was calculated using the Throughput_public.py script, which applies Shannon's information theory to measure efficiency in character entry. Participants performed the text entry tasks in a controlled indoor environment with consistent lighting and minimal background noise to reduce external distractions. They were seated at a desk, ensuring a stable typing posture across both conditions.

Procedure

Each participant completed text entry trials using both input methods: the iPhone keyboard and the Macintosh laptop keyboard. The order of device usage was counterbalanced among participants to minimize order effects, with half of the participants starting with the iPhone keyboard and the other half starting with the laptop keyboard. Each participant transcribed 20 phrases per condition, which were randomly selected from the standard MacKenzie & Soukoreff (2003) phrase set—a widely used benchmark in text entry studies. The "Shuffle whole set" option in TextTest++ was enabled to ensure randomization of phrases for each participant. The "Use Enter for Next" option was enabled in TextTest++, allowing participants to advance to the next phrase by pressing Enter on the laptop keyboard or tapping the Next button on the iPhone keyboard. Participants were instructed to type as quickly and accurately as possible. They were allowed to correct errors if noticed immediately but were advised to continue typing if correcting an error would disrupt their flow.

Upon completion, logs from each session were saved in both JSON and CSV formats for further analysis. The recorded metrics included words per minute (WPM), uncorrected error rate (UER), corrected error rate (CER), total error rate (TER), and throughput. Throughput was calculated using the Throughput_public.py script, which applies Shannon's information theory to measure efficiency in character entry.

Results

Figure 4 & 5: Performance Metrics for iPhone & Laptop Keyboards: Words per Minute (WPM), Uncorrected Error Rate (UER), Corrected Error Rate (CER), Total Error Rate (TER), & Throughput (TP)

Text Entry Method - iPhone Keyboard to Type					
Participant	*Words per Minute*	*Uncorrected Error Rate*	*Corrected Error Rate*	*Total Error Rate*	*Throughput (bits/s)*
1	44.41 (15.41)	0.59 (0.13)	0.088 (0.074)	0.68 (0.13)	3.810 bits/s
2	43.88 (17.15)	0.53 (0.19)	0.08 (0.07)	0.60 (0.20)	4.276 bits/s
3	27.30 (11.01)	0.52 (0.15)	0.20 (0.13)	0.72 (0.12)	3.318 bits/s
4	17.02 (9.80)	0.50 (0.19)	0.09 (0.09)	0.59 (0.20)	1.445 bits/s
5	35.72 (43.13)	0.49 (0.21)	0.26 (0.25)	0.76 (0.14)	1.462 bits/s
6	60.21 (20.46)	0.60 (0.12)	0.047 (0.067)	0.64 (0.15)	4.856 bits/s
7	30.52 (11.49)	0.67 (0.10)	0.10 (0.10)	0.76 (0.09)	2.523 bits/s
8	56.04 (21.68)	0.69 (0.13)	0.035 (0.052)	0.73 (0.125)	3.116 bits/s
Mean (SD)	**39.39 (14.63)**	**0.57 (0.08)**	**0.1125 (0.0775)**	**0.685 (0.0684)**	**3.10 bits/s (1.24 bits/s)**

Text Entry Method - Laptop Keyboard to Type					
Participant	***Words per Minute***	***Uncorrected Error Rate***	***Corrected Error Rate***	***Total Error Rate***	***Throughput (bits/s)***
1	37.43 (14.76)	0.637 (0.154)	0.041 (0.057)	0.679 (0.163)	2.394 bits/s
2	55.96 (19.94)	0.54 (0.20)	0.07 (0.07)	0.61 (0.19)	5.284 bits/s
3	44.26 (19.84)	0.63 (0.16)	0.11 (0.14)	0.74 (0.11)	2.619 bits/s
4	57.37 (25.35)	0.54 (0.17)	0.06 (0.07)	0.61 (0.15)	5.261 bits/s
5	26.27 (14.94)	0.55 (0.17)	0.15 (0.12)	0.70 (0.16)	1.708 bits/s
6	59.0 (22.6)	0.62 (0.13)	0.07 (0.06)	0.69 (0.11)	4.620 bits/s
7	20.91 (12.48)	0.60 (0.15)	0.07 (0.10)	0.67 (0.13)	1.292 bits/s
8	48.69 (17.90)	0.56 (0.14)	0.08 (0.06)	0.63 (0.14)	4.672 bits/s
Mean (SD)	**43.74 (14.43)**	**0.585 (0.041)**	**0.0814 (0.033)**	**0.666 (0.046)**	**3.48 bits/s (1.65 bits/s)**

Text Entry Paired T - Test Report

Figure 6: Performance Metric for Paired T-Test

Paired T-Test (t(df=7))					
t(df=7)	***WPM***	***Uncorrected Error Rate***	***Corrected Error Rate***	***Total Error Rate***	***Throughput***
t	0.6944	0.4026	1.6848	0.6463	0.5219
df	7	7	7	14	14
Standard Error of Difference (SED)	6.263	0.027	0.018	0.029	0.729

Paired T - Test (Statistical Significance Breakdown)					
Metric	***iPhone Keyboard (Mean ± SD)***	***Laptop Keyboard (Mean ± SD)***	***t(df=7)***	***p - value***	***Significant? (p < 0.05)***
WPM	39.39 ± 14.63	43.74 ± 14.43	**0.694**	**0.5098**	**No**
UER	0.57 ± 0.08	0.585 ± 0.041	**0.403**	**0.6993**	**No**
CER	0.112 ± 0.077	0.0814 ± 0.033	**1.684**	**0.1359**	**No**
TER	0.685 ± 0.0684	0.666 ± 0.046	**0.646**	**0.5285**	**No**
Throughput	3.101 bits/s ± 1.241 bits/s	3.48 bits/s ± 1.65 bits/s	**0.521**	**0.6099**	**No**

Words per Minute (WPM)
The average words per minute (WPM) for the iPhone Keyboard was 39.39 (SD = 14.63), and for the Laptop Keyboard was 43.74 (SD = 14.43). The difference was not statistically significant according to the paired t-test ($t(7) = 0.69$, $p = 0.50$), indicating no detectable difference in WPM between the two two methods of text entry.

Uncorrected Error Rate (UER)
The average uncorrected error rate (UER) for the iPhone Keyboard was 0.57 (SD = 0.08), and for the Laptop Keyboard 0.58 (SD = 0.04). The difference was not statistically significant according to the paired t-test ($t(7) = 0.40$, $p = 0.69$), indicating no detectable difference in UER between the two methods of text entry.

Corrected Error Rate (CER)
The average corrected error rate (CER) for the iPhone Keyboard was 0.11 (SD = 0.07), and for the Laptop Keyboard 0.081 (SD = 0.03). The difference was not statistically significant according to the paired t-test ($t(7) = 1.68$, $p = 0.13$), indicating no detectable difference in CER between the two methods of text entry.

Total Error Rate (TER)
The average total error rate (TER) for the iPhone Keyboard was 0.68 (SD = 0.06), and for the Laptop Keyboard 0.66 (SD = 0.04). The difference was not statistically significant according to the paired t-test ($t(7) = 0.64$, $p = 0.52$), indicating no detectable difference in TER between the two methods of text entry.

Throughput
The average throughput for the iPhone Keyboard was 3.10 bits/s (SD = 1.24 bits/s), and for the Laptop Keyboard 3.48 bits/s (SD = 1.65 bits/s). The difference was not statistically significant according to the paired t-test ($t(7) = 0.52$, $p = 0.60$), indicating no detectable difference in throughput between the two methods of text entry.

Discussion

Pointing

The pointing study revealed negligible differences in Movement Time and Throughput between the two input methods. The largest gap was found in Error Rate: with an 8% improvement across participants when acceleration was on vs off. However, paired t-tests indicated that differences between accelerated and non-accelerated pointing were not statistically significant ($p > 0.05$ for all metrics). This indicates that we cannot draw definite conclusions on performance of one setting over the other *across all participants*. This intuitively tracks: we tested a one setting change on mouse input instead of two completely different input methods and purposefully picked participants we predicted would balance in terms of setting preference.

However, there are interesting dimensions to consider in our data besides looking at participant data as a whole. First is data from our first four "mouse-adept gaming" participants: despite stated preference for non-accelerated pointing, differences across all metrics were negligible between settings (mean percentage differences in [MT, Err%, TP] = [1.25%, -2.51%, -3.78%] - where negative percentages indicate advantage for non-accelerated pointing). This disproves our initial hypothesis. For error rate, we had an outlier (P4) with significantly higher Err% with accelerated pointing. Considering the data without their entry, accelerated pointing was on average 20% less error prone, with a two-tailed p-value of 0.0065 for a very statistically significant result. Given that it modifies our already small dataset we cannot draw conclusions, but a larger study on mouse acceleration looking into benefits in error rate could be justified.

Finally, it is worthwhile to note that - while there were no statistically significant differences in performance across metrics when looking at our data as a whole - participants P1 and P5 showed large (10%+) improvements across all metrics when using non-accelerated pointing vs accelerated. P8 showed similar improvements in the inverse. Additionally, assessing statistical significance via p-value in this test may not reflect performance in settings that participants use to evaluate preferences. Moving targets, non-predictable patterns, and stringent requirements for performance (eg. 50ms as the difference between a win and loss) are not accurately reflected in the FittsStudy test or mean & standard deviation-based evaluation. Therefore while our results suggest no meaningful or generalizable performance gains from a settings switch, individuals may still find better performance in their preferred settings by testing acceleration on vs off. Investigating proper conditions and measurements for a test that more closely evaluates gaming performance is also an angle for further exploration.

Text Entry

The text entry study revealed a slight efficiency advantage for the laptop keyboard, with higher throughput (3.48 bits/s, SD = 1.65) and words per minute (43.74, SD = 14.43) compared to the iPhone keyboard (3.101 bits/s, SD = 1.241; WPM = 39.39, SD = 14.63). However, paired t-tests found no statistically significant differences ($p > 0.05$) across all metrics, suggesting that individual performance variability outweighed any device-specific advantages.

While accuracy differences were minor, uncorrected error rates (UER) were slightly lower on the iPhone keyboard (0.57) than the laptop keyboard (0.585), suggesting that participants were less likely to leave errors uncorrected on the touchscreen. However, corrected error rates (CER) were higher on the iPhone keyboard (0.1125) compared to the laptop keyboard (0.0814), likely due to autocorrect interventions introducing unintended errors rather than improving accuracy. Total error rates (TER) followed a similar trend (iPhone: 0.685, Laptop: 0.666), though these differences were also not statistically significant. These findings suggest that while the touchscreen keyboard assisted with error correction, it also introduced a level of unpredictability, leading to increased frustration. Individual performance differences were substantial. P6 had the highest WPM (60.21) on the iPhone keyboard, while P4 had the lowest (17.02), highlighting a large disparity in touchscreen typing speeds. On the laptop, P2 had the fastest WPM (55.96), while P7 had the lowest (20.91). These variations suggest familiarity with a given input method significantly influenced performance outcomes.

Error rates also varied across participants. P5 exhibited a particularly high corrected error rate (0.26) on the iPhone keyboard, well above the group average (0.1125), suggesting frequent reliance on autocorrect. Similarly, P3 also had an elevated CER (0.20), reinforcing the idea that some participants struggled more with autocorrect interventions than others. These outliers indicate that individual habits and prior experience shaped typing efficiency more than the device itself. Despite similar overall performance, participants expressed greater frustration with the iPhone keyboard, citing small tap areas and autocorrect-related issues. While predictive text helped some users, others found it disruptive, leading to unnecessary edits and typing delays. In contrast, the laptop keyboard was favored for its tactile feedback, larger key spacing, and more predictable error correction.

The small sample size (N=8) likely limited statistical significance, and variations in participant familiarity with mobile and physical keyboards may have influenced results. Future studies should expand the participant pool and categorize users by primary input method to better assess experience-based differences.

Lastly, the short task duration (20 phrases per condition) did not account for long-term adaptation, learning, or fatigue. Future research should examine long-term adaptation and explore alternative input methods like gesture typing, swipe keyboards, and voice input to better understand trade-offs in speed, accuracy, and usability.

Conclusion

This study investigated performance differences between pointing methods (mouse acceleration on/off) and text entry methods (iPhone/laptop keyboards). It revealed no statistically significant differences across speed, accuracy, and throughput metrics between modalities in either test. However, several participants (pointing P1, P4, P8 - text entry P7) displayed substantial performance improvements across metrics when switching modalities, suggesting that despite no generalizable advantage for accelerated/non-accelerated pointing or iPhone vs laptop text entry, individual users may benefit by switching between tested input methods or similarly performing input methods across technological contexts generally. We also received qualitative feedback on frustration with the iPhone keyboard due to small keys and autocorrect issues, highlighting the importance of considering user experience alongside quantitative metrics. These findings enhance our understanding of input method preferences and performance. They suggest (though not prove) that even when aggregate speed and accuracy metrics are similar between input methods or settings, configurability or support for alternative input methods may be important. This approach may better allow diverse users to interact with systems in ways that suit their needs—whether through quantitative performance gains or qualitative satisfaction.

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References

I. Scott MacKenzie and Poika Isokoski. 2008. Fitts Throughput and the Speed-Accuracy Tradeoff. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (Florence, Italy) (CHI '08). Association for Computing Machinery, New York, NY, USA, 1633--1636. https://doi.org/10.1145/1357054.1357308

Kristensson, P. O., & Zhai, S. (2004). SHARK2: A large vocabulary shorthand writing system for pen-based computers. UIST 2004, 43-52.

MacKenzie, I. S., & Soukoreff, R. W. (2002). Text entry for mobile computing: Models and methods, theory and practice. Human-Computer Interaction, 17, 147-198.

Wobbrock, J. O., Shinohara, K. and Jansen, A. (2011). "The effects of task dimensionality, endpoint deviation, throughput calculation, and experiment design on pointing measures and models." Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '11). Vancouver, British Columbia (May 7-12, 2011). New York: ACM Press, pp. 1639-1648.

Zhang, M.R. and Wobbrock, J.O. (2019). Beyond the input stream: Making text entry evaluations more flexible with transcription sequences. Proceedings of the ACM Symposium on User Interface Software and Technology (UIST '19). New Orleans, Louisiana (October 20-23, 2019). New York: ACM Press, pp. 831-842. DOI: 10.1145/3332165.3347922

Zhang, M.R., Zhai, S. and Wobbrock, J.O. (2019). Text entry throughput: Towards unifying speed and accuracy in a single performance metric. Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '19). Glasgow, Scotland (May 4-9, 2019). New York: ACM Press. Paper No. 636. DOI: 10.1145/3290605.3300866