Game Controller Text Entry with Alphabetic and Multi-Tap Selection Keyboards

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Abstract
In this paper we present a longitudinal study comparing an alphabetical selection keyboard to a multi-tap selection keyboard using a game controller as input device. Our experiment showed the alphabetic selection keyboard to be faster for novice (7.72 wpm vs. 6.34 wpm) and expert users (11.87 wpm vs. 9.64 wpm). The multi-tap selection keyboard was more error prone than the alphabetic selection keyboard. Qualitative results showed that over time the alphabetic selection keyboard was preferred by the users.

Keywords
Text entry, joystick, game controller, game pad, selection keyboard, alphabetic, multi-tap

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces - Evaluation/Methodology, Input Devices and Strategies.

Introduction
In 1977 the Atari 2600 first introduced a joystick in the homes of computer gamers. Two years later the game Asteroids made it possible to label the user's score in a

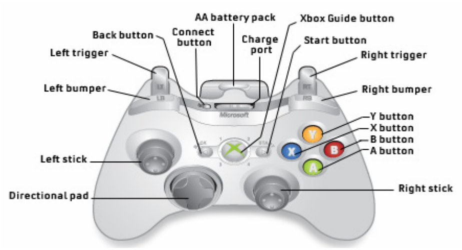

Figure 1. Sketch of a game controller (Microsoft Xbox 360 wireless controller)

high score table, hence text entry using a joystick was born. Nowadays, game consoles are shipped with more features and require more and more text entry tasks e.g. surfing on the web, exchanging text messages, labeling avatars or setting up the consoles configuration. The game pad as input device evolved as well over the last decades. Figure 1 shows an example of an ergonomic shaped controller with 2 sticks, a D-pad and several buttons.

Looking at the three newest consoles on the market we generally see two different implementations of selection keyboards. An alphabetic selection keyboard (Microsoft Xbox 360) and a multi-tap selection keyboard (Sony PlayStation 3). Using a Nintendo Wii one can choose between a selection keyboard with QWERTY or multi-tap layout. We can find implementations of these keyboards on mobile gaming devices as well (e.g. Sony PlayStation Portable).

Wobbrock et al. [7] summarized the need for joystick text entry and challenges writing with a joystick. He and others [6] noted that an effective text entry technique would greatly enhance game consoles. Several novel text entry methods have been introduced over the years. Wilson and Agrawala [6] reported that the distances to overcome on a traditional selection keyboard are high. They split a selection keyboard apart to reduce movement time. Their design outperforms all comparable non-split keyboards. Other techniques like Quikwriting [1] and EdgeWrite [7] have been adapted for joysticks. Experiments showed that users can achieve high speeds entering text. Other joystick text entry techniques are XNav [2], T-Cube [5], KeyStick[1], Weegie[2], myText[3] and MobileQWERTY[4].

Motivation

Unfortunately the novel techniques published have not been adopted by the industry. The goal of this paper is to evaluate the most widely used game controller text entry methods. We want to evaluate an alphabetic selection keyboard and compare it to a multi-tap selection keyboard looking at novice and expert users. Especially we look for answers if speed, error rate and preferences for both techniques change over time.

Design Issues

Our design of the selection keyboards follows the implementation of the popular game consoles Xbox 360 and PlayStation 3.

Alphabetic Selection Keyboard

The alphabetic layout of the selection keyboard can be seen in Figure 2. The left stick (Figure 1) was used as a 4-way navigation. The focus jumps discreetly from key to key. Our design also supported wrapping, e.g. deflecting the stick up at the *a* character moves the focus to *space*. When the user deflects the stick in one direction the focus moves one step forward. If the user does not return the stick to the center the focus automatically moves every 150 ms one step further in the given direction. By pressing the A button a

[1] http://www.n-e-ware.com/KeyStick.htm

[2] http://weegie.sourceforge.net

[3] http://www.my-text.com

[4] http://www.mobience.com/

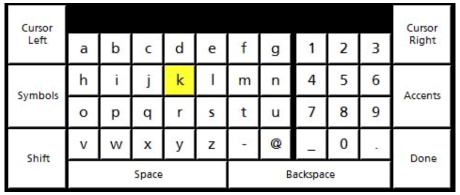

Figure 2. Alphabetic selection keyboard used in the experiment

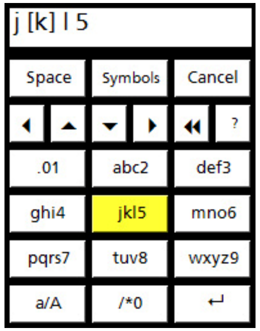

Figure 3. Multi-Tap selection keyboard used in the experiment

character is entered. We used the following buttons for shortcuts: X space, B backspace and Y shift.

Multi-tap Selection Keyboard
The multi-tap layout (Figure 3) is based on the implementation of the alphabetic selection keyboard, meaning that navigation and shortcuts were equivalent. Character selection was different due to the ambiguity. By pressing the A button one time (e.g. on the *JKL* key) the first character (*J*) is selected in the preview window. After 55 ms time-out the character is automatically entered. Pressing the A button two times the second character is selected (*K*) and entered after the same time-out. Time-out kill was supported by selecting a character and navigating to the next key.

Experiment

Participants
We recruited 10 volunteer participants (4 female, 6 male; 9 right, 1 left-handed) between 24 and 34 (mean=27.3, SD= 3.6) years. All participants were novice game controller text entry users. No participant regularly played with game consoles, and three never used a game controller before. Two participants classified themselves as novice multi-tap users on mobile phones, the others were regular users of multi-tap or predictive methods (e.g. T9). All participants had good English reading and writing skills, but they were native German speakers.

Apparatus
We implemented the alphabetic and multi-tap selection keyboard in C# using DirectInput. A Microsoft Xbox 360 controller for Windows served as input device.

We conducted all experiments on the same laptop computer in our laboratory or at the participant's homes in a controlled environment. The resolution of the display was set to 1024x768. The visualization of the alphabetic keyboard and the multi-tap keyboard was respectively 121x50 and 48x54 millimeter.

We used TextTest 2.1.4 [8] to present the phrases to transcribe. The results were analyzed using a character-level error analyzer by Wobbrock et al. (StreamAnalyzer 2.0.2 [8]. For calculating suitable numbers, we turned off all special keys in out selection keyboard implementation (e.g. cancel, ? = help) as well as keys for navigation.

Task
The task consisted of transcribing phrases presented on the display finished by the character *enter*. Participants were instructed to enter the text as fast as possible aiming at a minimum error rate. They could correct errors using backspace, but were allowed to leave errors in the transcription. Phrases were drawn randomly from the corpus. As corpus we used the built in phrase set from TextTest [8]. It is based on the 500 phrases by Soukoreff and MacKenzie [3].

Procedure
In the beginning a questionnaire for participant`s information and text entry background was completed. As a preliminary introduction, each new text entry method was explained verbally to the participant. Participants were not allowed to use the systems before the first session.

Each participant completed 15 sessions of text transcription. Each session consisted of two subsessions. One sub-session was for text entry with the alphabetic and the other for the multi-tap selection keyboard. For every sub-session participants entered 2 test phrases in the beginning and 20 phrases counting for the experiment. To minimize side effects we counter balanced the order of the text entry methods over all sessions. After every third session participants got feedback on their text entry speed. The sessions were distributed on up to 5 days conducting not more than 4 sessions per day.

After the first session participants were interviewed and they filled out a questionnaire about their impressions on the text entry methods. The same questionnaire and interview were repeated at the end of the experiment.

Design

In our experiment, the text entry method (two levels) and the amount of training (15 sessions) constituted the independent variables. The dependent variables were text entry speed and error rate (total, corrected and uncorrected). We used the error analysis metrics by Soukoreff and MacKenzie [4].

Results and Discussion

The participants transcribed in total 6,000 phrases over 62.91 hours, which resulted in 186,238 characters in the input stream for further analyses. For the alphabetic selection keyboard the mean time for one session was 11.38 minutes and for the multi-tap layout 13.78 minutes.

Speed

A main effect of method on text entry speed was statistically significant ($F_{1,9}=29.79$, $p<.001$). The effect of session ($F_{1,9} = 34.52$, $p<.001$) was also significant, meaning that performance improved over time. However, the interaction of method and session was not significant. In the first session participants were significantly faster ($t(9)=5.39$, $p<.01$) with the alphabetic layout (7.72 wpm , SD=1.77) than with multi-tap layout (6.34 wpm, SD=1.13) (see Figure 4). During the last session the alphabetic layout (11.87 wpm, SD=2.51) was significantly faster ($t(9)=6.23$, $p<.01$) than the multi-tap layout (9.64 wpm, SD=1.77). The fastest participant achieved a mean text entry of 17.13 wpm for the alphabetic and 13.53 wpm for the multi-tap layout during the last session. Over all sessions the mean text entry speed was 10.29 wpm (SD=1.16) for the alphabetic and 8.46 wpm (SD=1.01) for the multi-tap layout.

Two studies [6][7] present results of text entry speed for alphabetic selection keyboards for novice users. Users wrote at 5.79 words per minute (wpm) [6] and 6.17 wpm [7]. We suspect our participants were faster, because of the intensive use of shortcuts from the beginning. We found no studies with expert users or studies evaluating a multi-tap selection keyboard operated by a joystick.

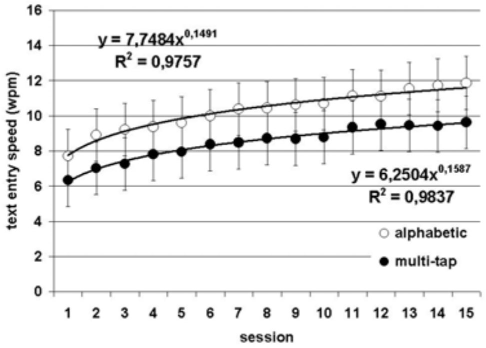

Figure 4. Average text entry speed

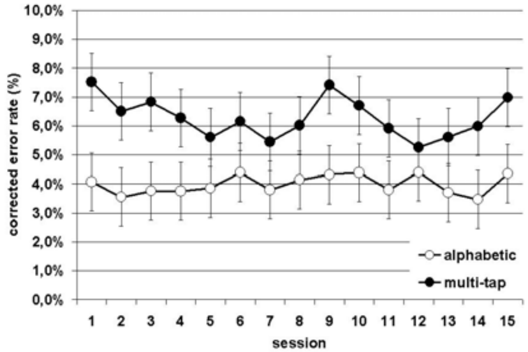

Figure 5. Average corrected error rate

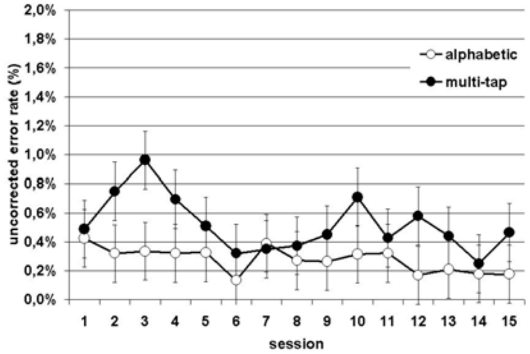

Figure 6. Average uncorrected error rate

Error Rates

We used the error metrics by Soukoreff and MacKenzie [4] for the analysis of our experiment.

TOTAL ERROR RATE

We found a significant effect of text entry method on total error rate ($F_{1,9}$=14.42, p<.01) meaning that overall the multi-tap layout was more error-prone than the alphabetic layout. The effect of session and the interaction of session and method were not statistically significant. During the first session participants made more errors (t(9)=5.15, p<.001) with multi-tap (8.01 %, SD=3.29) than with the alphabetic layout (4.5%, SD=2.41). In the last session more errors (t(9)=4.27, p<.01) were made with the multi-tap layout (7.44%, SD=2.26) than with the alphabetic (4.53%, SD=2.29). Over all sessions total error rate was 6.8% (SD=0.77) for multi-tap and 4.26% (SD=0.31) for the alphabetic layout.

CORRECTED ERROR RATE

The effect of text entry method on corrected error rate was significant ($F_{1,9}$=12.81, p<.01), meaning that participants correct a different number of errors with different methods (see Figure 5). The effect of session on corrected error rate and the interaction of session and method were not statistically significant. In the first session the corrected error rate was significantly higher (t(9)=4.74, p<.001) with multi-tap (7.52%, SD=3.71) than with the alphabetic layout (4.07%, SD=2.36). Meaning participants corrected more errors with multi-tap during the first session. In the last session corrected error rate was significantly higher (t(9)=4.05, p<.01) with multi-tap (6.98%, SD=2.15) than with the alphabetic layout (4.35%, SD=2.28). Over all sessions the corrected error rate for multi-tap was 6.28% (SD=0.7) and for the alphabetic layout 3.98% (SD=0.33).

UNCORRECTED ERROR RATE

The effect of method on uncorrected error rate was significant ($F_{1,9}$=6.90, p<.05). The participants left more errors in the text using the multi-tap layout (see Figure 6). The effects of session and the interaction of method and session were not statistically significant. The t-test showed no significant difference between the methods in the first session. The uncorrected error rate was 0.49% (SD=0.24) with multi-tap and 0.43% (SD=0.61) with the alphabetic layout. During the last session we found a significant difference of uncorrected

	Session 1	
Scale 1-5	**ABC**	**Multi-Tap**
Like-Dislike	2.8(0.79)	2.1(0.57)
Slow-Fast	2.3(1.06)	2.4(0.97)
Many-No Errors	2.2(0.92)	2.4(0.97)
Fun-Bored	2.5(0.85)	2.1(0.99)
Exhausting-Facile	3.1(1.2)	3.1(0.74)
Prefer method	**3.4(2.07)**	**2.6(2.07)**
	Session 15	
Like-Dislike	2.0(0.47)	2.8(0.63)
Slow-Fast	1.8(1.03)	2.7(0.67)
Many-No Errors	**1.9(0.74)**	**2.9(0.88)**
Fun-Bored	1.9(0.57)	2.5(1.18)
Exhausting-Facile	**3.5(0.71)**	**2.3(1.16)**
Prefer method	**1.4(1.26)**	**4.6(1.26)**

Table 1. Means (and standard deviations) of the questionnaires. The scale from 1 associated with the left extreme to 5 associated with the right extreme. Statistically significant results are bold.

error rate ($t(9)=3.60$, $p<.01$). The participants left more errors in the text with multi-tap (0.47%, SD=0.40) than with the alphabetic layout (0.18%, SD=0.89). Over all sessions the uncorrected error rate for multi-tap was 0.52% (SD=0.19) and 0.28% (SD=0.09) for the alphabetic layout.

Questionnaires and Interview Data

The results of the questionnaires after the first and last session are shown in Table 1. After the first session participants preferred the multi-tap rather than the alphabetic selection keyboard ($z=2.27$, $p<.05$). Participants noted that they already were skilled in using a multi-tap selection keyboard due to the frequently used mobile phone text entry. However, after the last session nine out of ten participants preferred the alphabetic selection keyboard ($z=2.53$, $p<.01$). We also found a significant difference within participants stating that they made more errors with multi-tap during the last session ($z=2.64$, $p<.01$). Participants also reported that multi-tap was more exhausting than the alphabetic selection keyboard ($z=2.59$, $p<.01$).

Conclusion and Future Work

In this paper we showed that the alphabetic selection keyboard outperforms the multi-tap selection keyboard for novice and expert use. Especially after some training, the users clearly preferred the alphabetic selection keyboard.

For future work this data could serve as baseline for text entry methods that better fit to the paradigm of a joystick or game controller than selection keyboards. According to press releases, console manufactures plan to enhance their selection keyboards with predictive methods. We plan to extend our implementation with a predictive system as well and rerun the experiment. Furthermore, we want to build models to calculate text entry speed to optimize the placement of the layout and calculate the maximum possible text entry speed. We could load our models with the data presented in this study.

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