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Evaluating change in user error when using ruggedized handheld devices

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A R T I C L E I N F O

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The increasing number of handheld mobile devices used today and the increasing dependency on them in the workplace makes understanding how users interact with these devices critical. This study seeks to understand how user error changes based on user age as well as input content type on ruggedized handheld devices. Participants completed data entry tasks of word and character input on two different devices, a physical keypad and touchscreen device. The number of errors and types of error, corrected and permanent were collected for each participant. Based on results on the study, touchscreen devices proved to be the optimal ruggedized handheld device to minimize user error.

1. Introduction

Text entry research has evolved over time with the growing number of mobile devices in the market. As of January of 2014, 90% of American adults own a cell phone with 58% of those phones being a smartphone (Pew Research, 2014). With such a large smartphone penetration in the consumer market, text entry research can lead to a greater understanding of speed and accuracy of text input. This knowledge can feed back into the research and development of new text input technologies. A need for text entry research is driven by the necessity for mobile text input devices in the workforce. With new technologies, customer service response times are expected to quicken there by revealing a need for technology to become more accurate and efficient. These devices must have the technological capabilities to serve the dependency placed on them in industry. As mobile text entry devices become more ubiquitous in the workforce, the operation of these devices becomes more critical. Recent research has explored the impacts of mobile and portable devices on posture, muscle activation, response time, and usability in existing products and product upgrades (e.g. Arman et al., 2014; Hsiao et al., 2014; Pereira et al., 2013; Strawderman and Huang, 2012; Werth and Babski-Reeves, 2014). This study evaluates how error rate changes based on user age as well as input content type on ruggedized handheld devices. Observing these changes can help gain a better understanding of the accuracy of text input.

The two primary evaluation metrics for text input are accuracy and speed (MacKenzie and Soukoreff, 2002). Of these two metrics, accuracy is more difficult to obtain (Soukoreff and Mackenzie, 2001). To learn more about determining accuracy, many studies have created and contributed to the knowledge base of typing error categorization. The three primary categories of typing errors are substitution, omission, and insertion. These categories have been expanded in many studies as shown in Table 1. This table was developed by Kano & Read to solve character level insertion ambiguities as a way to summarize the different typing error categorization methods that were developed between 1945 and 2007. Their research focused on eliminating the ambiguities of an error falling into multiple categories which occurs as a result of the expansion of the typing error categories. A blank cell in the table represents indicates that a method does not include that type of error categorization.

Physical keypad and touchscreen devices are two of the most common input methods for handheld mobile devices. While both types of devices are used for text input, keypads have physical key affordances which have been proved to be vital when typing (Paek and Hsu, 2011). When using a touchscreen, users are more prone to error without the affordances a keypad provides (Rudchenko et al., n.d.). As a result, users will perform worse on touch text entry than on a keyboard. A 1990 study asked participants to enter dates and airline flights on a keyboard and a touchscreen (both without autocomplete features). When looking at input speed, results showed that users of touchscreens took 73% longer when

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Table 1
Summary of typing error categorization methods from 1945 to 2007 (adapted from Kano and Read, 2009).

	White (1945)	Dvorak et al. (1936)	MacNeilage (1964)	Gentner (1983)	Logan (1999)	Wobbrock and Myers (2006)	Kano et al. (2007)
Insertion	Inserted strokes, double strokes, syllable division, repeating words		Interpolation error	Insertion, misstrokes	Immediate, preservation, space bar, separation, character separation, letter sequence, error habits, home-letter intrusion	Insertion	CT-Mu, DL, DS, ExE, IF, IL, IS, ISy, NT-MA, IW-A, IW-U, DW, DP, EE
Omission	Letter omission, omitting words	Omission, omitting words	Omission errors	Omission	Letter, syllable, word, space bar	Omission	OL, OS, OW, OP
Substitution	Substitution, transposition, capitalization, word substitution, adjacent letter substitution	Substitution, adjacent errors, copy reading, transposition, transposed doubling	Horizontal, vertical, diagonal, reversal, anticipation, phonemic, type errors, contralateral	Substitution, transposition, interchange, migration, doubling, alternating	Remote, horizontal, vertical, number sub, homologous, hand position, transposition (1 finger, 2 finger, 2 hands), interchange, migration, alternation, doubling, another word, perseveration	Substitution	AE, CE, CT-S, DE, IE, NT-S, SL, TE, ME, SW-A, SW-U, SP
Other	Spacing		Equivocal, multiple classification, unclassifiable		Spelling		U, ExE, CNE(error)

inputting text content in comparison to a keyboard; however, the ubiquity of devices in our daily lives could change these values today (Gould et al., 1990). In a study where participants performed tasks on an ATM with a numeric physical keypad and one with a touchscreen keypad, the input speed of older adults on a touchscreen was found to be faster than on a physical keypad (Chung et al., 2010; Rogers et al., 2005).

There have been a number of studies that seek to find age-related differences when using direct and indirect input devices (Chung et al., 2010; Mclaughlin et al., 2012; Pak et al., 2002; Rogers et al., 2005). A device is defined as indirect or direct by its manner of input and output of data (Mclaughlin et al., 2012). A device where input is completed on the output screen, such as a touchscreen, is considered a direct device. Devices that separate the method of input from the output screen, such as a keyboard or mouse, are considered indirect devices.

Chung et al. (2010) studied the impact of age on direct and indirect numeric keypad types. In his study, results showed that older adults perform faster when using touchscreen devices but tend to also make more errors on those devices compared to the physical keypad. The study attributes this increase in error to the lack of affordances on a touchscreen. Much of the literature concludes that the touchscreen yields faster input speeds for younger and older age groups and suggests this to be the optimal device but this is not always true. Rogers et al. (2005) found that, while for younger adults the type of task can often determine the optimal input device, older adults do not return a steady pattern. Rogers concludes that with older adults, individual differences may be the indicator impacting the optimal device for a specific task.

When comparing generations currently in the workforce, two commonly studied groups are the Baby Boomer-aged employees (born between 1945 and 1963) and Gamer-aged employees (born between 1979 and 1995). Studying these two generations is important as the Baby Boomer generation retires and more organizations begin hiring the incoming Gamer generation. Learning more about the differences of the two generations becomes relevant as organizations are impacted by this change (Burch and Strawderman, 2014).

2. Methods

2.1. Experimental procedure

The experimental procedure consisted of three parts: 1) a questionnaire about demographics and device preference of the participant, 2) recorded data entry on the first ruggedized handheld device, 3) recorded entry on the second ruggedized handheld device. To begin, prior to data entry, participants began by answering a brief series of questions. The questions asked established what generational group the participant was a member of, their age, and their work job function. Additionally, participants were asked about their current status of ownership of a cell phone or smartphone and about their experience level with consumer-grade handheld devices that have a keypad or touchscreen. Participants then confirmed their years of experience with ruggedized handheld devices.

Data was collected from 40 participants. Of these 40 participants, 20 were from the Gamer generation and 20 from the Boomer generation. All of the participants were regular users of the ruggedized keypad device used in the study and were experienced with a touchscreen device. Participants began data entry with one of the two types of ruggedized handheld devices picked at random. For the purpose of counter balancing, ten participants from each generational group started with the keypad and ten started with the touchscreen.

The two ruggedized handheld devices used were the Motorola MC9500 and the Motorola ETI (Fig. 1). The devices were chosen based on similar functionality related to package scanning. The two devices also had very similar height, weight, and key size. This helped to ensure that participants would hold the devices in a similar fashion. The Motorola MC9500 was chosen to represent the standard device used in the participants' current company operations. Participants were familiar with this device as they used them in daily operations. The Motorola ET1 was chosen to more closely replicate the input type used in most consumer smart phones.

Once beginning the data entry task, each participant manually entered the contents of the task list into a word processor application that was installed on the ruggedized handheld device. Within the task list provided to each participant were 30 container names and 30 associated comments. The container names were composed of 10 characters, alpha and numeric, and the associated comments were composed of words, 19–24 characters. Both devices required the use of a shift key to access the numerical keys. Below is an excerpt from the task list (see Fig. 2).

After each line in the task list, one carriage return was required. Once each data entry set of the container name and comment were completed, an additional carriage return was required. Notes were provided to remind the participant of the rules regarding carriage returns and data entry format.

Participants were instructed to complete the data entry tasks as quick as possible but also to be as accurate as possible. Participants were encouraged to go back and correct mistakes. All participants'