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Ruggedized handheld device input effectiveness by generation: A time and error study

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ABSTRACT

The objective of this study is to determine whether ruggedized handheld scanning devices used for industrial purposes should contain one of the most prominent features provided on commercial smart devices: data entry via touchscreen as opposed to a physical keypad. Due to harsh environments, physical keys have been the preferred means of input for rugged handhelds. Advancement in touchscreen technology along with technology expectations brought about by the workforce demographic shift are influencing a notable shift to touch-only input for rugged equipment. Hypotheses expect there to be a difference in usability by worker generation and so 20 Gamers (Millennials) and 20 Baby Boomers performed manual data entry on ruggedized handhelds: one with physical keys and one touchscreen only. All participants took 19% less time on touchscreen than physical keys. Gamers were 31% faster than Boomers on physical keyed devices and 28% faster on touchscreen only. There was no significant difference in errors entered for either device by either age group; however, an 83% increase in permanent errors by Gamers on touchscreen was noted. Transitioning to a rugged device with touch-only input is recommended for industry as it could offer an increase in work productivity. This study presents timely insight into a new tool option for industrial workers.

Relevance to industry: This research describes the paradigm shift in the ruggedized handheld device market from physical keys to touchscreen only input and identifies real time productivity savings and error risks that can be expected by different generations of workers in the industrial workforce.

1. Introduction

Ruggedized handheld device solutions are used today by industrial, retail, and service-based organizations. Rugged devices are mobile computers that scan and perform data entry within locations that have environmental requirements or restrictions. Ruggedized computer devices are designed to operate properly in damaging, punishing environments and in extreme temperatures (between −20 °F and 140 °F). They have ingress protection against dirty environments and wet conditions ranging from bad weather events to complete submersion under water (IEC 60529, 2013). Also included in ruggedized device requirements is the ability to withstand a series of shocks and drops (four to ten feet in height) as defined by the military testing standard, MIL-STD-810G (US DoD, 2008).

Not only must ruggedized handhelds withstand extreme environments, they must also be usable by a diverse workforce that includes employees from differing generations. Baby Boomers, or Boomers, will continue exiting the workplace at a rate of 10,000 per day for the next 20 years (DePass, 2012). These retirees are being replaced by members of the Gamer Generation (or Millennials), someone 35 years of age or younger (Carstens and Beck, 2005) born between 1979 and 2000 (Burch and Strawderman, 2014). The two largest issues created by this demographic shift are employee retention (Sujansky, 2009) and knowledge transfer (Kapp, 2007).

Research has shown that employees in the Boomer and Gamer generations work differently. Modern technology adoption increases morale for Gamers and lessens their turnover (Cairncross and Buultjens, 2007). They learn best via their consumer technology (Kapp, 2007) and often bring their own solutions into the workplace (Blackburn, 2011) which should be encouraged (Tulgan, 2009). Bringing unfamiliar solutions into a mature work culture can be difficult and create time consuming issues (Schein, 1999) due to

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Boomers' lower desire to learn new technologies (Rogers, 2003) as well as their slower adoption rate of mobile technologies (Kurniawan et al., 2006). However, organizations can ill afford not to learn and adopt new technology in order to survive given how the external environment is changing ever more swiftly (Shih and Allen, 2007); therefore, a device must be usable by members of both generations. The intent of this study is to understand how changing a key component, the input method, of ruggedized handheld devices and mobile terminals affects usage between these two generations that bookend most workforce populations.

1.1. Data entry and physical keypads

Large organizations that purchase substantial quantities of ruggedized devices typically follow a five- to seven-year life cycle plan. The applications that run on these devices aiding worker job functions are generally developed in-house. No matter how anticipatory the applications become, manual data entry is always required and is used by field workers during their shift. Manual data entry may be regarded as one of the more time intensive interactions with the ruggedized device and, in logistical environments where every second counts, multiple manual entries could make the difference in on-time delivery.

To date, most manual input into rugged handheld devices is performed through a physical keypad. Keyed rugged devices generally support touchscreen input but the screen display size ranges between 3.0 and 4.0 inches diagonal and isn't conducive to prolonged manual entry on a virtual keyboard given the small surface area of the keys. The physical keypads on these devices range in size and configuration. Keypads with larger keys are in alphabetical order and utilize a shift function to enter numbers. Physical keyboards with QWERTY configurations have smaller keys in order to achieve the same layout as a keyboard. The alphabetical keys in a QWERTY configuration are approximately half the surface area of the keys in alphabetical configurations. The numeric keys either are separate from the others and larger or a shift function is required. Alphabetically ordered keys cause a learning curve for new users and the QWERTY configuration is often too small for workers with large sized hands.

Physical keys on ruggedized handhelds have their disadvantages, such as becoming points of failure for extended use and they lack the flexibility of virtual keypads that can be designed to meet any button configuration. But physical keys have also been found to be a necessity when job tasks must be performed in cold weather while wearing gloves. Using a touchscreen with capacitive interaction has been found to be problematic in rain and snow or while wet.

1.2. Technology shift to touchscreens

In 2014, vendors began offering ruggedized handheld solutions that have touch-only input. Smartphone-like solutions will look to take market share by appealing to consumer-based expectations of the end users. These solutions will utilize stronger glass so that the display size can support an inch to two-inch increase in diameter without weakening the overall integrity of the device. New hardware and software capabilities within these touchscreen-only devices will create the sensation of key pushes, allow accurate key presses while wearing any pair of thick gloves, and will be usable with water on the screen. Industrial capability can now meet consumer expectations. In an ideal situation, software for the future devices will be written in such a way that minimal to no manual data entry will be required on the part of the end user as manual text entry decreases the competitive advantage of a full touchscreen interface (Kwon et al., 2009). Unfortunately, exceptions will always be required and in ever evolving work environments, the need to manually enter information must exist to some degree.

1.3. Touchscreen usability considerations

How users will hold and interact with a rugged device that has touchscreen-only input must be taken into consideration. As these touch-only rugged devices have a minimal presence in industrial environments at the time of this article's preparation, key insights can be drawn from their consumer counterparts. Studies performed on users of touch-only smartphones by Hoober (2013) have found that individuals prefer to hold their devices one-handed and with their right hand being the primary hand two-thirds of the time. When users cradle the device with one hand while performing data entry with the other, they perform data entry with their right thumb and hold the device in their left hand the majority of the time (Hoober, 2013). Holding the device vertically in portrait mode was shown to be most common where turning the phone horizontally for data entry only occurred about 10% of the time (Hoober, 2013). Studies also found that younger adults are better with multiple types of input including touch (McLaughlin et al., 2009). However, all participants are generally slower on smaller buttons (smaller buttons were more detrimental to older adults). Contrary to Fitt's Law, all participants were faster on buttons in the center as opposed to buttons of the left and rights sides of the touchscreen (Rogers et al., 2005).

Additional insights can be found in studies that simply evaluate physical keys versus touchscreen on other devices such as kiosks. Chung et al. (2010) found that numeric data entry via touchscreen was preferred over physical keys by both younger and older adults on devices typically used as automated teller machines (ATMs). While the mean entry time of the younger users was found to be faster than the older users, the older adults still operated more quickly on touch than on the physical numeric keypad (Chung et al., 2010).

1.4. Input preference versus reality

Is a shift from physical keys to touchscreens a productive one? Considering the generational component, members of the Gamer Generation are most engaged in learning complex skills and job functions when it's done via modern technology (Main and O'Rourke, 2011). But just because a worker desires a newer device form factor and may even be inclined to learn job processes more quickly while using it, there is no guarantee that there will be an actual increase in work productivity (Sonderegger and Sauer, 2010). Nor is there any concrete evidence to indicate that Baby Boomers, or Boomers, a cohort known to not be nearly as quick at adaption of new technology (Rogers, 2003), will lose productivity on technology that moves away from more traditional and familiar characteristics like physical key pads.

Putting preference aside, the goal of this study is to determine which input type, keypad or touchscreen, on ruggedized handheld devices is best for the generations leaving and entering the workforce, the Boomers and the Gamers. A future device must be accepted and useable by employees on both ends of the workforce spectrum in order for an industrial organization to receive the full benefit of a paradigm shift in mobile computing technology in a rugged environment. So while Boomers are leaving the workforce, a new device in the field must provide immediate benefit in order to cost justify making a change of this kind. Organizations can ill afford to wait until all Boomers have transitioned out of the work environment to evaluate new technology trends. Likewise, these companies also can't afford to keep devices used today in service