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Pickup Usability Dominates:
A Brief History of Mobile Text Entry Research and Adoption

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ABSTRACT

Text entry on mobile devices (e.g. phones and PDAs) has been a research challenge since devices shrank below laptop size: mobile devices are simply too small to have a traditional full-size keyboard. There has been a profusion of research into text entry techniques for smaller keyboards and touch screens: some of which have become mainstream, while others have not lived up to early expectations. As the mobile phone industry moves to mainstream touch screen interaction we will review the range of input techniques for mobiles, together with evaluations that have taken place to assess their validity: from theoretical modelling through to formal usability experiments. We also report initial results on iPhone text entry speed.

Keywords: *ambiguous keyboards; evaluation; handwriting recognition; predictive text entry; text entry touch-screen text entry; unambiguous keyboards; usability techniques; user studies*

INTRODUCTION

Many mobile services such as text/instant messaging, email, web searching and diary operations require users to be able to enter text on a phone. Text messaging has even overtaken voice calling as the dominant use of mobile phones for many users with mobile email rapidly spreading. Handheld screen technologies are also making it increasingly convenient to read complex messages or documents on handhelds, and cellular data network speeds are now often in excess of traditional wired modems and considerably higher in wi-fi hotspots. These technological developments are leading to increased pressure from users to be able to author complex messages and small documents on their handhelds. Researchers in academia and industry have been working since the emergence of handheld technologies for new text entry methods that are small and fast but easy-to-use, particularly for novice users. This article will look at different approaches to keyboards, different approaches to stylus-based entry, and how these approaches have been evaluated to establish which techniques are actually faster or less error-prone. The focus of the article is both to give a perspective on the breadth of research in text entry and also to look at how researchers have evaluated their

work. Finally, we will look at perceived future directions attempting to learn from the successes and failures of text entry research. Throughout this article we will cite words-per-minute (wpm) as a fairly standard measure of typing speed, for reference highly skilled office QWERTY touch typists achieve speeds of around 135wpm while hand-writing with pen and article achieves only about 15wpm.

KEYBOARDS

The simplest and most common form of text entry on small devices, as with large devices, is a keyboard. Several small keyboard layouts have been researched that try to balance small size against usability and text entry speed. Keyboards can be categorized as unambiguous, where one key-press unambiguously relates to one character, or ambiguous, where each key is related to many letters (e.g. the standard 12-key phone pad layout where, say, *2* is mapped to *ABC*). Ambiguous keyboards rely on a disambiguation method, which can be manually driven by the user or semi-automatic with software support and user correction. This section looks first at unambiguous mobile keyboard designs, then at ambiguous designs and, finally, discusses approaches to disambiguation for ambiguous keyboards.

Unambiguous Keyboards

Small physical keyboards have been used in mobile devices from their very early days on devices such as the Psion Organiser in 1984 and the Sharp Wizard in 1989 and have seen a recent resurgence in devices targeting email users, such as most of RIM's Blackberry range. While early devices tended to have an alphabetic layout, the standard desktop QWERTY family of layouts, e.g. QWERTY, AZERTY, QWERTZ and QZERTY, was soon adopted as there is strong evidence that alphabetic layouts give no benefits even for novice users (Norman, 2002; Norman & Fisher, 1982). When well-designed, small QWERTY keyboards can make text entry fast by giving the users good physical targets and feedback with speeds measured in excess of 60wpm (Clarkson et al 2005). However, there is a strong design trade-off between keys being large enough for fast, easy typing and overall device size with large-fingered users often finding the keys simply too small to tap individually at speed. Physical keyboards also interact poorly with touch-screens, where one hand often needs to hold a stylus, and they reduce the space available on the device for the screen.

The QWERTY keyboard layout was designed as a compromise between speed and physical characteristics of traditional manual typewriters: the layout separates commonly occurring pairs of letters to avoid head clashes on manual typewriters and is imbalanced between left and right hands. Faster touch-typing office keyboards such as the Dvorak keyboard (Fig 1) are significantly faster but have not been widely adopted—primarily because of the learning time and invested skill-set in QWERTY keyboards. This investment has been shown to carry over into smaller devices, where the sub-optimality issue is even stronger as users tend to type with one or two thumbs—not nine fingers envisaged of touch-typists. While optimal mobile layouts could be designed around two-thumb entry, these are likely to be so different from users' experiences that initial use would be very slow and, as with the Dvorak, rejected by end users (and would still be sub-optimal for one-thumb use!).

The half-QWERTY mobile keyboard (Matias, MacKenzie, & Buxton, 1996) (fig 2-left) builds on QWERTY skills and the imbalance between left and right hands by halving the keyboard in the centre. The keyboard has a standard left half of a QWERTY keyboard, while the user holds the space bar to *flip* the keyboard to give the right side letters. Targeting smaller size and fast one-handed entry, experiments have shown that users of the half-QWERTY keyboard quickly achieved consistent speeds of 30 words per minute or higher (when using a keyboard with desktop-sized keys). The FrogPad™ is a variant using an optimised keyboard, so that use