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Text Entry Interface Design Requirements at a Glance

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Abstract

This analysis of HF/E literature on preferences for text entry distills the findings to guide designers in applying optimum solutions for devices such as PDAs and cell phones.

Keywords

usability evaluation; psychology; design principles; mobile solutions; text entry; requirements

As Computing Becomes Embedded in everyday devices, designers are challenged to create new interfaces for tasks that may already be well learned in other systems. A prominent example of this phenomenon is text entry. In computer-based systems such as electronic voting and airport check-in kiosks, only minor modifications to the standard keyboard may be required to accommodate unique functions. Other systems – vehicles and video systems, for example – present designers with input and display constraints based on factors that include user motion and multitasking.

These constraints often require creative solutions for occasional text entry, particularly when the user interface is a critical marketing element (e.g., iPod™). How do designers meet requirements for occasional text entry without increasing system complexity? Which aspects of solutions derived from widely used typing and mobile devices can be transferred to other devices? Are there other factors that designers should consider? These questions, and their answers, are the focus of this article.

Historical View of Text Entry Devices

Since the first typewriter keyboard was patented in 1878, researchers have examined typing comfort and performance from the perspectives of psychology, biomechanics, and industrial engineering (Kroemer, 2001). That research produced detailed requirements for typewriter features (e.g., optimal key dimensions and spacing, tactile characteristics of keys, and key press responses) and guidance for understanding text entry tasks and developing effective typing training programs.

The widespread use of mobile phones and personal digital assistants (PDAs) for text messaging and brief e-mailing has also promoted research on optimal text entry for mobile devices. MacKenzie and colleagues (MacKenzie & Soukeroff, 2002; Silfverberg, MacKenzie, & Korhonen, 2000) reviewed 15 years of research on text entry for mobile phones and developed guidelines for optimal movement and visual search, predictive models, and metrics. Other researchers (e.g., Wobbrock, Myers, & Hudson, 2003; Zhai, Hunter, & Smith, 2002) have extended this research to virtual keyboards for PDAs, introducing novel text entry solutions and techniques for creating specialized keyboard layouts. These studies represent examples of systematic evaluation methods that promote continued refinement and innovation in text entry.

For each device category, we analyzed features and design decisions to determine what contributed to effective and optimal use of the device.

Text entry research identifying *why* a specific usage situation might dictate specific requirements has been limited. Therefore, designers have relied on well-developed intuition to select design features, which results in solutions that may only partially satisfy system requirements. For example, the Blackberry keyboard uses the QWERTY arrangement, well known by typists and computer keyboard users. Psychological research suggests that typists not only have a visual memory for approximate locations of individual letters but also develop motoric memory to select letters in the typing process (Salthouse, 1986). Both types of knowledge can transfer to a Blackberry-type device and may increase typing speed on these devices, at least for experienced users.

Typists are typically unaware of this motoric knowledge and may instinctively use a different schema that does not transfer to Blackberry text entry. Although the manual contains the recommendation to select a given letter using the same hand used for typing that letter on a computer keyboard, typists could learn this optimal approach more effectively if guidance were located on the device itself. Guidance placed “in the world,” such as separation between right- and left-hand keys on the device, may cue letter selection through transfer of normal typing knowledge more effectively than expecting users to consult a manual. This technique is generally recommended by human-computer interaction (HCI) guidelines (e.g., Norman, 2002), but research is needed to more fully articulate requirements for system features that facilitate ease of learning and effective transfer of interaction knowledge.

Text entry research identifying *why* a specific usage situation might dictate specific requirements has been limited.

Our objective was to provide guidance for effective design by identifying and organizing psychological constructs that are important for text entry. We conducted a review and analysis of relevant literature to identify psychological constructs that are most relevant to text entry. From our review, we developed a framework to guide effective analysis, enhance the specification of design requirements, and facilitate the design of text entry elements.

Our Approach

To develop a framework of relevant psychological constructs, we utilized both a top-down and a bottom-up approach. The top-down perspective involved reviewing psychology, engineering, and computer science peer-reviewed journals to identify psychological constructs that have been examined in text entry research. We selected constructs that are critical to performance, as demonstrated by emphasis in task analysis and models (e.g., MacKenzie & Soukoreff, 2002) and their impact in empirical studies (e.g., Sears, Jacko, Chu, & Moro, 2001) or design evaluations (e.g., Marshall, Foster, & Jack, 2001).

For the bottom-up perspective, we identified psychological constructs of existing but nonstandard devices that allow text entry. We selected 14 text entry devices (see Table 1) from Internet and online HCI database (e.g., ACM Digital Library) searches for further evaluation. Devices were representative of systems that meet current needs (e.g., Senseboard®, a small device that straps to a user's hands, allowing him/her to type on any flat surface) or expected future needs (e.g., Twiddler2, a handheld chording device developed for wearable computing applications). We organized the devices into five categories according to a core functional requirement: mobile phone keypad, task-specific input, one-handed rapid input, mobile touch-typing input, and portable messaging.

This framework can be used during the early phases of system development to establish a comprehensive understanding of the task and usage situation from a user's perspective, facilitating user-centric design.

Each selected device fit only a single category, though other current or future devices may fit into multiple categories, particularly as devices with multiple functions (e.g., iPhone™) continue to emerge. Finally, we reviewed device descriptions in each category to map previously selected psychological constructs with design features and expected usage situations. Gaps in which important features and situations did not map to these constructs were filled by selecting the psychological construct closest to the purpose of the feature or situation, based on standard system task analysis (e.g., Luczak, 1997).

We organized the resultant psychological constructs and developed design-focused criteria for each construct. For each device category, we analyzed features and design decisions to determine what contributed to effective and optimal use of the device. Based on this analysis, we created questions to help designers assess and describe each requirement during the systems analysis phase of product development.

Table 2 presents the resulting framework created to guide a comprehensive understanding of system requirements and to facilitate appropriate design. The constructs and subcomponents are the important psychological processes that should be considered in the selection or design of a text entry system. Questions that guide the documentation of system requirements, constraints, and usage situations are listed in the last column of Table 2.

Applying the Framework

To make this framework more concrete, we illustrate how it is used to translate high-level requirements into detailed requirements during the development of text entry systems. Below we have listed high-level descriptions of each device category created for this evaluation.

- *Mobile phone keypad.* Many mobile phone designs allow users to input short alphanumeric messages and telephone contacts on small, numerically based keypads.
- *Task-specific input.* Some devices, such as in-car navigation systems, allow few functions within a limited domain, so designers optimize the controls and displays for these few functions. Yet users may also need to use the same controls and displays to enter text in order to perform additional functions – for example, entering an address to obtain navigation guidance.
- *One-handed rapid input.* In some environments, frequent users of multifunctional computer systems may need to input text rapidly and accurately while leaving one hand free for other tasks. Examples of these environments include wearable systems, battle management systems, and NASA command centers.
- *Mobile touch-typing input.* Users of mobile systems may need lightweight input devices to enter text more effectively than is possible with entry on small keyboard devices. For instance, airline passengers may find it difficult to compose reports on a laptop PC, especially if the passenger in front of them has reclined the seat.
- *Portable messaging.* Specialized portable devices with small displays and controls are used for reading and entering text that is shared with others. Primary uses of these portable devices are e-mail, calendar, and phone directory management. Many of these devices feature the ability to input text with a stylus and have optimized letter arrangements.

Summary

Table 3 elaborates these high-level descriptions by documenting example requirements that respond to questions from Table 2 for each category of device. These examples show how psychological constructs can be translated into design requirements that are specific enough for designers to follow and for analysts to test before devices are released on the market. This translation was essential in devising a framework that can help designers focus on actual user needs and constraints rather than making assumptions about those requirements.

Note that the following requirements are common across categories:

- Letters and numbers should be organized to simplify visual search.
- Design should rely on common knowledge of the basic text entry task on phones and generic computer keyboards.
- Designers must provide cues and guidance for users to learn correct device use through experimentation or from others.
- Design should be based on the expectation that users are rarely motivated to complete training.

If these usage requirements are identified during the early stages of development, designers can compile a short list of solutions derived from existing systems that will require only minor modifications. On the other hand, Table 3 shows that customized design is often needed to support expected attention and memory use with specific movement options, entry techniques, and feedback. Developing text entry systems for these constructs entails more creativity, but the psychological framework (Table 2) can constrain the solution set by highlighting critical factors that should be addressed during design. Sample requirements for each category (Table 3) can also stimulate new ideas when existing solutions cannot be reused.

Recommendations

Designers face many challenges in creating devices that meet engineering requirements for specific functionality, marketing requirements for excellent aesthetics, and high user acceptance. Our proposed framework addresses these requirements by applying the results of theoretical and empirical research to practical problems faced in designing text entry systems for a variety of environments. This framework can be used during the early phases of system development to establish a comprehensive understanding of the task and usage situation from a user's perspective, facilitating user-centric design.

Solutions for common requirements can be directly transferred or adapted from existing solutions. Solutions to unique requirements can be shaped within a comprehensive set of guidelines that provide the user's perspective on the task. The design can thus evolve into a text entry system that meets or exceeds business and user expectations.

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Biography

Marita A. O'Brien is a graduate student in engineering psychology at the Georgia Institute of Technology. Her current research is based on her interest in bridging the gap between the practical guidance designers need and psychological literature. She has more than 10 years of experience advising Fortune 500 clients on the design of customer service and networking solutions at Deloitte Consulting and Morgan Stanley & Co. She may be reached at Georgia Institute of Technology, 654 Cherry St., Atlanta, GA 30332, marita.obrien@gatech.edu.

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FEATURE AT A GLANCE

A critical challenge in creating text entry interfaces for noncomputer-based devices is to devise a highly usable solution that blends aesthetic and functional concerns. As psychologists, we study user and environmental factors that facilitate usability, although this research often is not presented in a format that designers can use. This article presents a framework for guiding the systematic and comprehensive analysis of design requirements through the assessment of critical psychological components. We highlight several solutions from typing and mobile devices that can be directly transferred into a new system and note those areas that typically call for customized solutions.

TABLE 1**DEVICES SELECTED FOR EVALUATION**

Device	Reference Link	Device Category
ATOMIK	www.almaden.ibm.com/u/zhai/papers/ZhaiHunterSmithHCIGalley.pdf	Portable messaging
Canesta Electronic Perception	www.canesta.com	Mobile touch-typing input
Fastap	www.digitwireless.com	Mobile phone keypad
Frogpad™	www.frogpad.com	One-handed rapid input
Hertz NeverLost	www.neverlost.com	Task-specific input
iDrive	www.bmw.com/com/en/insights/technology/technology_guide/articles/idrive.html	Task-specific input
MessageEase™	exideas.com/ME/ICMI2003Paper.pdf	Mobile phone keypad
Nokia 6800	www.nokia.com	Mobile phone keypad
Optimized layout	www.almaden.ibm.com/u/zhai/papers/Softkeyboard/AlphaShort1.pdf	Portable messaging
Palm Zire™	www.palm.com	Portable messaging
RIM BlackBerry®	www.rim.net	Portable messaging
Senseboard®	www.senseboard.com	Mobile touch-typing input
TiVo®	www.tivo.com	Task-specific input
Twiddler2	www.handykey.com	One-handed rapid input

TABLE 2

FRAMEWORK TO GUIDE ANALYSIS OF REQUIREMENTS FOR TEXT ENTRY

Psychological Construct	Subconstructs	Key Questions for Gathering Requirements
Perceptual/motor	Visual search	<ul style="list-style-type: none"> Will users need to search for items on display, or is layout based on well-known letter arrangement?
	Movement control	<ul style="list-style-type: none"> Is cursor movement compatible with input device? Will users practice task enough to develop motoric memory?
Attention	Selective	<ul style="list-style-type: none"> Will letter selection require focused attention to confirm correct item is chosen?
	Divided	<ul style="list-style-type: none"> How much attention will users be giving to text entry (vs. other concurrent tasks)?
Memory	Working	<ul style="list-style-type: none"> Will individuals have sufficient working memory to enter text given available feedback?
	Procedural	<ul style="list-style-type: none"> What other text entry techniques do users know? How will users select letters given the input device?
	Semantic	<ul style="list-style-type: none"> Is good spelling required?
Feedback	Audible	<ul style="list-style-type: none"> Will users be able to see letters/words they have entered?
	Tactile	<ul style="list-style-type: none"> How will users know they have made correct input motions to select a letter? How salient is the feedback in the target environment?
	Visual	<ul style="list-style-type: none"> Is feedback adequate to support learning?
Previous knowledge	Cultural knowledge	<ul style="list-style-type: none"> Will users have previous knowledge of system usage based on their cultural background (e.g., dialing numbers, prefix usage)?
	Individual differences	<ul style="list-style-type: none"> Will differing technology experiences from different users affect system expectations?
	Mental model	<ul style="list-style-type: none"> What is previous experience of users with text entry systems or this device?
Training	Incidental learning	<ul style="list-style-type: none"> How are users expected to learn the system?
	Training required	<ul style="list-style-type: none"> Does system include control or display features that facilitate incidental learning? What kind of training will be provided? Is provided training appropriate for likely or potential users?
Motivation	Training motivation	<ul style="list-style-type: none"> What are users' goals for entering text?
	User goals	<ul style="list-style-type: none"> Are users willing to invest time reading the manual before system use? Are users willing to invest additional time in training and practice to develop optimal entry techniques?

Psychological Construct	Subconstructs	Key Questions for Gathering Requirements
		<ul style="list-style-type: none">• Are different users entering unique, diverse types of information?

TABLE 3

Sample Requirements for Text Entry Systems

Device Requirements for Categories of Selected Devices						
Psychological Construct		Mobile Phone ^a	Task-Specific ^b	One-Handed ^c	Mobile Touch-Typing ^d	Portable Messaging ^e
Perceptual/motor		<ul style="list-style-type: none">Letters must be visible on keys for visual search	<ul style="list-style-type: none">Letters must be visible on keys for visual search	<ul style="list-style-type: none">Visual search will not be available	<ul style="list-style-type: none">Typical typing movements for a computer keyboard can transfer to mobile keyboard	<ul style="list-style-type: none">Letters must be visible on keys for visual search
		<ul style="list-style-type: none">User must be able to input text with one finger	<ul style="list-style-type: none">Organize letters and numbers to simplify visual search	<ul style="list-style-type: none">Keys should be physically separated to facilitate manual search and motoric memory development		<ul style="list-style-type: none">Organize letters and numbers to simplify visual search
			<ul style="list-style-type: none">Allow cursor movement among letters that is intuitively compatible with input device movement	<ul style="list-style-type: none">Design text input technique for optimal movement planning and motoric memory development		<ul style="list-style-type: none">Design text input technique for optimal movement planning and motoric memory development
Attention		<ul style="list-style-type: none">Support users' attention allocation to monitoring button presses on multiletter keys to select correct letter	<ul style="list-style-type: none">Situation dependent:<ul style="list-style-type: none">–Driving: Support users' sharing attention–Entertainment: Assume user will be focused on this task	<ul style="list-style-type: none">Support users' sharing attention with other tasks	<ul style="list-style-type: none">Support additional focused attention allocated to typing technique for accurate typingAssume user will be focused on task	<ul style="list-style-type: none">Situation dependent:<ul style="list-style-type: none">–Driving: Support users' sharing attention–Entertainment: Assume user will be focused on this task
		<ul style="list-style-type: none">Support users' sharing attention				
Memory		<ul style="list-style-type: none">Include procedure for selecting one letter from multiletter key	<ul style="list-style-type: none">Facilitate user recognition of a target name from listAccommodate spelling corrections	<ul style="list-style-type: none">Support users' medium to high use of working memory to track progress	<ul style="list-style-type: none">Accommodate spelling correctionsSupport users' use of working	<ul style="list-style-type: none">No need to correct spelling and grammar

Device Requirements for Categories of Selected Devices				
	<ul style="list-style-type: none"> No need to correct spelling and grammar 	<ul style="list-style-type: none"> memory to track progress and accuracy of entry 	<ul style="list-style-type: none"> and accuracy of entry Include chording procedure to use multiple keys to select one letter 	
Feedback	<ul style="list-style-type: none"> Tactile and audio feedback are important for accurate key selection 	<ul style="list-style-type: none"> Visual feedback must be particularly salient to guide infrequent usage Tactile and audio feedback can supplement visual feedback on item selection 	<ul style="list-style-type: none"> Tactile feedback is critical for accurate key selection 	<ul style="list-style-type: none"> Audio feedback can provide substitute/complementary feedback in systems with reduced or no tactile feedback Visual feedback to confirm accurate key selection must be salient
Previous knowledge	<ul style="list-style-type: none"> Leverage well-known alphabetic letter arrangement in users' primary language Accommodate users' speaking multiple languages Leverage users' knowledge of text and number entry from mobile phones and computers 	<ul style="list-style-type: none"> Leverage well-known alphabetic letter arrangement in users' primary language 	<ul style="list-style-type: none"> Use a key layout that supports development of appropriate mental representation for faster entry Assume user knows generic text entry task 	<ul style="list-style-type: none"> Leverage users' knowledge of text and number entry from mobile phones and computers Leverage users' knowledge of stylus use and input technique (e.g., Graffiti) from PDAs Use a key layout that supports development of mental representation for faster entry
Training	<ul style="list-style-type: none"> User-dependent: <ul style="list-style-type: none"> Infrequent users: Provide cues and guidance New users: Provide experimental practice 	<ul style="list-style-type: none"> User-dependent: <ul style="list-style-type: none"> Infrequent users: Provide cues and guidance New users: Provide experimental practice 	<ul style="list-style-type: none"> Training tutorial should provide users with both instructions and practice on entry technique 	<ul style="list-style-type: none"> Situation-dependent: <ul style="list-style-type: none"> Primary use: Provide cues and guidance for users to learn device use through experimentation or from other users, though manuals or tutorials may

Device Requirements for Categories of Selected Devices

provide initial guidance

–Experimental use: New entry technique must be taught and practiced to develop motoric memory for stylus movements and key location

Motivation					
	<ul style="list-style-type: none"> Assume users are rarely motivated to complete training Accommodate users with different text entry goals: <ul style="list-style-type: none"> –Some users seek only optimal numeric input –Other users also seek efficient text messaging 	<ul style="list-style-type: none"> Assume users are rarely motivated to complete training 	<ul style="list-style-type: none"> Assume users may be motivated to complete tutorials and practice to develop fluency 	<ul style="list-style-type: none"> Assume users are rarely motivated to complete training 	<ul style="list-style-type: none"> Assume users may be motivated to complete tutorials and practice to develop fluency

^aExamples include Fastap, MessageEase™;

^bHertz NeverLost, BMW iDrive, TiVo®;

^cTwiddler2, Frogpad™;

^dCanesta Electronic Perception keyboard, Senseboard®;

^ePalm Zire™, RIM BlackBerry®, ATOMIK, optimized layout with alphabetic ordering.