The Effectiveness of Tactile Cues in Cellular Phones

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As cellular phones get smaller, there has been a concurrent reduction in the size of the control interface. Two studies examined whether tactile cues might facilitate dialing on small cellular phone keypads. The first study, a questionnaire administered to 289 individuals, suggested that people believe that tactile cues can benefit users of cellular phones. The second study, an experiment comparing dialing performance with vision precluded between two keypad-types (textured keys and smooth-keys), showed that performance in the former condition was better than that latter. Implications for cellular phone keypad designs are offered.

INTRODUCTION

Cellular phone use has grown substantially over the last few years. A recent estimate indicates there were approximately 180 million cellular phones in use in the U.S. (Scarborough Research, 2002). Approximately 62% of Americans own a cellular phone. With the current trend towards miniaturization and added features, there has been an increasing need to address the human factors/ergonomics (HF/E) aspects of the interface (Nam, Kim, Smith-Jackson, & Nussbaum, 2003).

Miniaturization of phone size has made keys smaller making them more difficult to discriminate (Goodman, 1999). Stevens and Patterson (1995) report that tactile acuity of adults diminishes by one-percent each year after the age of 20. In addition to declines in tactile acuity, the range in visual accommodation decreases such that by the age of 60, little accommodative capacity remains. Thus, miniaturization may result in difficulties of usage.

There are safety concerns of using cellular phones while driving. Parkes (1993) has found that the operation of manual controls while driving can contribute to lane deviations, decreased reaction time and detection of gaps in traffic. Green (2000) found that one of the more frequent causes of cellular phone-related car crashes was due to dialing while driving. Dialing-related accidents were second only to answering the phone (see also Nowakowski, Freidman, & Green, 2002). While people are at least somewhat aware of safety concerns of driving with a cellular phone, many people perceive the risk to be less so for themselves than for others (White, Eiser, & Harris, 2004). The addition of tactile features may decrease distraction that occurs when an individual physically handling the phone must look at the interface to dial. Smaller keypads may contribute, at least in part, to degradation in driver performance such that individuals may have to switch more attention from the dialing task to the dialing task.

Prior work suggests that tactile information such as texture can be readily discriminable during times when the visual modality is not in use and perform as well as the visual modality (Heller, 1982; Heller, 1989). Most cellular phones have relatively few tactile cues other than key placement. Many cellular phone keypads have smooth surfaces that make it difficult to discriminate the keys from one another and the phone body. Tactile cues such as raised surface dots may enhance discrimination of the keys from the body. Research on texture and haptics has shown that participants can generate a representative image based on a stimulus' texture and spatial patterns (Sathian, 1989).

The present research examines the potential benefit of tactile cues to cellular phone users. The first study used a questionnaire to examine participants' beliefs about the utility of tactile cues. The second study was an experiment examining dialing performance between two types of keypads: smooth keys on a smooth surface vs. soft-rubber raised keys above the phone surface. It examined whether tactile cues could improve performance on a dialing task where there was no visual information provided

STUDY 1

This study used a questionnaire to investigate individuals' perceptions regarding the usefulness of tactile cues in cellular phones.

Method

Participants. A total of 289 individuals from Raleigh-Durham, North Carolina participated ranging in age from 18 to 83 years (M = 27.9, SD = 12.27). Participants were recruited by students associated with an Ergonomics class who administered the questionnaires to participants in various places in the community (e.g., schools, malls, etc.).

Stimuli and apparatus. A multi-page questionnaire was produced in the Cognitive Ergonomics Laboratory at North Carolina State University. Included were items on aspects of dialing cellular phones that comprise the present. Participants were asked to rate how much they agreed with statements presented to them. The ratings were on a 9-point Likert-type scale with the following numerical anchors and text: (0) not at all agree; (2) somewhat agree; (4) agree; (6) very much agree; and (8) extremely agree. Table 1 shows a set of statements that participants rated on the extent to which they agreed with them. Approximately half the participants received the statements in one randomized order and the others received another order.

Table 1. *Mean agreement ratings and standard deviations (SD) as a function of questionnaire items (scale ranged from 0-8 with higher rating indicating greater agreement)*

	Statement	Mean	SD
a.	When I navigate menus of cellular phones, I am likely to look at the buttons to locate them before pressing them.	4.85	2.21
b.	It would be helpful to have button features to help locate them by touch or feel them in situations where you are not looking at the phone.	4.76	2.28
c.	When I am not able to see the buttons on a cellular phone, for example because of low lighting conditions, I am almost always successful in navigating and dialing.	4.25	2.15
d.	When I make a phone call on a cellular phone, I always look at the actual buttons to locate and dial them.	4.12	2.34
e.	I would be willing to pay more for a phone that would recognize my voice to make menu commands and dial a phone number.	4.00	2.48
f.	I would consider buying a phone with features that allow the buttons to be identified by touch or feel.	3.87	2.42
g.	I would be willing to pay more for a feature that allows the buttons to be located by touch or feel.	2.92	2.36
h.	I would be willing to pay more for menus on a cellular phone that “speaks” when I press the different buttons.	2.76	2.46

Results and Discussion

Of the 289 individuals who participated in the study, only 6 reported never having dialed a cellular phone to complete a call. Of the remaining 283 who had operated a cellular phone, 245 participants (85%) reported currently owning a cellular phone. Also, 206 participants (69%) indicated that they had used a cellular phone without looking at the buttons or display.

Table 1 provides the mean ratings (and SDs) ordered from high to low agreement. The overall mean ratings show that participants believe that tactile cues would be beneficial to cellular phone users such that the majority of means represented a value of “agree” or above. Even the items with the lowest means had scale values that were between “somewhat agree” and “agree” indicating a moderate level of agreement with the items.

The results of this questionnaire-based of this research suggest that there could be a benefit of adding tactile features to cellular phones to aid in dialing. Although the item (f) that asks whether participants would consider purchasing a phone with tactile features had a mean of 3.87, its position on the scale lay closer to 4 (agree) than to 2 (somewhat agree) indicating that at least some of the participants had favorable attitudes towards the addition of tactile features. It suggests that tactile cues would serve a beneficial function under foreseeable conditions.

For example, consider the relatively high agreement to statement (b), which considers the utility of having button features that can be felt tactually when in situation where one cannot look at the phone. One of these situations is, of course, driving and participants gave an overall mean rating of 4.76, which is anchored between “agree” and “very much agree.” Thus, in general, these results demonstrate that individuals believe that tactile cues may benefit the dialing task. The next study was conducted to examine whether tactile cues benefit dialing performance in conditions where vision is precluded.

STUDY 2

The purpose of this study was to examine how well individuals could perform in a dialing task where they were unable to see the cellular phone keypad. This experiment compared performance between two different cellular keypads where one keypad had more tactile cues and the other had less tactile cues. The dependent measure in this study was the number of dialing errors for each 7-digit number.

Method

Participants. The second study consisted of eight participants from the Raleigh-Durham area ranging in age from 24 to 33 years (M = 26, SD = 2.9) who volunteered to participate in the study.

Stimuli and apparatus. Two Motorola StarTAC flip-open cellular phones were used. The phones were not in service but they could be electronically charged so that numbers could be entered in the keypad and registered onto the display. A large wooden box was constructed with a curtain to prevent participants from seeing the keypad as they entered the numbers. The only difference between the phones was the textural feel of the keys.

The two cellular phones were identical except for the textural feel of the keys. One phone had hard smooth keys level with the phone casing and the other had raised soft-rubber textured keys (the keys were raised from the phone casing). The “home” key indicators (or raised dots typically found on most cellular phone and calculator keypads on or near the central key of the numerical interface) were removed from both phones in an effort to compare the phones solely on the textural differences of the keys.

Ten fictitious 7-digit phone numbers were printed onto self-adhesive labels and affixed to index cards. Participants wore auditory-isolating earmuffs to reduce ambient auditory noise. A large sturdy box with an opening for hand insertion was used. The opening was covered in a black curtain, which prevented individuals from viewing the cellular phone during the dialing task.

Procedure. Before the experimental session began, participants were given a short questionnaire that contained demographics and task performance expectation items. After the initial questionnaire was completed, the experimenter read aloud a set of instructions. The participants were asked to place onto their heads auditory-isolating earmuffs and to place their hand through the black curtain. Then, the experimenter placed the first cell phone in the participant's hand to briefly familiarize themselves with the keypad before the start of the experimental procedure also used for the other cellular phone condition.

The session then began with the dialing task by presenting the first index card in front of the participant. Upon being showed the card, the participant attempted to enter the number into the keyboard based on touch alone. After each 7-digit number was entered, the next index card was presented. This procedure was repeated in this manner for both phones until the trials were complete. The 7-digit numbers that were used were balanced across conditions so that each appeared an equal number of times in both conditions. Half of the participants started with the smooth then textured phone while the other half started with the textured then smooth phone. Each participant was given a maximum of 15 s to dial each number. All of the participants were able to dial the numbers in the allotted time. When asked if individuals felt rushed during the dialing task, all participants reported they felt they had ample time.

Results and Discussion

A repeated-measures ANOVA was conducted on the error rates. To be counted as correct, the numbers had to be totally correct. One or more errors in a dialed number was counted as a single error. The cellular phone with raised soft-rubber keys rate (M = 0.84, SD = .58) produced a lower mean error than did the other cellular phone with the smooth plastic surface (M = 1.8, SD = .48); $F(1,14) = 12.56$; $p < .005$. Analyses were also conducted to assess whether there was any gender and/or order (smooth to textured or textured to smooth) effects; no significant effects were found.

The results of the second study demonstrate that different tactile characteristics of keypads can lead to significant differences in performance. In this study two otherwise identical phones, except one had soft-rubber keys while the other had hard-smooth keys, were used under conditions of visual occlusion. The phone with the more textured surface (rubber keys) yielded significantly lower errors than the phone with the hard-smooth keys in a dialing. The performance benefit of the textural keys might be attributable, at least in part, to characteristics of the rubber keys such as resistance, friction, and cutaneous depression.

While this experiment had a relatively small number of participants, power was enhanced by using a within-subjects design, and within that, multiple trials. Finding an effect with so few participants suggests that the effect of tactile feedback is fairly substantial.

GENERAL DISCUSSION

This research comprised two studies which concerned perceptions of tactile cues in cellular phone keypads as well as the utility of those cues. In the first study, participants expressed that tactile cues can be beneficial to cellular phone usage. The second study empirically examined whether tactile features of keypads facilitate dialing performance. The second study revealed that tactile cues can reduce dialing errors when visual feedback is unavailable.

Future technology may reduce physical handling risks with incorporation of tactile cues. But if people still use handheld phones, then it would seem incumbent that cellular phone manufacturers and service providers offer systems with multiple cues to help people use their phones under foreseeable usage situations. Tactile cues would be useful when the visual sense cannot be used in operating the cellular phone.

People are likely to benefit from tactile cues not only in normal operating situations but also in reduced-visual conditions. The tactile cue employed can be as simple and cost-effective as that used in this study with readily discriminable raised soft-rubber keys. Our results show that by simply employing buttons that have a more discriminable surface, participants' performance is better than when dialing a smoother, less-discriminable surface.

Research of tactile cues on cellular phone keypads is one that has received relatively little attention. The research reported here only addresses a small portion of the potential domain of research. There are a number of areas where future research ought to be conducted. One area is the evaluation of the impact of miniaturization on older adults especially since the decreased ability to focus is one of several visual declines as adult age known collectively as presbyopia (Kline & Scialfa, 1997). Thus, it would be desirable to examine how beneficial the incorporation of tactile cues in cellular phones is for older adults.

A second area is to identify those tactile cues that may be most effective. Useful tactile characteristics may include key shape, size, texture, and other attributes. A third area is to explore the impact of various tactile cues in more ecologically valid context such as simulated driving tasks.

Our findings suggest that the design of future phones should incorporate tactile cues which can in turn potentially enhance the usability of cellular phones. That increased usability may translate to increased safety of users especially in reduced-visibility situations such as driving. This area warrants greater attention since the issue has societal impact beyond the simple usability of a common consumer device.

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