HAPTICS:
Improving the Mobile User Experience through Touch

Independent research suggesting how haptics can be used to improve the user experience, and how operators can use haptics to increase differentiation and customer satisfaction, enhance brand, and drive additional revenue using high-value, haptic content and services.

Driven by a competitive business climate, handset user interface design is receiving a great deal of study and attention. Technology advances have turned the mobile phone into the ultimate portable tool for information, communications, productivity, and entertainment. Designing a user interface (UI) that can handle these capabilities—and still remain useful, usable, and uncomplicated—is the challenge. In addition, mobile phones are among the most personal of devices, and UI designers know that appealing to subscribers' emotional, as well as physical (utilitarian) needs, is a winning combination.

Wireless operators concerned about improving the mobile user experience will understand the sense of touch as a tremendous and underused source of both physical and emotional attachment. After all, people learn the language of touch from an early age, having absorbed its lexicon, grammar, and syntax even before verbal language. And though many of the leading handset manufacturers have started to leverage the sense of touch through tactile feedback (haptics*), visual and auditory communication channels are still the most often used. Yet because the mobile handset is such a capable and complex tool, and because people intuitively and effortlessly understand communication through touch, the mobile communications experience stands to gain immeasurably from the use of haptics technology.

Independent research indicates that haptics can be used to:

- Provide a new way to interact with phones and network services that can be as powerful and useful as the sense of touch itself
- Improve user performance (speed and accuracy) and reduce complication and stress
- Increase user satisfaction, because people prefer tactile feedback in their mobile phone interactions
- Enhance the subscriber experience by making phones more intuitive and usable and services more satisfying and sticky

See Appendix: **Applying Haptics in Mobile Devices**, page 9, for a description of selected applications of haptics in mobile phones, including:

- Advertising
- Dialing cues
- Games
- Messages and alerts
- Movie trailers
- Ringtones
- Scrolling
- Touchscreen presses

The Prada by LG
The LB3100 PRADA by LG uses tactile feedback in an advanced interface that does not include the conventional keypad.

* Haptics, from the Greek "hapesthai," meaning "to touch." Haptics technology used in mobile device user interfaces is also known as haptic, tactile, touch, and vibrotactile feedback.

Haptics Research

The following research covers the use of haptics in several implementations: (1) as the primary means of conveying information, (2) as a means to convey secondary or peripheral information, and (3) along with sight and/or sound to produce a multimodal interface. It is organized into the following broad categories that describe the results of a haptic UI:

- Expand the interface
- Improve performance
- Reduce cognitive loading
- Increase user satisfaction

Expanding the Mobile Device Interface

Research has demonstrated that users can distinguish between many types of tactile sensations, leading to the conclusion that the sense of touch can be used as a high-bandwidth communications channel—even when the phone is in silent mode. Studies document that, for some interactions, haptics supplies information or an aspect of operation that cannot be provided by either sight or sound. A key advantage of haptic information is that it is silent, discreet, and personal—experienced only by the user—unlike other types of signaling that can cause an unwelcome broadcast into the surroundings. Through haptics, users can understand information that is both simple and complex.

As a unique bi-directional communications channel, haptic feedback can provide benefits that also include important UI paradigms that are either impossible or extremely difficult to produce without it. These benefits are most clearly articulated by MacLean (MacLean 2000):

Continuous Control. Haptic feedback provides immediate information to users during task execution, allowing them either to modify their behavior to more effectively multitask or execute one task.

Affective Computing. Haptic feedback, because of its intimacy, can help communicate emotion. It can add social context where it otherwise would be lost.

Dealing with Complexity. There are numerous situations where human task performance suffers from overly complex procedures or visual overload. Haptic feedback can help offload the visual channel for users, helping them reduce stress and improve efficiency.

Tactile Communication: From Simple to Complex

As early as 1960, University of Virginia Psychology Professor Frank A. Geldard observed that cutaneous sensations, especially unusual vibrational patterns, would be highly attention-demanding and therefore provide a good "break-in" sense; that is, an alert (Geldard 1960). He observed that it would be possible for the simplest and most straightforward of all messages—emergency warnings and alerts—to be delivered cutaneously.

Brown and Williamson (Brown and Williamson 2007) have explored using multimodal audio and haptics for mobile interpersonal communication. They observed that such messages could be used to communicate a range of meanings, from the practical ("Home safely.") to the emotional ("Thinking of you.").

Haptic emoticons could communicate a range of meanings based on a haptic language. Such a service was launched by Softbank Mobile of Japan in 2006. The Feeling Mail service lets senders insert into their messages emotional pictograms that include a vibration and light display.

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NTT DoCoMo (Fukumoto and Sugimura 2001) performed early research on adding haptic feedback to mobile devices. They distinguished between feedback felt by the hand that holds the device and feedback felt by the fingertip in contact with the screen. They saw that these two operating modalities each have their own benefits, depending on context.

The work of Dosher and Hannaford (Dosher and Hannaford 2005) indicates that tactile feedback can convey significant quantities of information and use does not need to be confined to simple notifications. The researchers developed a fingertip tactile display that provided both kinesthetic and vibrotactile feedback, which varied in amplitude, wave shape, and duration during interaction with haptic icons. The authors report that observed throughput was positively correlated with tactile effect amplitude, with bit rate improvements of as high as 50%. They also report that rough feedback (high tactility) has a lower threshold of detection than smooth feedback (low tactility).

Research published by Nokia (Silfverberg 2003) also reinforces the value of tactile feedback in mobile scenarios. In this work, subjects were prompted to type numbers on phones with both rough and smooth buttons, both with and without looking at the keypad. (Note that no programmable haptic feedback was involved in this study.) The results indicate that with direct visual information, the phone tactility made no statistical difference. However, without visual information, subjects were 25% slower and made over 6 times as many errors with the low tactility phone (see Figure 1).
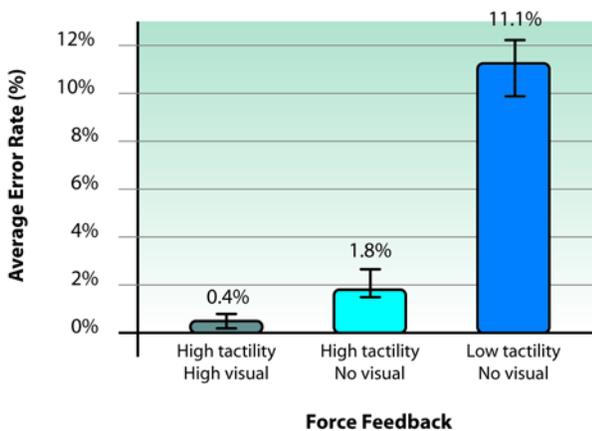
Adapted from Silfverberg 2003.

Figure 1: Nokia found that without visual feedback, rough, not smooth, buttons reduced errors significantly.

Touch: The First Language
Studies show that, from a very early age, we become sensitive to the specific qualities of touch rather than its mere presence or absence. Mothers are capable of eliciting specific behaviors from their infants using touch (Stack and Arnold 1998; Stock and LePage 1996), and touch can convey messages that are just as specific as those conveyed by other means, such as facial expressions. (Tronick 1995; Stack and Muir 1990, 1992).

During investigation of the Tadoma non-visual communication method in which a deaf-blind person feels the movement of the lips and vibrations of the vocal cords, Tan and others (Tan et al 1999) developed a three-finger haptic feedback device suitable for Tadoma-like communication. They report that using only three amplitudes and three frequencies, equivalent performance to human Tadoma communication is possible. Findings show that a communication rate of 12 bps is attainable with their device. This communication rate is not insignificant and easily supports rich non-verbal, non-visual communication. This work is consistent with other researchers investigating purely tactile communications. Brewster and Brown (Brewster and Brown 2004) for example, proposed a novel vibrotactile language whereas Van Erp and Spapé (Van Erp and Spapé 2003) showed that untrained subjects can distinguish among a variety of purely tactile melodies.

Haptics has been used to underscore the beat of a ringtone, making the experience like "turning up the subwoofers." In silent mode, distinctive haptic ringers can provide discreet caller identification or priority notification.

The ability to identify a variety of unique tactile sequences was confirmed in work by Ternes (Ternes 2007). A statistical sampling methodology was developed to enable valid evaluation of users' ability to identify different rhythmic patterns among all possible tactile rhythms. Findings showed subjects were able to reliably identify up to 85 distinct haptic rhythms.

Improving Performance

Several studies have investigated how user performance is affected when tactile feedback is reduced, such as commonly occurs when mechanical or electromechanical controls are replaced with electronic interfaces (for example, touchscreens). When used along with visual and/or sound cues, haptic feedback has been found to enhance or emphasize the interaction or the information being conveyed, helping the user improve performance. Research on using haptics to increase tactility for electronic membrane and touchscreen controls shows decreased error rates and increased input speeds.

Comparisons: Typing, Trains, and Touchscreens

Several authors in the early and mid 1980s compared error rates and typing performance between mechanical keyboards and membrane keypads. Membrane keypads have no kinesthetic travel, but do provide tactile feedback in the form of raised key edges. Roe and colleagues (Roe, Muto, and Blake 1984) and Loeb (Loeb 1983) found that skilled touch-typists recovered their throughput (error rate and typing speed) on a membrane keypad after some learning. However, for non-skilled typists, without tactile feedback, there was no learning effect, and these typists remained consistently less efficient on the keypad.

Recently published work by Brewster, Chohan, and Brown (Brewster, Chohan, and Brown 2007) examined the value of adding haptic feedback to a smartphone-type device to provide button press confirmation for text entry. Subjects were asked to enter a series of poems on the device in a laboratory setting and on a moving subway train. Corrected and uncorrected error rates indicated that haptic feedback provided improvement in both situations. See Figure 2.
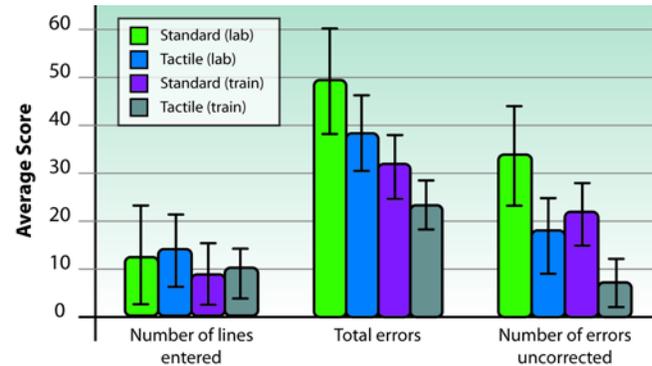
Adapted from Brewster, Chohan, and Brown 2007

Figure 2: Haptic feedback was shown to improve typing speed, reduce errors, and contribute to higher error correction.

The use of tactile feedback in mobile devices was also demonstrated by Nashel and Razzaque (Nashel and Razzaque 2003), who proposed providing haptic feedback for button presses on smartphone touchscreens. They noted that such phones do not provide as satisfying a user experience when the mechanical feel of buttons is absent.
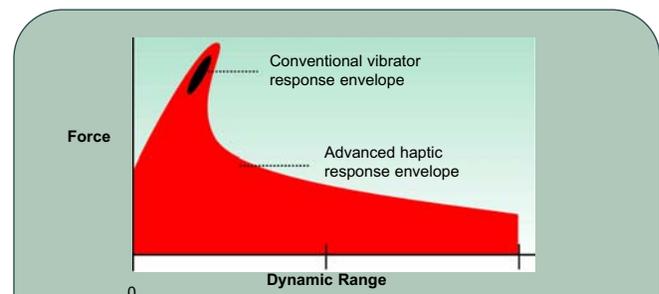
Advanced Programmable Haptics:
Far More than the Conventional On and Off Buzz
Understanding of both simple and complex tactile information is easier when haptic feedback can be varied to provide intuitive clues, according to the application. For example, an alert for a calendar reminder needs to feel completely different than an alert signaling receipt of a text message. Today's technology allows haptic feedback to be varied in frequency, waveform, amplitude, and duration. Further, it provides precise control of these parameters allowing nearly unlimited—and memorable—variation.

Frequency of Use and Throughput

Research has also examined the difference in input performance between a mechanical keyboard and a flat touchscreen for high throughput tasks.

Barrett and Krueger (Barrett and Krueger 1994) compared the typing performance of both skilled and unskilled operators on both mechanical and touchscreen keyboards. Their study took care to identify learning effects associated with the touchscreen by having the same subjects repeat a basic typing task five days in a row. The authors analyzed the inter-key duration, as well as the number of corrected and uncorrected errors, to arrive at an error-adjusted throughput measure for both keyboards for each day of the study. It was determined that non-expert users learned to operate the touch panel over the course of the study, and by the fifth day, had a 10–15% throughput advantage when using the mechanical keyboard vs. the touch panel. For expert users, there was no observed learning effect, and in fact these operators maintained a mechanical keyboard throughput advantage of approximately 50% during the study. This result and the results from Loeb and from Roe, Muto, and Blake indicate that tactile feedback is an essential feature of high performance keyboard input.

The LG LX570 Muziq uses a capacitive sensing surface for its external music playback controls. The addition of haptic feedback gives users valuable confirmation of their control interactions.

Human factors researchers at NCR (NCR 2004) also discovered that operator performance of touchscreen interfaces is lower than for mechanical interfaces for a variety of high-throughput transactions (for example, supermarket check-out). The researchers postulated that a key factor affecting

The Samsung Ultra Smart F700 is typical of the new design for mobile phones where a large touchscreen replaces a smaller display and mechanical keypad. Using haptics, interactions are confirmed for the user, and lack of tactile feedback, one of the central usability challenges of touchscreens, is solved.

this performance difference is the lack of tactile confirmation in the conventional touchscreen-based solution vs. the company's DynaKey product that provided tactile feedback. See Figure 3.

Adapted from NCR 2004
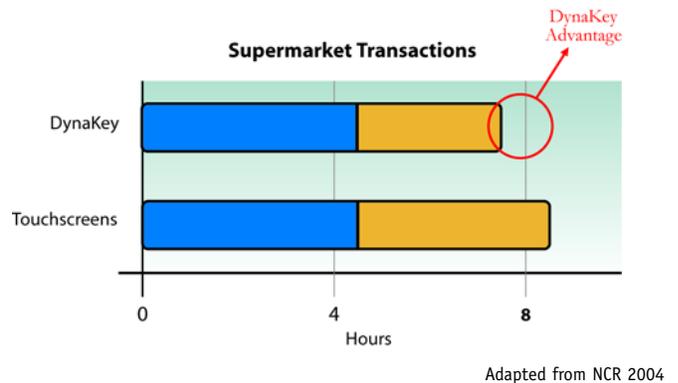
Figure 3: NCR researchers found that a touchscreen's tendency for double touches and lack of tactile feedback for confirmation could lead to increased errors that slow transactions. Their DynaKey product offered the advantage of numeric entry including tactile feedback, which resulted in fewer errors and faster transactions.

Multimodal Is Better

An extensive study of the value of auditory feedback on typing throughput for flat touchscreens was carried out by Bender (Bender 1999). Conducting detailed user studies, he examined the effects of auditory feedback duration and key size. Findings included that auditory feedback alone could not recover performance losses associated with movement time (time to move between keys) and contact time (time spent in contact with each key). However, auditory feedback did reduce error rates, especially for small key sizes. Bender concluded that for touchscreens that do not provide haptic feedback, it is important to provide some type of auditory feedback and to make keys as large as possible.

Multimodal, multisensory interactions have been found to help users in noisy or visually distracting environments.

Tang and others (Tang et al 2005) investigated the ability of haptic feedback to present complex, organized information during difficult cognitive tasks. Researchers had subjects visually track three out of six moving objects on a monitor while simultaneously assessing whether a haptic rendering was of very-low, low, medium, high, or very-high strength. Results showed subjects could complete both tasks simultaneously, with a haptic task accuracy rate as high as 93%. This experiment demonstrated the multimodal information processing capacity of the human sensory apparatus.

Wickens proposed a theory of multimodal sensing called multiple resource theory (MRT) (Wickens 2002). The idea is that human sensory processing must manage multiple simultaneous sensory channels during task execution. When these sensory channels are providing dissonant or unrelated information, there is additional cognitive loading and a subsequent reduction in task performance. Conversely, when there is consistent multimodal sensory input, cognitive loading should lessen and result in increased task performance.

Using MRT as a psychophysical framework, Burke and colleagues (Burke, Prewett, and Elliot 2006) performed an analysis of 43 published studies, evaluating the aggregate performance of visual (V), visual + audio (VA), and visual + tactile (VT) interfaces. Each study was analyzed using Hedges' meta-analysis statistical method, which yields a "g-value" indicating the significance of the result in each study. (In this case, the higher the g-value, the stronger and more credible a difference between modalities). In addition to a global analysis of performance for each multimodality, Burke categorized the 43 studies into sub-groups to provide some insight into the value of multimodal feedback for various types of tasks. The results are shown in Figure 4, showing that for high workload or multiple task scenarios, visual and tactile feedback provides a strong performance benefit, even with respect to visual and audio feedback. In addition, visual and tactile is clearly an ideal mechanism for displaying alerts, warnings, and interruptions.

A multimodal system developed by Akamatsu, Sato, and MacKenzie (Akamatsu, Sato, and MacKenzie 1994) provided vibrotactile and auditory feedback to users during a drag-and-drop task using a tactile mouse. The authors report small performance improvements due to bimodal (audio and visual or haptic and visual) and trimodal (audio, haptic, and visual) over visual feedback alone.
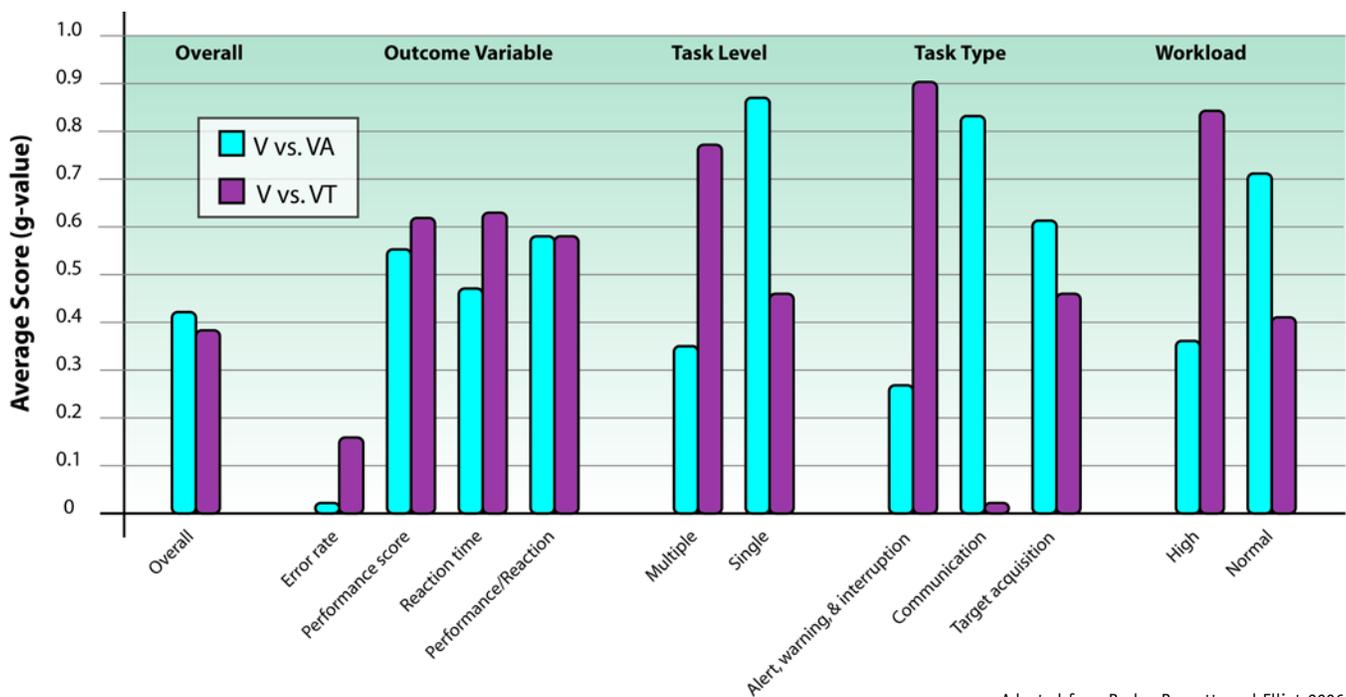
Adapted from Burke, Prewett, and Elliot 2006

Figure 4: Haptic feedback provides strong performance benefits during high workload tasks and for multitasking and alerts.

Reducing Cognitive Load

Research shows that haptics can off-load the sight and/or sound channel, which can ease interactions and reduce complication and stress. In addition, studies show that haptics can be used to convey significant quantities of information, not just simple notifications.

Researchers examining touch as a secondary information channel (Poupyrev, Maruyama, and Jun 2002; Poupyrev and Maruyama 2003) proposed that haptic feedback can function as a peripheral awareness interface. The idea behind a peripheral awareness interface is to provide sensory stimulation on a subconscious or peripheral level, which leaves the user's primary focus on another task. These studies note that, when using mobile devices, people are often preoccupied with tasks such as walking, driving, or even participating in a business meeting, and that these scenarios provide the perfect context for non-visual tactile communication.

The authors investigated the advantage of haptic feedback for a scrolling task, a typical user interface task performed by mobile users on a smartphone. Quantitatively, subjects performed on average 22% faster with haptic

Haptics can provide discreet and cognitively lightweight signaling in situations that are socially sensitive or where attention on a primary task must be maintained.

feedback. Users' subjective responses indicated that they preferred the haptic feedback device, not because of performance improvement, but because they perceived it to supply a better user experience.

The notion of haptic feedback as a secondary or supplemental information source was also carefully investigated by Lindeman and others (Lindeman et al 2003). The researchers asked subjects to locate a specific letter from a dynamically updated jumble of letters. Subjects were assisted by various visual and vibrotactile cues. Results indicate that visual cueing is dominant, providing a 30% average performance increase. However vibrotactile cueing also provided a 12% performance increase, making it a viable option when users are visually occupied.

Van Erp and Van Veen (2001) presented various investigations into the use of vibrotactile feedback to provide non-visual information to users while they execute other tasks. One of the goals of this research was to evaluate tactile feedback for use in providing private, low-cognitive load information to military and civilian first responders. The authors demonstrated that users are able to receive information through tactile feedback even under extreme 6 g-force loading conditions experienced during aerobatic maneuvers.

In another study (Van Erp et al 2005), subjects used information presented on a vibrotactile belt to navigate a series of waypoints while operating either a helicopter or a military watercraft. Subjectively, the results indicate that touch is a highly effective secondary communication channel that leaves the visual sense able to better attend to other control issues.

Weissgerber, Bridgeman, and Pang (Weissgerber, Bridgeman, and Pang 2004) studied multimodal feedback by having subjects perform a protein alignment visualization task with and without peripheral vibrotactile feedback. Their study demonstrated a nearly 50% improvement in task execution times when reinforcing tactile feedback was used.

Increasing User Satisfaction

Several studies document that people prefer tactile feedback over sight or sound alone, especially when it is an expected part of the experience, such as when pressing a button—and even when there is no measurable performance increase. In the user preference studies cited below, users typically perceive haptic feedback as providing additional information, confirmation, or other enhancement.

Research conducted by Immersion Corporation on both touch panels and mobile phones indicates that users prefer or strongly prefer programmable haptic feedback. A user preference study on mobile games (Ullrich 2005), showed a 15–17% increase in user satisfaction for the overall game experience with advanced haptics, versus simple on-off vibration or audio only feedback. Users also stated that advanced haptics helped their game play, increasing satisfaction by 52% over audio feedback alone.

Results of an Immersion touch panel user study were reported along with similar work by Visteon (Serafin et al 2007). These studies demonstrate that, when users are shown both haptic and non-haptic touch panel interfaces and asked to express a preference, the haptic display is strongly preferred. This may be because non-haptic interfaces do not provide the mechanical confirmation that most users expect when pressing a button.

In addition to the PDA scrolling task described under Cognitive Loading, Poupyrev and his colleagues (Poupyrev, Maruyama, and Jun 2002) collected users' subjective responses. Users said they preferred the tactile feedback device, not because of performance improvement, but because they perceived it supplied a better user experience.

Motorola (Chang and O'Sullivan 2005) investigated user preference for haptic feedback in conjunction with audio for mobile phones. Users were presented with two phones, one with audio-only feedback and one with bimodal audio-haptic feedback. The authors reported that of the 42 subjects, 35 indicated they prefer a mobile phone with haptic feedback over one without.

The Brewster, Chohan, and Brown smartphone-train study (discussed under Performance) also asked subjects to answer a modified NASA TLX workload assessment to subjectively evaluate cognitive loading with and without tactile feedback. Results indicate that subjects strongly preferred tactile feedback in every category. See Figure 5.
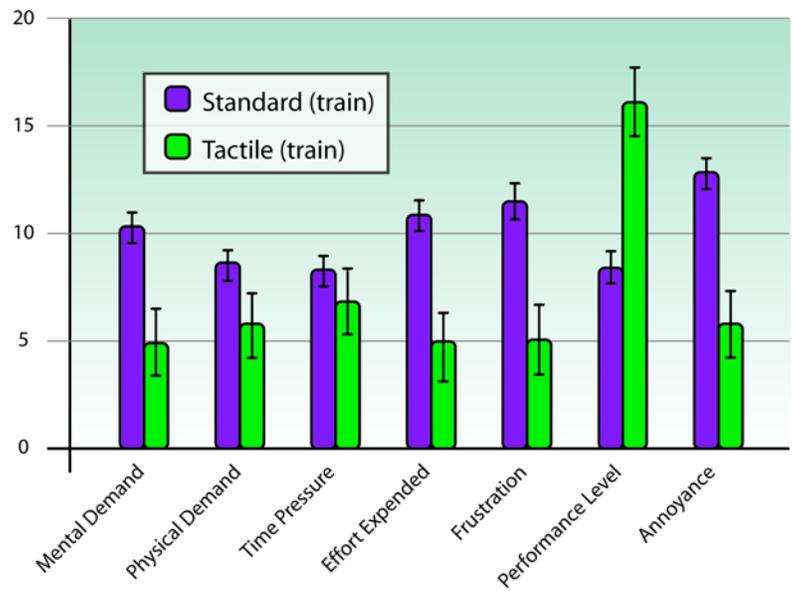
Adapted from Brewster, Chohan, and Brown 2007

Figure 5: Users indicated that, with haptics, PDA use is less mentally and physically demanding as well as less frustrating and annoying.

Conclusion

The independent findings noted here suggest that leveraging the sense of touch can provide many advantages for the user experience—and for operators looking to profit from enhanced phone features and network services.

Delivering a differentiated, personalized, and more satisfying user experience can help strengthen an operator's brand. Haptics can allow operators to provide phones that are considered "cool" and easy-to-use—and innovative high-value services. Supplying cutting-edge phones and services is one of the ingredients needed for decreasing churn and for increasing customer loyalty and ARPU.

Users prefer haptic feedback because they perceive it supplies a better user experience.
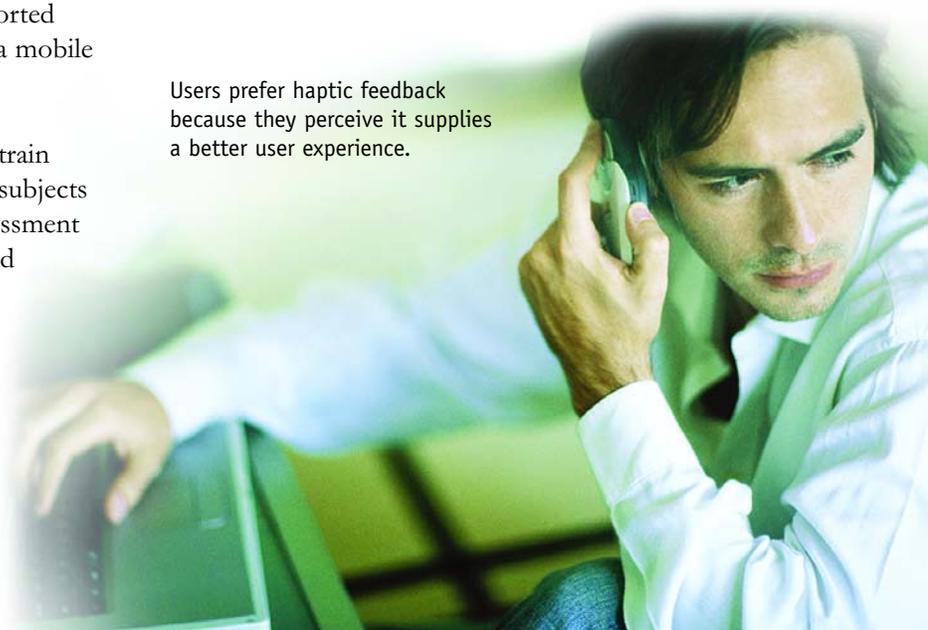
Applying Haptics in Mobile Devices

The following examples illustrate how haptic feedback has been used, or could be used, to expand the interface, improve performance, reduce cognitive loading, and increase user satisfaction.

UI Function and Design

Touchscreen presses

Haptic feedback can be used in mobile device touchscreens to supply input confirmation, including when pressing buttons, scrolling, and using full-track music controls. Using the sense of touch increases interactivity, and for that reason could make browsing and navigation easier and more enjoyable and productive. Haptic feedback enables a multimodal usability advantage, especially when the environment is noisy or the phone's sound is turned off.

Keypad/control surface presses

Mobile device buttons are usually small and many have shallow travel. Programmable haptic feedback could be used to supply confirmation of key press and to differentiate keys such as "Send" from "OK."

Scrolling

Haptic feedback can be used to help users quickly and with little or no looking scroll through a list and identify unread messages or distinguish between messages from friends, family, or business associates. High-priority and low-priority messages could feel different, as well. The user could set priority based on a particular person or group, or the sender could mark the priority of their message, causing it to produce a sensation that communicated urgency. Names or groups in the contacts list could also be assigned different vibrations. The top and bottom of the list could feel like a stop, or wrapping around to the top of the list could accompany haptic feedback that felt like going over a hill.

Dialing cues

Call waiting, call forwarding, call connecting, and call dropped can all be understood through intuitive tactile vibrations. Some of the advantages are elimination of the frustration of "talking into thin air" after a call has been dropped; fast, unmistakable understanding of call status, even in noisy environments; conversations uninterrupted by audible beeps; and more relaxed ergonomics without the static phone-to-ear position, which can be awkward and uncomfortable.

A branded haptic signature

A network's unique branded vibration that plays when the phone is opened or closed, or powered up or down, could emphasize the network's services and value. OEM brands are prominently displayed on phones, so this pneumonic could support network brand recognition. The network's "tactile jingle" may also supply a usability feature when the user can't be looking at the phone to verify it has been turned on.

Haptic intensity control

Providing the user with control over haptic intensity would personalize a very personal feature, touch interaction. With the new advantages of a haptic interface, tactile feedback intensity control is more than simply "a nice touch." It is also intelligent and sophisticated.

Ringtones

Haptic ringtones provide a new twist to a successful product. They underscore the beat or melody, supplying "the subwoofer effect" for greater entertainment. A more practical use is a silent haptic rhythm that can identify the caller even when sound is turned off or the environment is too noisy for the phone to be heard.

Haptic Messages and Alerts

Differentiated status alerts

Haptic status alerts (calendar reminders, entering or leaving the service area, low account balance, call timer, battery status, Bluetooth connect/disconnect, and push-to-talk ready and receive) can de-clutter the user's sound channel. Haptic feedback cues can clearly communicate status without beeps. Moving status alerts from the sound channel to the touch channel can help reduce cognitive load, provide additional information, and overcome usability problems associated with distractive and loud environments.

Event alerts
With haptics, users can know immediately—and privately—when the flight to Spain drops below $400, for example.

Message alerts
Rather than an annoying beep or a single-frequency vibration that does not evoke clear recognition for the user, a unique and memorable haptic alert can communicate that a message has arrived—and whether it is a text, e-mail, photo, or instant message. The arrival vibration could also convey sender identification and/or message priority.

IM presence
A subtle haptic bump can signal when a favorite IM buddy logs on.

Haptic emoticon
Users can attach a haptic vibration to pictures or text messages that communicate the emotion behind the message, for example a heart beating or laughter.

E-mail, other application prompts
Haptic feedback can be used to support user productivity for many mobile applications. As an example, an e-mail client could provide haptic alerts when an e-mail has bounced, when a message remains in the outbox, or when the address field is not filled in.

Boundary or navigation markers
Supplying page-boundary or Web page section haptic "bumps" could be used to help users interpret information on the small screen.

Sales force automation
Special vibration alerts, dispatches, and workflow notifications could be used to help sales personnel and mobile workers respond faster.

Navigation and mapping
Intuitive tactile cues can provide directions without glance time, promoting safety. Without looking at the phone, users can walk or drive and receive a pulse when it's time to turn. One pulse could mean turn right, two pulses could mean turn left. Vibrations could become faster as the user approaches their destination.

E-commerce
For mobile commerce, haptic feedback can supply unmistakable confirmations, supporting more completed transactions for vendors and a more satisfying experience, with fewer errors, for users. Haptic feedback could supply indications that information is incomplete or missing and that the transaction is in process or completed. It could also be used to accompany a notification that prices are rising or falling or that a purchased item—a ringtone, photo, or other type of content—has arrived.

Social networking
Users could be alerted with haptic feedback the moment someone in their online social community posts new content or when a picture, blog post, or buddy match is delivered to their phone.

Location-based Services
A haptic buddy finder could supply a subtle vibration when buddies are in the area. Faster vibrations could indicate the distance is closing.

Mobile advertising
Ads that arrive with arresting or amusing vibrations could provide a unique appeal to compel viewing.

Entertainment

Games
Force feedback rumble has become a common and expected feature in most video console game genres. A similar type of feedback could be used for mobile games to enliven vehicle acceleration, explosions, and sports action, as well as to signal status, taking damage, alerts, warnings, etc.

Movie trailers, videos, mobisodes
Unlike other types of entertainment, users are holding the device (the screen) in their hand. Haptic feedback used to underscore the action of a volcano, motorcycle, or door slam could help make the small screen more engaging, fun, and exciting.

Haptics can give mobile gamers an experience similar to the rumble action expected in video console games.

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Contact Immersion at VibeTonzInfo@Immersion.com for a list of URLs where these research papers can be downloaded or purchased.

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Founded in 1993, Immersion Corporation is a recognized leader in developing, licensing, and marketing digital touch technology and products. Using Immersion's advanced touch feedback technology, electronic user interfaces can be made more productive, compelling, entertaining, or safer. Today, Immersion is truly the expert in the design and control of haptic feedback for user interfaces. Core competencies include our understanding of how interactions should feel and our knowledge about which solution would best achieve that feeling. We have designed vibrotactile actuators and firmware solutions that meet accuracy, resolution, latency, frequency, cost, and power requirements for mobile and other applications. Our inventions also include many generations of authoring tools for creating, visualizing, modifying, archiving, and experiencing haptic feedback. Immersion's patent portfolio includes over 700 issued or pending patents in the U.S. and other countries.

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