Sound in the Interface to a Mobile Computer

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1 Introduction

Mobile telephones, Personal Digital Assistants (PDAs) and handheld computers are one of the fastest growth areas of computing. One problem with these devices is that they have a limited amount of screen space: the screen cannot be large as the device must be able to fit into the hand or pocket to be easily carried. As the screen is small it can become cluttered with information as designers try to cram on as much as possible. In many cases desktop widgets (buttons, menus, windows, etc.) have been taken straight from standard graphical interfaces (where screen space is not a problem) and applied directly to mobile devices. This has resulted in devices that are hard to use, with small text that is hard to read, cramped graphics and little contextual information.

One way to solve the problem would be to substitute non-speech audio cues for visual ones. Sound could be used to present information about widgets so that their size could be reduced. This would mean that the clutter on the display could be diminished and/or allow more information to be presented. This must be done in a way that maintains usability otherwise these smaller widgets will render the device unusable.

There has been little previous research directly in the area of sound in mobile computing devices. Some research has been done on different selection techniques using a pen and graphical display on mobile devices (Ren & Moriya, 1997) but not using sound. Research at Glasgow has demonstrated the effectiveness of sound in desktop widgets (Brewster, 1998) but not so far in mobile devices. The work reported here brings these together.

2 Experiment

An experiment was conducted to investigate the affect that sound would have on the interaction with on-screen buttons in a mobile computing device. Sixteen participants from the Computing Science Department at Glasgow were used. The selection was made up of postgraduate and undergraduate students and staff, nine male and seven female, all between the ages of 21 and 45.

The experiment used a fully counterbalanced, two-condition, within-groups design. The independent variables were button size and sound type. There were two conditions: standard (16x16 pixels) and small (8x8 pixels) buttons (see Figure 1). Both of these sizes are commonly found on PDAs. There were two 7-minute treatments in each condition: visual only buttons and visual plus sound.

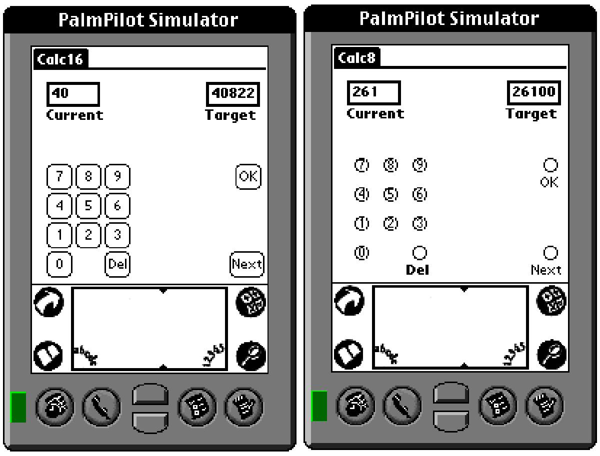

Figure 1: Screenshots from the large and small buttons conditions.

The experiment was run on a 3Com PalmIII handheld computer with input via a stylus. The task the participants had to perform was similar to that of Brewster *et al.* (1995). Participants had to enter a series of five digit strings (shown in the target window in Figure 1) using the numeric keypad. After each digit had been tapped the OK button had to be pressed to confirm it. The numbers appeared in the window labelled ‘Current’.

The dependent variables were subjective workload (using the standard NASA TLX workload test) and number of strings entered. Together these gave a good quantitative and qualitative measure of usability. Training was given before each part of the experiment began and NASA TLX workload scales were completed after each treatment.

The main hypotheses were:

- Subjective workload would be reduced in both conditions when sounds were present as participants would receive information they needed to operate the buttons more effectively. This would be demonstrated by a reduction in the NASA TLX workload scores.
- The efficiency of button use would increase in both conditions when the sounds were present because the sounds would allow users to hit the buttons more easily and know when they had mis-clicked them. This would be shown by an increase in the number of strings entered.

The sounds used in the study were *earcons* (Blattner *et al.*, 1989). These are structured non-speech sounds that have been investigated in detail by Brewster (1998). Three earcons were used based around those of Brewster *et al.* (1995). Results from a previous experiment by Brewster & Cryer (1999) showed that sophisticated sounds were more successful at improving usability than simple ones. The standard PalmIII keyclick sound was used to indicate pen release on a button. A second sound indicated pen down on a button. This signified that users had hit the target (especially important for small targets) and was a higher pitched version of the basic sound. Finally, a sound was played if the user mis-hit a button – again common if targets are small and hard to hit (Brewster *et al.*, 1995). This was a lower pitched version of the basic sound. The earcons were all simple as the Palm's audio capabilities were restricted.

3 Results

The results of the subjective workload tests can be seen in Figure 2. Each was scored out of 20 and *T*-tests were used for the statistical analysis. Results for the large buttons showed that in all cases (except for time pressure) the sonically-enhanced buttons reduced workload. This confirmed the hypothesis. Time pressure was identical for both treatments so no change was expected.

For example, mental demand was significantly reduced (T_{15}=3.81, p=0.001), as was annoyance (T_{15}=2.38, p=0.03) and overall preference was significantly increased for the large buttons with sound (T_{15}=3.40, p=0.004). Due to lack of space all the results cannot be reported here.

For the small buttons the results were again in favour of sound - workload was significantly reduced in all of the categories except for physical effort and time pressure. This again confirmed the hypothesis.

For example, effort expended was significantly reduced (T_{15}=5.80, p=0.00003) as was frustration experienced (T_{15}=4.99, p=0.0002) and subjective performance achieved was significantly increased (T_{15}=4.01, p=0.0011) for the small buttons with sound.

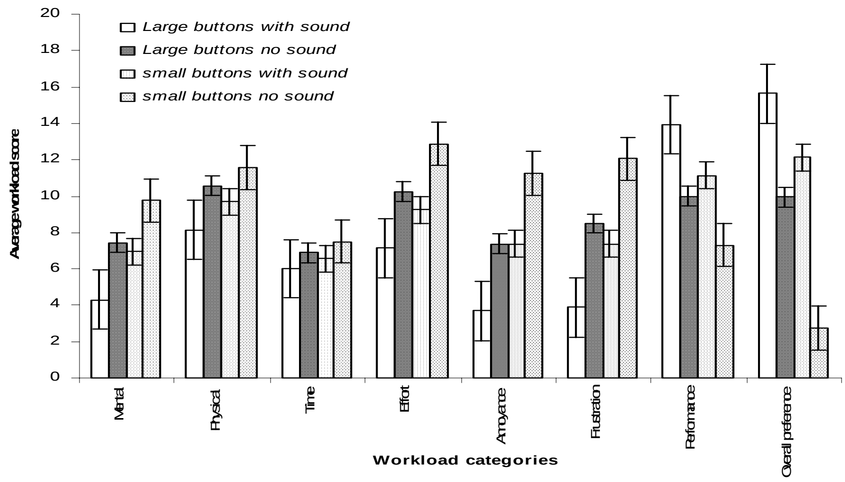

Figure 2: Average NASA TLX workload scores for the two conditions and two treatments. For the first six categories higher scores mean higher workload, for the final two higher scores mean lower workload. Standard error bars are shown.

The quantitative results can be seen in Figure 3. This shows the number of 5-digit strings that were entered in each of the treatments. The results show that in both of the sound treatments performance was very significantly improved (large buttons: T_{15}=9.22, p=0.0000001, small buttons: T_{15}=7.79, p=0.000001).

4 Discussion and Conclusions

The results from the experiment show that sound can have important effects on usability in mobile computing devices. The qualitative results show that sound had a big effect on workload for both button sizes. In almost all of the categories workload was significantly reduced when sound was present. The results also showed that the sounds did not annoy the participants, in fact they rated the annoyance as significantly less when sounds were present. They also rated the sounds as preferable to the silent buttons. This indicated that sound can improve the qualitative experience users have with mobile devices.

The quantitative results also back up the hypothesis that sounds will improve usability as participants were able to enter significantly more strings when sounds were present for both button sizes. The sounds helped users target the buttons better, know when they had been pressed correctly and when they had been mis-hit. This made them significantly easier to operate.

These results give designers a simple way to increase the usability of buttons (one of the most common widgets) in mobile devices. This work also indicates

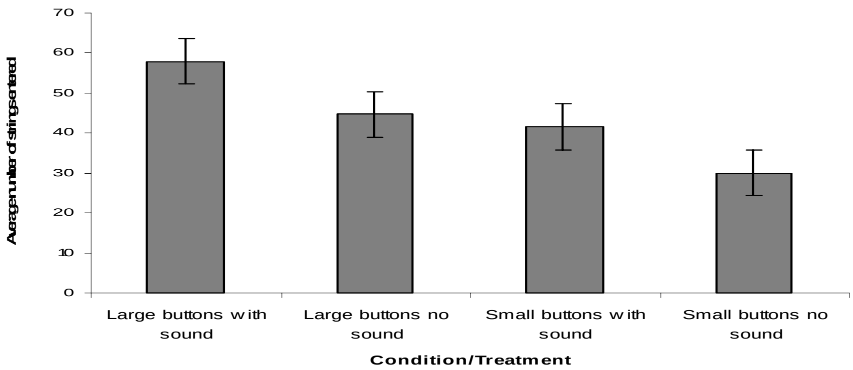

Figure 3: Average number of strings entered. Standard error bars are shown.

that the research carried out on sound in desktop widgets (Brewster, 1998) can be applied to hand-held devices and show the same benefits.

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5 References

All references by Brewster can be found at http://www.dcs.gla.ac.uk/~stephen

Blattner, M., Sumikawa, D. & Greenberg, R. (1989). Earcons and icons: Their structure and common design principles. *Human Computer Interaction*, 4 (1) 11-44.

Brewster, S.A. (1998). The design of sonically-enhanced widgets. *Interacting with Computers*, 11 (2), 211-235.

Brewster, S.A. & Cryer, P.G. (1999). Maximising Screen-Space on Mobile Computing Devices. *To appear in Summary Proceedings of ACM CHI'99*, Pittsburgh,: ACM Press Addison Wesley.

Brewster, S.A., Wright, P.C., Dix, A.J. & Edwards, A.D.N. (1995). The sonic enhancement of graphical buttons. In Nordby, Helmersen, Gilmore & Arnesen (Eds.): *Proceedings of IFIP Interact'95*, (pp. 43-48), Lillehammer, Norway: Chapman & Hall.

Ren, X. & Moriya, S. (1997). The best among six strategies for selecting a minute target and the determination of the minute maximum size of the targets on a pen-based computer. In Howard, Hammond & Lindfaard (Eds.), *Proceedings of IFIP Interact'97*, (pp. 85-92), Sydney, Australia: Chapman & Hall.