MENU SONIFICATION IN A MOBILE PHONE - A PROTOTYPE STUDY

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Nokia Mobile Phones

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ABSTRACT

We have studied the effect and acceptance of a sonified menu structure in a mobile phone. In this experiment, mobile phones with a special software were given to test users for a period of three weeks. Sonification design was done using earcons, and it covered the whole menu structure, except the Services and Phonebook applications (the structures of which are dynamic, not predefined). Test users were able to adjust sonification parameters – depth of sonification in the menu, and loudness of the sounds. Data was collected using questionnaires and interviews before, during and after the test period, and some laboratory experiments were performed after the test period.

The main focus of the study was in the subjective reactions of the users, but we also tried to collect some objective data. We will report the findings in this paper.

1. INTRODUCTION

The works is largely based on previous studies conducted by Leplâtre and Brewster at the University of Glasgow on user interface sonification in computers and mobile phones. [1, 2]. In previous works, effects of sonification have been tested in laboratory conditions, using computer simulations of user interfaces. In this test, we wanted to give users something closer to a real product for an extended period of time, hoping that it would more closely resemble actual usage, and then collect data about effects of the feature on usability, as well as subjective opinions.

1.1. Mobile Phone User Interfaces

The common way to access various functions in a mobile phone is to use a menu feature. The menu is arranged hierarchically so that the number of available items in a single selection list can be kept within reasonable limits, and to guide the user logically through various features in the phone.

While navigating, the menu of a typical modern mobile phone gives feedback in the form of texts and graphics (icons). Sounds are not used except for keypad tones, which are the same regardless of the context or the key pressed.

The Nokia brand phones have a feature called Profiles, which allows the user to define different sets of phone settings to be used in various usage contexts, like outdoors, meetings or home. Most of the settings controlled by the Profiles are related to phone sounds – ringing tones, alert tones, keypad tones and so on.

1.2. Improving Navigation with Non-Speech Sounds

Telephone-based interfaces such as mobile phone menus offer by nature a very basic form of interaction. Because the size of the screen prevents the menus to offer as much graphical feedback as desktop menus do, and because the menus involved can feature several hundred nodes, users can easily lose track of their actions while navigating.

Several studies indicate that non-speech sounds have a potential for improving navigation in hierarchical menus [3, 4]. A subsequent study by Leplâtre and Brewster showed that non-speech sounds did increase the performance of various complex navigational tasks in a mobile phone menu [2].

The present study illustrates how the design of sounds had to be accommodated to both meet the technical requirements of the device and respect our initial design principles.

2. DESIGN OF THE SOUNDS

2.1. Design Principles

The design of the sounds has been inspired by those used in the simulation presented in [2], according to several principles. These principles are based on a study of navigation requirements:

1. Use non-speech sounds to increase the perceptive difference between fundamental menus. This principle aims at emphasize the semantic differences between the main menu items.
2. Use non-speech sounds to notify depth changes while navigating in the menu hierarchy. In a standard desktop menu such as that of Figure 1, the depth (or level) in the hierarchy is obvious, since all the parent menus remain displayed. The present principle aims at compensating for the absence of such information by conveying information regarding the depth in sound.
3. Use non-speech sounds to supply information regarding the relative position of the current menu within a list of menus. In the menu represented in Figure 1 users would not necessarily remember a stream of menu names (*Filter, Sharpen, Sharpen Edges*) to retrieve the item *Sharpen Edges*. Graphical elements such as the vertical and horizontal coordinates of the item and its parents constitute essential contextual cues. Again these graphical cues lack in a visually restricted interface and the current principle aims at supplying such information in sound.
4. Use non-speech sounds to provide information regarding the size of the branch of which the current menu is the root. This principle differs from the two previous ones in the sense that it does not intend to compensate for a lack of graphical information, but to take advantage of the audio medium to supply pieces of information that do not exist in desktop menus. Providing an approximate idea of a menu content size can be beneficial to users whilst carrying various navigational tasks.
5. Respect the continuity and homogeneity of the sonification. This principle addresses the aesthetical issues regarding the design.

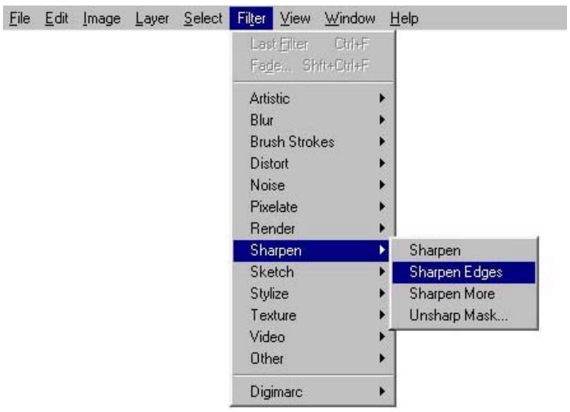

Figure 1. *A standard graphical desktop menu.*

2.2. Technical Constraints

The design of the sound was subject to very constraining technical limitations. With the standard hardware and middleware, we were only capable of producing sounds through a very basic pulse synhesizer driving a buzzer. These constraints, as well as the implications these have on the application of the design principles described above, are summarized below:

- **Single instrument**: the only sound available in the synthesizer was a normal buzzer tone. The timbre of the tone *i.e.*, the properties of the square shape of the signal cannot be modified. The fact that only one instrument was available was a serious limitation in the design. Indeed the preferential means to implement the first principle of the previous section involves using distinct timbres or musical instruments to emphasize the semantic differences between the principal menus. As a consequence, it was more difficult to design sounds that represent clearly distinct categories.
- **Limited perceptive character of the sounds:** Buzzer tones are widely used to provide brief audio feedback in many mobile devices. This fact is not a matter of aesthetical choice but is the direct consequence of technical limitations. In today's consumer products the audio quality is improving, providing a greater variety of more subtle tones than basic beeps (sonification sets provided with Microsoft Windows operating systems for example). Consequently, the shift in users expectation regarding the timbres used in a complex sonification is likely to affect the subjective appreciation of the present sonification.
- **Poor control over the sounds:** Not only was there only a single instrument available, but the control allowed over it was extremely limited:
  - Limited volume control: five volume levels were available and the volume cannot be modified within a motif.
  - No control over the envelope**.**
  - No control over the timbre.
  - No dynamic control. The synthesis parameters of the sounds were determined before the sound were played. Once a sound has started, its parameters (including pitch and volume) could not be modified.
- **Monophonic:** this constraint prohibited the performance of chords. This is a serious limitation as it forces all the notes to be played sequentially, which implies that only basic audio messages can be played in a brief interval of time.
- **Limited pitch range:** only a narrow frequency range was available: 440 to 2096. This prevented us from using any low register note. The register available extends on over two octaves.

2.3. Overcoming the Technical Constraints

Because of the technical constraints described in the previous section, the possibilities available to apply the design principles proposed in 2.1 were very limited. In particular the design carried out in the study described in [2] could not be used directly. Consequently, we had to undertake the implementation of our principles from a drastically different point of view.

If the present study allowed us to move forward as far as understanding the impact of sounds in mobile devices was concerned, we certainly had to move back in time to design the menu sounds. Indeed our technical constraints were very similar to those that sound designers had to face two decades ago when they designed computer game sound effects and background music. The easily identifiable aesthetical qualities of the soundtracks of games developed for Amstrad or Atari platforms in the early eighties illustrate the sonic world in which our design had to take place. *Audio 1*[1] gives a concrete illustration of this aesthetical style.

In dealing with the constraints, we have examined the design parameters available:

- **Melodic**: contour is the most obvious parameter to use in this context. The sound generator being monophonic, brief melodies are the only auditory structures one could deal with. Unfortunately, in very limited intervals of time it is only possible to design basic melodic structures
- **Harmonic**: sound progressions can be implemented with harmonic progressions. Harmonic differences can also be used to emphasize semantic differences between menus (*e.g.*, to implement the first principle mentioned in 2.1).
- **Rhythm, meter and tempo**: The scope for action is very narrow with regards to the temporal aspects of the design, for two reasons. Firstly there is not much space for the designer to convey a strong sense of rhythm in the very short time allocated to each sound. Secondly, the true rhythm and tempo of the sonification are imposed by the user. They correspond to the rhythm and tempo at which he/she presses the keys to navigate in the menu. Imposing an interaction tempo and a rhythm which might risk to be in conflict with the user's is a typical recipe for annoyance.

From the description of the design parameters available it is clear that the emphasis had to be put on the syntactic relations between sounds. A previous study showed that syntactic differences between sounds (all the sounds played with the same instrument) could be used successfully to locate these sounds in a 24-node hierarchy [1].

Concerning monophony, which is a costly limitation considering the time constraint, we have attempted to overcome the problem by using *pseudo-chords*. Pseudo-chords can be defined as arpeggios played rapidly. This technique is similar to that of a violinist attempting to play a chord on more than two strings. This was possible because the duration of a note played by the phone synthesizer could be as short as 25ms. To illustrate this idea, *Audio 1* shows how the polyphonic fragment of *Audio 2* can be adapted in a pseudo-polyphonic, yet monophonic fashion. The notion of pseudo-polyphonic is in fact a simple consequence of the fusion/segregation phenomenon which has been comprehensively investigated by Bregman [5, 6].

2.4. Sonification Levels

In a previous study, we introduced the idea that providing different degrees of sonification would prove beneficial [2]. We have developed several sonifications to illustrate this idea, and the fourth one was chosen to be implemented in the mobile phone prototype.

- **Set I**: The first set is a trivial sonification in which all the sounds are identical. This level of sonification is only mentioned to highlight the progression between most of today's mobile phone menu sonifications and more sophisticated ones described below.
- **Set II**: In the second set each main menu is represented by one minimal sound *e.g.*, one note. Each main menu sound is then used everywhere within its submenus.
- **Set III**: In this sonification the motifs used are distinct for each main menu, and also across subsequent submenus.
- **Set IV**: This set uses the same paradigm as above and, the size of the menus is also taken into account to design the sounds.

2.5. The Sonification

The first part of the design consisted in creating a sound for each main menu item. Figure 2 shows the final motifs chosen for the eleven main menu items. The structure of each sound reflects the size of the menu the sound is associated to, as recommended by the fourth principle in 2.1. It appears on Figure 2 that the motifs can be grouped in three distinct categories regarding the size of the menus to which they are associated: motifs 6, 7, 8, 9, 10 and 11 represent small menus which should not cause any problem as far as navigation is concerned; motifs 1, 2 and 5 represent menus of intermediate sizes (between 20 and 40 nodes); motifs 3 and 4 represent the largest menus (over 50 nodes). The structure of the sounds results in a natural decomposition of the stream of motifs as follows: [1,2],[3,4],[5],[6,7,8,9,10,11], which partially meets the requirements of the first principle proposed in 2.1. The continuity and homogeneity of the main menu sonification (addressed by the fifth principle in 2.1) has been achieved by basing the musical movement of the main menu stream on a pentatonic scale represented on Figure 3. The first five motifs are based on an ascending progression on that scale whereas the last six are based on a descending movement on that scale.

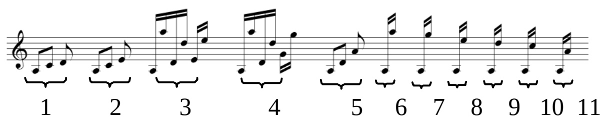

Figure 2. *Main menu sounds (cf Audio 3).*

We used the same approach for the design of the submenu motifs. The second and fourth principle (cf. 2.1) were implemented jointly by reducing the density of the motifs when the depth in the hierarchy increased. The third principle was also respected since the list of menu items were mapped to a progression based on the pentatonic scale. The second level from the top on Figure 4 illustrates this point: when the list of menus are played from right to left, the sounds played follow an ascending movement based on the pentatonic scale. Figure 4 represents the complete sonification of the first menu of the phone: *Messages*.

To reinforce the difference between the levels, we have also modified the duration of the motif notes. This was particularly important for the motifs located at the bottom of the hierarchy, for they are identical to their father. Therefore the duration of the notes of each motif was set as follows:

- Level 1 (that of *Messages*): 96ms
- Level 2: 64ms
- Level 3: 48ms
- Level 4: 32ms

These values were used for all the menus of the hierarchy. Deeper menu motifs (Level > 4) were all designed with 25ms notes, which was the smallest possible duration for the synthesizer.

[1] Audio examples played at the conference. These are available on request to the authors.

Figure 3. *Pentatonic scale on which the main menu motifs design is based (cf Audio 4).*

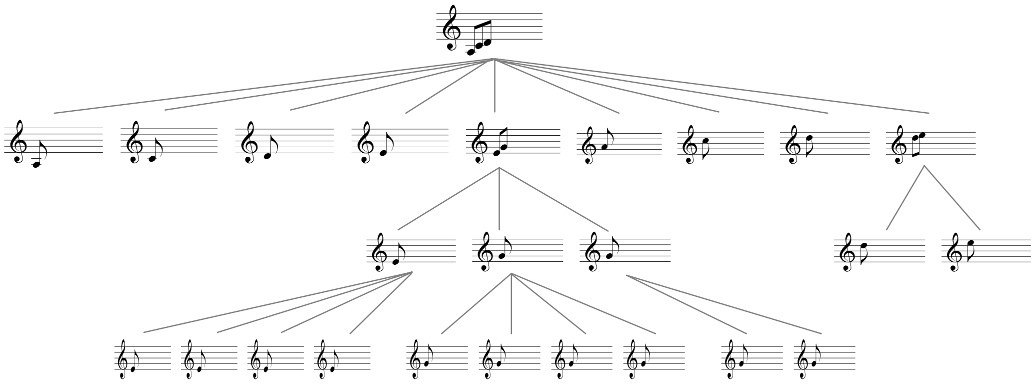

Figure 4. *Sonification of the Messages menu.*

3. THE EXPERIMENT

3.1. Hypotheses

The hypothesis about the advantage of menu sonification is that the user gets additional information about navigation when there are sounds related to the current context, helping them in knowing where they are within the menu structure. A specific assumption is that it should be noticed more easily when a misnavigation has occurred, as the tone sequence differs from the one the user expected to hear.

A negative kind of hypothesis (particularly with this implementation with the limitations of the buzzer output – see the Test Platform chapter below) was that people might think the sounds are annoying, especially in quiet public places or in office environment.

We did not try to study a possible time advantage in navigation. There is some evidence of this in prior work by Leplâtre and Brewster [2].

3.2. The Test Platform

Mobile phones of the type Nokia 8210 were used as the test platform. A custom software was written, allowing the sounds whose design has been described in Section 2 to be added to

- **Messages**
  - Inbox
  - Outbox
  - Write messages
  - Picture messages
  - Message settings
    - Set 1
    - Message centre number
      - Messages sent as…
      - Message validity
      - Rename this set
    - Set 2
      - …(as above)
    - Common
      - Delivery reports
      - Reply via same centre
  - Info service
  - Fax or data call
  - Service command editor
  - Voice messages
    - Listen to voice messages
    - Voice message number
- **Call register**
  - Missed calls
  - Received calls
  - Dialled number
  - Erase recent call lists
  - Show call duration
  - Show call costs
  - Call cost settings
- **Profiles**
  - General
    - Activate
    - Personalise
      - Incoming call alert
      - Ringing tone
      - Ringing volume
      - Vibrating alert
      - Message alert tone
      - Keypad tones
      - Warning & game tones
  - Silent
    - … (as above)
  - Meeting
  - Outdoor
  - Pager
  - Headset
- **Settings**
  - Alarm clock
  - Clock
  - Auto update of time and date
  - Call settings
    - …
  - Phone settings
    - Language
    - …
    - Menu tones
    - Network selection
  - Security settings
    - …
- **Call divert**
  - Divert all voice calls
  - Divert when busy
  - Divert when not answered
  - Divert when off coverage
  - …
- **Games**
  - …
- **Calculator**
- **Calendar**
- **Infrared**
- **Services**

Figure 5. *Menu structure of the test phone. Some submenus have been omitted from the list.*

the nodes of the menu hierarchy. The differences from the standard software for the phone type were limited to the added audio feedback, and to one new setting which allowed the user to control the presence of menu tones: the tones could be set to work in five different menu depths from the first level (main menu) down to fifth level, or turned completely off. The loudness of the tones could be adjusted using the keypad tones setting within the Profiles feature (off, levels 1-3). This control exists in standard software as well. In this case it just had the additional effect of controlling the menu tones.

The audio was reproduced using the buzzer in the phone. The buzzer is the component used to play the ringing tones and other loud tones of the phone. There are limitations with buzzers: the frequency response is very uneven; loud tones can only be produced at certain narrow bands, and they can only play one frequency at a time. Polyphonic sounds are not normally achievable. The transducer is driven with a signal that consists of pulses; the pulse width is used to control loudness. (There are ways to produce more wide-band and polyphonic sounds by specific modulation techniques, but those are not possible with the standard hardware we used.). The implications of such constraints on the design of the sonification have been described in Section 2.

3.3. Test users

There were 17 test users, 7 males and 10 females, aged from 24 to 45. All were Nokia employees working in office environment in various occupations, and experienced mobile phone users.

3.4. The Experiment Procedures

Each user was given a phone for personal, daily usage for a period of three weeks. The start briefing advised the users to use the test phone just like their own. The briefing mentioned the “menu tones” feature and gave instructions for adjusting the sounds, however, without any advice about when and how to make use of the feature. Menu tones were on (full depth, keypad tones level 1 or 2) when the users received the phones.

At the beginning of the test, users filled in a questionnaire about personal phone usage patterns. During the test period, a few questions were sent by e-mail e-mail, concentrating on the menu tones and profile settings.

After three weeks, the phones were collected back. At this time there was another questionnaire about usage patterns with the test phone. We had a short oral interview with each test user, in which their experiences and subjective feelings were discussed. As a more objective part in the interview, sequences of menu tones were played to those users that had had the tones mostly on during their test period, and they were asked if they could recognized them. This gave us some information about how well users were able to utilize the added feedback.

3.5. Results

Start questionnaire: A finding in the start questionnaire that has an obvious connection to this study is that 10 users (59%) had their keypad tones normally turned off in their own phones. It indicates the tones can be regarded as disturbing enough to make it worthwhile to change the setting, even though the tone quality is softer for keypad tones than the menu tones in the test software. It should be noted here that the menu tones setting was connected to the keypad tones, so it was not possible to turn keypad tones off while keeping menu tones on.

The following phone features (apart from voice calls) appeared to be the most used ones:

	A	B	C	D
Text msg receive	15	2	0	0
Text msg send	14	3	0	0
Check missed calls	11	6	0	0
Alarm clock	10	0	5	2
Change profile	6	7	1	3

Table 1. *A = daily; B = a few times a week; C = a few times a month; D = rarely or never. Numbers indicate the number of persons.*

Users’ relation to music was asked also. Six persons had been active in music (playing or singing themselves) whereas two reported as not having any specific interest in music.

Intermediate questions: After a few days’ use we asked by e-mail how test users had modified the settings of their phones. Most had changed ringing tones and other tone settings in Profiles. Roughly half of the persons had turned off menu tones (keypad tones) either completely or at work. In general they were considered as too noisy in the office, and in a few cases the user admitted keeping the tones on because it was a test. One user who had turned the tones off in the general profile told he had found them useful with headset while driving.

End questionnaire: At the end of the test period, each user filled another questionnaire. It included an identical section about feature usage as the start questionnaire; it showed similar results, indicating that test phones were used in the same way as respondents’ own phones.

The section about tone settings indicated that menu tones (or keypad tones) were turned off in 9 users’ primary profile. Some users had them on in another profile that was used at home, outdoors or somewhere else.

Other questions concentrated on the menu tones, and the responses can be summarized as follows:

What was your first impression of the Menu tones feature?

For seven persons the first impression was disturbing or annoying, six considered sounds first funny or amusing. One thought about it as a “new marketing gimmick”.

Did you find menu tones annoying, and if so, in what kind of situations?

Practically all considered the sounds disturbing in places where others are present, especially in situations like meetings, but also in public places, trains or buses. Functions like locking the keypad (which requires entering the menu) were reported as causing too much noise. Silent profile was used more often than usually.

How would you judge the sounds from aesthetics/musical point of view?

Answers to this question were quite diverse. Descriptions like ‘high-pitched’, ‘sharp’, ‘irritating’ were used as well as more neutral or positive terms. It is difficult to find any correlation to users’ interest in music, but the few positive comments all came from musically experienced persons.

Your opinion of the lengths of sounds?

About half of the users considered the sounds too long especially in the beginning of the main level. Five users replied ‘OK’ or ‘fine’, however.

How well do you think the sounds were suited to corresponding features?

Twelve of the users either did not reply, or the answer could be classified as ‘did not notice the association of tones and features’. A few had more negative feelings, but two users commented positively about the sound sequence in main menu.

Do you think the menu tones feature affected your use of profiles, or had some other effect on your phone usage?

Eleven users did not think it affected their usage at all. Two reported that they used Silent profile more often, and this could actually have happened with some of the others too. One user said that phone usage was sometimes postponed until at a better situation (in order to not disturb others).

Did you find menu tones useful? In what way?

Eleven users did not find the tones useful. One considered them a fun feature. Four users found something useful to mention: "Maybe hearing the tones helped in 'surfing' the menu." "Maybe helps in the long run when feature & sound pairs get memorized." Possible benefits for visually disabled users were mentioned, and one user found the tones useful when having a headset on. (Headsets were not given with the test phones.)

Interview: An informal interview followed the end questionnaire. We discussed the issues that seemed approriate with each user, based on the questionnaire data. The following comments are collected from these interviews.

Many users turn even the subtle keypad tones off in normal use, so it should not be a surprise that most users did not want the menu tones played in everyday usage and had them turned off in their primary profile. One user considered the tones as disturbing as a ringing phone when in a meeting. Some users got comments about a strangely beeping phone from other persons in the office.

Three persons thought children or teenagers might be fond of the sounds. A few also mentioned visually disabled persons as potential users. Three persons commented that the tones might be useful while driving – although playing with a phone in that kind of situations should not be encouraged in general.

There were two users that found some clear benefit in the sounds: “Sounds helped browsing the menu, I could recognize the sounds.” “I learned the sequences and knew how to go to a certain place.” One of them used the sounds mostly with a headset in a car, and he reported that sound nuances could be perceived better with the headset. Headset also prevents sound radiation, helping to minimize the disturbances.

Experiments: We did some experiments with the users that had used the tones most of the time.

Sequences of menu tones were played to those users, and they were asked if they could recognize the sequences. The most used features were used as targets, and sometimes we would go somewhere close but not to the ‘correct’ place. The *Write new message* item was an easy target, having a short menu path, and a few users were able to recognize it seemingly easily. However, in most cases the users responded by saying for example “Sounds really familiar” but were not really sure about it. The number of tests was so low, and the experiment method so informal, that we would not draw any reliable conclusions based on them.

Two users did a number of navigation tasks with tones on and off. The tasks were recorded on video, but no difference was found in the error rates or execution times.

4. CONCLUSION

The work reported in this paper allowed us to progress in different aspects of the sonification of devices with restricted graphical display and audio output capabilities. We have demonstrated that the principles used to design a mobile phone sonification in an ideal audio context (cf Leplâtre and Brewster’s previous study [2]) are flexible enough to be applied, even with very limiting audio constraints.

In the user study, it was clearly indicated that the prototype implementation of sounds was not well suitable for regular usage as it was considered too disturbing by most users. A more sophisticated sound reproduction system would be needed, and sound radiation should be limited by some means, or the sounds should be restricted to certain usage situations. However, we received also signs of usefulness from a few test users. Those may encourage developing the concept further.

5. ACKNOWLEDGEMENTS

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