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Using Compound Earcons to Represent Hierarchies

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ABSTRACT

Previous research on non-speech audio messages called *earcons* showed that they could provide powerful navigation cues in menu hierarchies. This work used *hierarchical* earcons. In this paper we suggest *compound* earcons can provide a more flexible method for presenting this information. A set of sounds was created to represent the numbers 0-4 and dot. Sounds could then be created for any node in a hierarchy by concatenating these simple sounds. A hierarchy of four levels and 27 nodes was constructed. An experiment was conducted in which participants had to identify their location in the hierarchy by listening to an earcon. Results showed that participants could identify their location with over 97% accuracy, significantly better than with hierarchical earcons. Participants were also able to recognise previously unheard earcons with over 97% accuracy. These results showed that compound earcons are an effective way of representing hierarchies in sound.

INTRODUCTION

In a previous experiment Brewster *et al.* [2] showed that structured audio messages could provide navigational cues in situations where graphics were not usable, for example telephone-based interfaces such as phone banking, or interfaces for blind and partially-sighted users.

In this previous work hierarchical earcons were used to represent the structure [1, 3]. By manipulating sound parameters such as instrument, rhythm and tempo sounds were constructed to represent a hierarchy of four levels and 27 nodes, (see Figure 1) [2]. However, hierarchical earcons have problems. Making the hierarchy from Figure 1 deeper than four levels is difficult because once the parameters described have been used then there is nothing left to manipulate to create new levels. How can this problem be solved? It was decided that compound earcons [1, 3] could be used if the hierarchy was represented in a different way. Compound earcons use short sounds for small components that can be concatenated to create longer messages. The idea of a book was used to represent the hierarchy, with chapters, sections and subsections, for example Chapter 1, Section 1.1, Sub-section 1.1.1. Figure 1 shows how this was mapped on to the hierarchy.

A set of simple sounds was created for each of the numbers and dot. The earcon for any node could then simply be constructed from the concatenation of these sounds. This method of representing the hierarchy had the advantage that, with a complete set of sounds to represent the numbers, any hierarchy of arbitrary size and depth could be created, overcoming the problem with hierarchical earcons. An experimental investigation was needed to assess the effectiveness of this method.

EXPERIMENT

The same hierarchy used by Brewster *et al.* [2] was used again so that the results could be compared (see the previous experiment for more details). Fifteen participants were used.

The main hypothesis was that participants would be able to recall their position in the hierarchy with the same accuracy as in Brewster *et al.* [2]. Participants should also be able to listen to an earcon and position it in the hierarchy even if they have not heard it before by using the rules from which

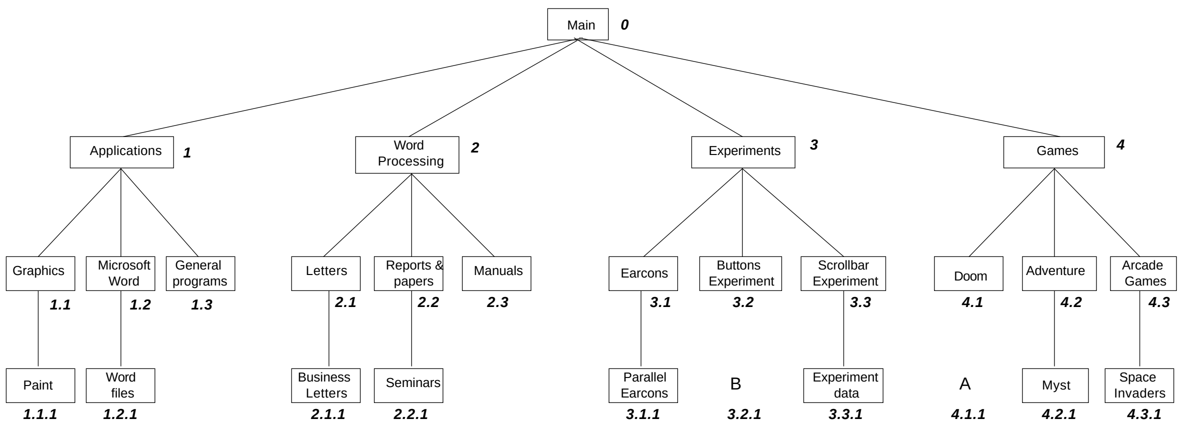

Figure 1: The hierarchy used in the experiment. The numbers by each node show the position in the hierarchy. A and B mark the new earcons presented to the participants during testing.

the earcons were constructed. This would be demonstrated by high rates of recognition when participants were presented with new earcons.

Training and testing were the same as in Brewster *et al.'s* previous experiment so that the results could be directly compared. Participants had the set of sounds described to them once and then had five minutes to learn the sounds themselves. During testing the same set of 14 questions was used as in Brewster *et al.'s* experiment. This included the new, unheard earcons for nodes A and B shown in Figure 1.

Sounds used

Simple sounds were constructed to represent the numbers 0-4. These were single notes (1 sec. duration) played at C_3 (261Hz). They were created on a Yamaha TG100 synthesiser and played back via HyperCard. The sound for 0 was a sitar, 1 was a piano, 2 an orchestral hit, 3 a bell, 4 a flute and marimba for dot. These instruments were chosen because each one sounded distinctive and different from all of the others. Earcons for each node in the hierarchy were created by concatenating the required sound components.

For numbers greater than 4 the instruments would be re-used but the note played two octaves higher. For example, 5 would be a note played at C_1 (1046Hz) on the sitar. For numbers greater than 9 the two motives would be added together, for example 10 would be a piano followed by a sitar. This would allow the differentiation of 11 from 1.1 because 11 would not have the separator dot between the two piano notes. Thus there were five sounds for 0-4, a rule indicating 5-9, and a sound for dot. This meant that the total number of rules was within the range of 7±2 making them as easy to remember as possible.

RESULTS

The overall recall rate of the 12 trained earcons was very good, with 97% recalled correctly (see Figure 2). This was significantly better than the 80% recall rate in [2] ($F_{1,22}$=13.89, p=0.001). The results indicated that compound earcons were a successful method of presenting hierarchy information. The recognition rate of the new, unheard earcons was also good with an average of 97% again recognised correctly (questions 13-14 in Figure 2). This indicates that participants could recognise the new compound earcons well.

DISCUSSION

This new design for the earcons was significantly better than the hierarchical earcons in Brewster *et al.* [2], indicating that compound earcons can provide effective navigation information in hierarchies of information. The advantage of using this type of earcons is the possibility of creating arbitrarily sized hierarchies The results also showed that new, unheard earcons could be recognised by the listeners with a high degree of accuracy. This is important as it means that users could understand new sounds without being trained on them.

One problem that compound earcons have is that they get longer the deeper one gets into the hierarchy. This may cause several problems. The first is that the user has to listen to the full earcon before he/she gets the location

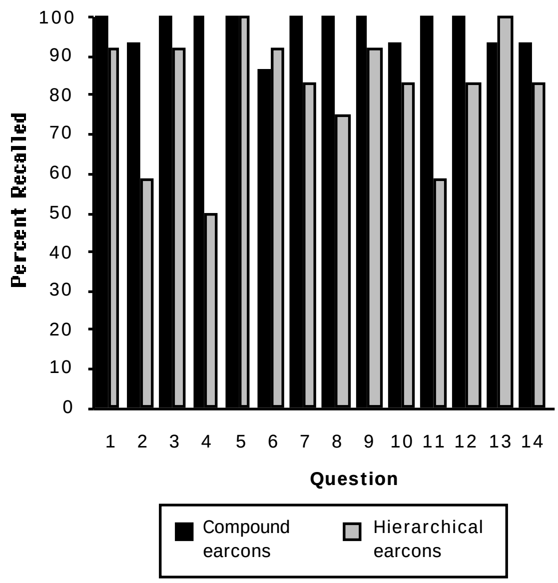

Figure 2: Recall rates for the compound earcons in this experiment compared to the hierarchical ones from Brewster et al. [2]. Questions 1-12 are the trained earcons and 13-14 are A and B, the new earcons.

information. If only part of the earcon is heard, for example the user is on node 1.1.1 but decides to move on after hearing only 1.1, then he/she may become confused about the location. In addition, the longer the sound gets the harder it is to recall. The user will remember the latter parts of the earcon but forget the former, again leading to confusions about location. Part of the problem of the length of compound earcons has been addressed by *parallel earcons* [4]. These allow the component parts of a compound earcon to be played simultaneously, rather than sequentially. Initial results with compound earcons look very promising but more investigations are needed to find the maximum size of hierarchy that could be represented with such sounds.

REFERENCES

Sound samples and references by Brewster are available from http://www.dcs.gla.ac.uk/~stephen/

1. Blattner, M., Sumikawa, D. and Greenberg, R. Earcons and icons: Their structure and common design principles. *Human Computer Interaction* 4, 1 (1989), 11-44.
2. Brewster, S.A., Raty, V.-P. and Kortekangas, A. Earcons as a method of providing navigational cues in a menu hierarchy. In *Proceedings of BCS HCI'96* (London, UK) Springer, 1996, pp. 169-183.
3. Brewster, S.A., Wright, P.C. and Edwards, A.D.N. An evaluation of earcons for use in auditory human-computer interfaces. In *Proceedings of ACM/IFIP INTERCHI'93* (Amsterdam) ACM Press, Addison-Wesley, 1993, pp. 222-227.
4. Brewster, S.A., Wright, P.C. and Edwards, A.D.N. Parallel earcons: Reducing the length of audio messages. *International Journal of Human-Computer Studies* 43, 2 (1995), 153-175.