NON-SPEECH SOUNDS AS ELEMENTS OF A USE SCENARIO: A SEMIOTIC PERSPECTIVE

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ABSTRACT

At present most sound design methods for non-speech sounds in auditory interfaces are based on empirical knowledge, often resulting in sounds derived from random selection or the personal preferences of the designer. A more theoretical design background is required which will create a framework that can be integrated with a practical approach to create the required results. The design framework selected and presented in this paper is based on a semiotic approach to the design of non-speech sounds. In this approach, the design process is conceptualised by referring to structural semiotics, taking into account the unique qualities of non-speech sounds, as a mode of conveying information. The central question is how individual non-speech sounds in an auditory interface can be integrated within their overall use context. A sound design method is presented as a synthesis of the theoretical points. This method is based on a rich use scenario presented to a design panel. Finally, a case study where the design method has been applied is presented and evaluated.

1. INTRODUCTION

Despite developments in audio interfaces for commercial devices, effective use of non-speech sounds in user interfaces remains a relatively underdeveloped area of human computer interaction. Traditionally advances in the design of non-speech sounds for auditory interface design have remained in the field of academic human computer interaction outside of mainstream technological environments. More recently there has been a shift in mainstream user interface design away from purely visual displays for a variety of reasons;

- In order to fully enable multimodal interaction, sound must be developed to its full potential.
- Significant developments in small intelligent devices with limited screen sizes have demanded an alternative to purely visual interaction.
- Developments in mobile computing contexts have challenged user interface designers to design multimodal interaction techniques that allow a user interact simultaneously with a device and the visual environment around them.
- Developments in assistive technologies for blind and partially-sighted computer users require effective use of non-speech sounds to convey information that cannot be communicated through speech.

Technical development in the audio properties of ICT-products enables better opportunity and choice for designers of audio displays. However, the sophistication of sound production and synthesis technology does not only mean fulfilment of existing audio design needs but also presents new challenges. Primitive sound production technology only allowed variations across a very limited number of parameters e.g., rhythm and frequency of a simple waveform. However, the more computational power the audio device has, the more complicated the design task. The complexity of contemporary digital audio design tools makes a purely analytical approach appear a utopian concept. Analysing the effect of variation across several single sonic dimensions is not sufficient; it is necessary to analyse the synergy of different combinations of properties of a sound to form a coherent abstract analysis.

Although there is a large body of research concerning audio design within the field of human computer interaction, much of this work is based on ad hoc empirical settings. Sound design for user interfaces is often based on intuition and available technology rather than a framework or theoretical analysis. There have been attempts to provide such a theoretical framework through sound design guidelines [e.g., 1]. However the complex nature of sound makes it difficult to define rules to control all physical and sensory parameters of sound.

If a purely analytical approach is utopian, and intuition based approach can be hit-and-miss in terms effective sonification of meaning, what is an appropriate basis for sound design? Accepting that a purely abstract analytical approach to the complexity of sound design is unfeasible does not mean that existing knowledge about effects of different parameters of non-speech sounds in human-computer interaction is irrelevant. Existing guidelines provide valuable support to sound designers, but there is still a broad gap between the scope of an analytical approach and an implemented sound. In this paper, the focus of sound design in the user interface is no longer based on entirely on empirical knowledge but a design framework that integrates the theoretical and the practical. The support of creative group work within a design group is fundamental within this process.

The underlying motivation for designing a non-speech audio element in a user interface is to convey meaning. Thus an audio element can be called an audio sign. Semiotics as a study of signs could be seen as the related theoretical framework. In this paper, we first explore the background of structural semiotics and then derive a non-speech sound design method from it. The embodiment of structural semiotics in our method is a rich use scenario. The preparation of a rich use scenario has a central role in our method and therefore the rationale behind it will be examined in detail. Finally, we describe a case study in which the method was applied to an auditory interface at the early stages of design.

2. NON-SPEECH SOUNDS AS SIGNS

Existing literature of auditory displays, defines the following categories of sounds in user interfaces:

1) Verbal audio signs have been studied and applied intensively, concerning both input (speech recognition) and output (e.g., speech synthesis). By definition, the analysis of semantic content of verbal audio signs is firmly bound to linguistics.

2) Auditory icons [2] imitate non-speech sounds produced in real life events. An obvious analogy that can be applied to auditory icons is the concept of visual icons in a graphical interface, which represent real life objects. The communicative value of auditory icons is usually based on close resemblance between the sign and what it stands for (nomic relationship), and, in the cases of metaphorical and symbolic use, the interpretation of the recognised sound in the context of use.

3) Earcons are a more complex concept to define. Most related empirical research in designing earcons is based on the syntax of western classical music (as in the work of Blattner [3], which stresses the compositional nature of earcons). However, in this study we expand this category to cover all non-speech audio signs that do not directly imitate sounds of real-world events. In other words, all auditory signs, which are neither verbal audio signs nor descriptive auditory icons, are classified as earcons.

The emphasis in the current study is on earcons as symbolic sounds, which are designed to convey certain meaning to the user. This approach doesn't exclude auditory icons nor verbal audio signs, but since they are quite different in terms of semantic analysis, the focus of this study will deal with earcons.

2.1. Semiotic perspective

The origin of modern semiotics is commonly described as bipolar. The cornerstones were formulated at the same time, independently from each other, by Charles Peirce and Ferdinand de Saussure. Despite the similarities between these two traditions, they have been further developed separately. The European tradition (de Saussure) was mostly concerned with language and often referred to as structuralism. Structuralism (or structuralist semiotics), despite its origin in textual analysis, has been a basis for semiotic analysis of other semiotic systems as well [4, 5]. This branch of semiotics has been most applicable in systems where an analogy with language can be illustrated, like in music. Alternatively Peircean semiotics deals more with the ontology of signs and is therefore not bound to any specific semiotic system (like language).

In this study earcons are treated as components of a larger sequence, the use scenario, (see next section), just as words are components of a sentence or musical motifs part of a composition. Therefore the structuralist school of semiotic thought is best suited to this approach.

In the structuralist semiotics of de Saussure, the central concepts in signification are signified (the concept) and signifier (mental representation of the form the concept takes). These together constitute the sign [6]. In other words, to be a sign, both are needed. A conceptually interesting feature of this idea is that de Saussure defined both signifier and signified as mental entities, even though later theorists have taken a more materialistic view referring to the signifier by its physical form (which in colloquial language would be 'sign').

Existing literature concerning non-speech sounds in UIs has a strong emphasis on the recognition and semantics of sounds (for example in the work of Edworthy [7]). Most of the research is focused on the design, analysis and empirical evaluations of individual sounds. However, from a semiotic perspective, context of use is as important as the properties of individual sound. In structural semiotics, semantic analysis is performed across two different dimensions: syntagmatic and paradigmatic (e.g., [5, p. 195]).

In a paradigmatic dimension, the relationships within a class of signifiers are analysed. A paradigmatic choice is to choose one signifier from a class of signifiers. Each member of the class meets the structural requirements, but the choice has an influence on the meaning of the whole. A typical example is word choice when constructing a sentence. When speaking about vehicles, "this is a car" has different meaning than "this is a bicycle". In this case, the names of vehicles constitute a paradigm within which the choice has to be made. Syntagmatic analysis refers to the analysis among constituents of a meaningful whole, e.g. relationships among the words of a sentence. Another typical example is an outfit: while considering what to wear, we choose each item of clothing in terms of a whole outfit which, in turn, is dependent on aesthetic aspects and cultural conventions. There are only a limited number of acceptable combinations of pieces of clothing. In this case, the syntagma is the rule defining the classes of clothes required in each outfit (e.g., pants, shirt, socks, trousers and shoes). It is not possible to choose five shirts and define it as an outfit, because the syntagma requires one piece from each category. Each paradigmatic choice (the category of clothes), must take into consideration the relationship to the whole i.e. the outfit. This is paradigmatic analysis. In syntagmatic analysis, the semantic value of an individual signifier is dependent on its relation to the whole (syntagma). Therefore the individual signifier and the whole are reciprocally dependent on each other.

2.1.1. Defining a syntagma in auditory display context

Syntagmatic and paradigmatic analysis have been successfully applied in various contexts, e.g. films, theatre, photography and music. Analogy with textual analysis is clear in contexts that have a temporal sequence, but the approach has also been applied to contexts where the syntagma is spatial in nature (like photography). Therefore, applying similar kind of analysis to a user interface in HCI is not overly ambitious.

When creating non-speech sounds in interactive systems, it is possible to get some support for paradigmatic analysis from existing literature concerning the design and analysis of individual sounds (like [1]). Syntagmatic analysis has not been considered in existing literature on interactive systems and is an interesting area for discussion. For instance what is the syntagma of an audio sign in a computer application? In other words, what is the 'whole' in which we design audio elements? In order to discuss the syntagma of a non-speech audio sign we present three examples of three different kinds of technical and socio-cultural environments:

1) In a workstation application with a graphical user interface, sounds can obviously be considered as a part of the whole user-interface. The syntagma is then the UI itself. However, depending on the nature of the task for which computer is used, entities outside the actual UI might be more essential. Therefore, a clear vision of the whole context, with its physical, social, psychological and other important aspects

would work as a syntagma. This kind of vision could be phrased as a use scenario.

2) In mobile applications, the application may be in operation independent of user interaction and awareness. For instance, when a mobile phone is switched on in the pocket of its user, it is constantly ready to receive incoming calls. Only when a call is coming, the phone alerts the user. Designing an effective audio alert would be more beneficial than designing a detailed visual cue. Therefore a detailed use scenario could be understood as a syntagma.

3) In the design of applications for visually-impaired people, the audio modality needs to be exploited more extensively than in applications for sighted people. As blind people largely observe their environment through audio information, sounds produced by the interface of the application are only one part of that whole. Designing an audio element for an application for blind users would thus require a lot of information about the audio environment in which the application is intended for use. If that information were articulated in the form of a rich use scenario, it could be interpreted as the syntagma of individual audio signs.

In this study an extensive application of use scenarios in non-speech audio design and analysis is proposed in order to provide a basis for semiotic analysis. This approach is analogous to the approach in musical semiotics, since in musical semiotics, the way that individual elements interact with the whole musical piece is often the foundation of the analysis. For example in the structuralist and segmentational musical analysis of Ruwet [8] and Nattiez [9, 10], where the overall piece is broken down into units and worked upwards to form a holistic analysis, the piece is the syntagma. In order to find an analogy between the design of a detail (sign) in a piece of music and an audio sign in user-interface, we parallel musical piece with use scenario as a syntagma.

2.2. Syntagmatic Analysis of Earcons: Rich Use Scenario as Syntagma

The practice of applying use scenarios to different stages of application development is not a novel approach. "…Explicitly to envision and document typical and significant activities early and continuingly in the development process" [11, p. 46] has been found an effective method of handling the complexity of design process. Use scenarios provide concrete tasks or user scenarios, which bind together and give form to a complex group of features and functions as defined for example in a requirement analysis. The creation of a use scenario may work as a communicative tool within group application development; as it explicates implicit, subjective visions of the user, tasks and use context. Use scenario thus provides a concrete criterion for the design of individual user-interface elements.

There are different approaches to the creation of use scenario. Carroll [11], for instance, speaks about task scenarios, while Cooper [12] is more concerned with users in his Persona-approach. Although both use scenario ideas have beneficial methods, neither approach is adequate for the construction of a use scenario representing a syntagma for audio sign design. Carroll's and Cooper's advice result in somewhat mechanical and superficial descriptions of tasks and users. Non-speech sounds are capable of communicating meanings far beyond this surface level of tasks or user goals. For instance, if the purpose of a certain audio sign is to evoke a certain kind of emotional state, in the syntagmatic analysis the designer needs a syntagma, which contains appropriate emotional elements. Otherwise, there is no defined referential context in which the emotional aspect of the sound would get its semantic value.

In order to become a syntagma, a use scenario has to be, just as Carroll expresses [11, p. 46], "stories about people and their activities". However, it also needs to be easily understood and enable a designer's identification with the people it is talking about. In that sense, the approach adopted by scriptwriters of fiction films [13] would be applicable. This is one means of avoiding flat characters, clichés, stereotypes, technology driven task scenarios etc. However, the disadvantage of film script approach is that film scripts concentrate on overt behaviour. It is up to the director and actors of a film to make the characters live, to reflect the mental life of the characters. Use scenario is more like prose: there are no mediators between the scenario and its interpreter. Therefore, we propose the use scenario to have qualities that enable the interpreter (in case of a written use scenario, 'reader') identify him/herself with the character. To identify with more superficial, condensed use scenarios we refer to our approach as *rich* use scenario.

There certainly are many other applicable approaches. But whatever the method of creating user scenario is, the resulting scenario has to be articulated so that the relationships among its constituents – whether task descriptions, user descriptions, descriptions of the physical or social environment – and individual user-interface elements like audio signs can be analysed and interpreted.

Use scenarios for the needs of audio design have special characteristics. On the basis of rich use scenario as syntagma as described above, we propose the following method for designing non-speech audio.

1) Prepare a task description about the use of functions of the application

2) Prepare a user description, based on a vision of a plausible user. In order to avoid flat character, concentrate on one character (or whatever will be the number of characters in the use scenario). The fictitious character should not be designed to hold generic qualities, as the aim is not to cover as many users as possible but to create a lively, inspiring character.

3) On the basis of stages 1 and 2, write a short story in which the interaction among the character and the application is in important role. The perspective is the one of the character – remember that there are many other things than just the application in his/her life and mind. In the story, leave blanks or pauses for the audio effects (the sounds to be designed).

4) Organise a design panel session with 4-5 panellists. Start the session by reading the use scenario, keeping a brief pause in the place of each sound. Having read the story, discuss the story at a general level. Then return to the story, and read again the sentence that includes a blank space for a sound effect. Ask the panellists to try to describe, what kind of sound would be appropriate. Do the same with each sound to be designed. Record the session.

5) Implement the panellist's ideas of the appropriate sounds.

6) Organise a new session with different people. This time, use the draft sounds (implemented in stage 5) when reading the story. In other respects, follow the steps of the first session.

7) Analyse the ideas of the second session. Complete the draft sounds accordingly.

This method provides concrete criteria for the quality of individual sounds: Each sound is assessed according to its suitability to the use scenario. This obviously raises question

about the suitability of the same sound in different kind of context other than the specific use scenario described to the panel. However, the aim of this design method is not to optimise the versatility of the resulting earcons. The method is constructed to support creative earcon design, to fill the gap between an analytical approach and a physical sound.

3. DESIGN CASE STUDY

3.1. Design Case: Auditory Interface to Convey Spatial Information to Visually Impaired Internet Users

An auditory interface specifically designed for a Multi-modal Browser plug-in [14] to convey spatial information on a web page to visually impaired Internet users was used as a case study to test the design method. It is intended that this system will convey spatial information on a web page in terms of the location of images, links and other web objects such as web forms on a web page through both audio and haptic feedback. The spatial information conveyed using the multi-modal browser should enable blind and sighted users to work together navigating and describing the same space on a web page using spatial directions and descriptions which is currently not possible with current screen reading technology. Although a prototype of the auditory interface for this plug-in had been implemented and evaluated, the design of the auditory interface was still at an appropriate phase for applying this design method. Haptic feedback was mentioned as part of the system description in the use scenario but the main focus of the design sessions was on the audio interface.

3.2. Applying the Design Method

3.2.1. Use Scenario Description

The use scenario applied in this study describes a visually impaired character buying a music file online using the multimodal plug-in. The character is introduced as a young visually impaired student and the scenario describes the character's mood, the technology he is using and the sounds in the environment around him.

> *It was one of those mornings, which Kenny would have preferred to skip…..He did not have a screen reader or any other special tools designed for the blind, but had coped reasonably well to date with the help of little plug-ins his former girlfriend had installed on his computer. These plug-ins provided haptic and audio cues to help find and locate graphical objects in a user-interface…. as he scrolled through the playlist to cover the dull sounds of Monday morning: Doors, toilets, showers and all kinds of household appliances produced in a block of flats create an enormous symphony when people wake up and leave for to work.*

The scenario describes the user's movements in the process of finding and buying a music file using the multi-modal plug-in. Task descriptions are punctuated with spaces for possible sounds.

> *Kenny typed in the address of the site and soon heard the sound [sound 1] that indicates that the page had successfully opened. At the start page of the online shop, called Cheaphits, Kenny moved the mouse across the page, from left to right, then down. He was already familiar with the tactile and audio feedback and soon got an overall impression of the page. He was especially happy with the sound that guided him towards the links [sound 2] – it attracted the mind like a magnet and made the hand move the mouse towards the link area. A similar kind of magnetic effect led the mouse towards images [sound 3]….*
>
> *… In this page, all ads appeared to be images, so it was quite easy to distinguish them from the useful information because of the clear sound [sound 4] indicating that the mouse was on the image. Another sound [sound 5] told Kenny that he had reached the link area.*

3.2.2. User Panel 1 – Belfast

Four people took part in the panel, two visually impaired females and two fully sighted males. All four participants were involved in audio or music related research. Two researchers acted as moderators to read the use scenario and chair the discussion.

One researcher read the use scenario to the group all the way through and engaged the group in discussion with a question about the user's character. The discussion was then focused on possible sound design solutions based on the participant's understanding of the tasks and requirements of the visually impaired character in the user scenario. One of the researchers led the discussion to deal with each section of the scenario that required a sound idea without leading the group towards any sound design solutions. Participants described their ideas for sounds by referring to specific examples of distinctive timbres or sounds from television or software programmes, which are listed in Table 1.

Some sound ideas that participants described in the first panel were abstract involving descriptions of aesthetic quality. For example participants discussed the idea that sounds should be designed with very little attack and smooth decay to produce a "swelling" quality. It was felt that this type of sound would be unobtrusive to the listener, which was important if the interface should be used for long periods. Participants considered that the volume of sounds should be regulated with other sounds within the auditory interface for the plug-in but also with other sounds in the system as a whole. One participant described his frustration with a particular notification sound on his laptop that was considerable louder than all other sound events. The panel concluded that sounds should not only have an unobtrusive quality within the auditory interface of the application/plug-in but should be integrated and regulated according to other applications on their computer and even the environment around them.

Many of the sounds suggested by the first panel to signify tasks were environmental auditory icons, based on metaphors. For example a keyboard/typing sound was suggested to notify a

user of a web form on a web page. Panellists felt that environmental sounds were more intuitive for creating metaphors, which would make the interface faster to learn and reduce the memory load of the user. However panellists agreed that the user could simply learn certain abstract sounds over time. Furthermore participants felt that an audio standard for auditory icons could be developed comparable to the development of visual icons

3.2.3. User Panel 2 - Glasgow

This panel consisted of five sighted researchers in the University of Glasgow, two female and three male participants with one moderator present. This session used the same use scenario and design case as the first user panel. However, in the in the second user panel, participants were presented with implemented sounds designed using the comments and recommendations from the first session. These sounds were intended to have a "mock-up" or unfinished quality to encourage participants to discuss alternative solutions. It was considered that if the sounds had a final polished quality, participants might not feel involved in a creative design process. An additional visual mock-up of the web pages in the use scenario was also used to explain the context of sounds. This was employed to focus participants in the design session when they became confused about the interface and user tasks.

As in the first user panel the researcher read the use scenario to the group all the way through and engaged the group in discussion with a question about the user's character. The implemented sounds were then played to the group with a reminder of the task and requirement that the sound was associated with in the use scenario. Participants were asked to react to these sounds, explaining why they felt sounds were effective in conveying the intended meaning and also on their aesthetic quality. They were also asked to suggest alternative solutions to the sounds. The second user panel reacted strongly to the sounds presented to them, their reactions are presented in table 2.

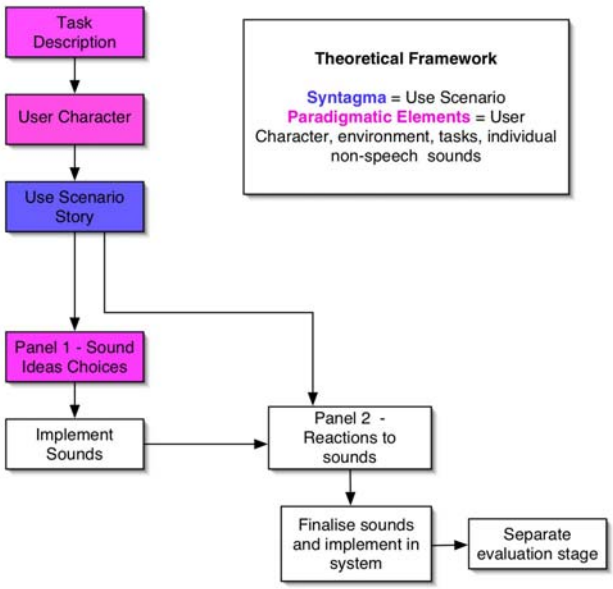

Figure 1 Overview of theoretical framework and practical approach.

3.2.4. Recommendations for Further Development of the Method

Following both user panels, free form feedback was requested from the panellists by e-mail. Feedback was not restricted but panellists were encouraged to honestly report their experience as participants. Based on this feedback and video data collected from the two user panels, we have developed the method further.

The underlying idea of purposely using draft and incomplete sounds in the second session was based on the analogy to the design of visual layouts. In methods like contextual design [15] hand drawn drafts are favoured because they encourage users/designers to suggest changes. Polished, precise or complete prototypes can make participants of a design session cautious and polite – participants can be reluctant to display negative criticism of hard work. Similarly in this study it was assumed that rough sonic drafts would work in the same way. Through analysis and evaluation of the second user panel it emerged that this was not the case Sound is such a strong modality that if it is too obtrusive (which a draft sound easily is) listeners cannot respond constructively. During the playback of some of the less polished sound samples panellists were observed to become frightened and rejected even the underlying idea of the sound. Rather than developing the draft sounds further participants started all over again and suggested a new sound. Taking this into consideration, we propose that for the second session, the draft sounds should not be purposely rough. Furthermore when panellists react negatively against a sound they should be encouraged to give alternative suggestions to describe the reason they reacted against the sound in terms of audio parameters such as timbre, pitch, rhythmic intensity etc.

The benefit of user character and use scenario was particularly apparent in the second design session where all panellists were sighted and needed the use scenario to identify with the tasks of the visually-impaired character. The benefit of using the rich use scenario could also be seen in the motivation of the panellists. In the feedback, many of the sighted panellists mentioned that they found it appropriate, even "fun".

For the stages of our method it seems that a third session would be necessary. However in the proposed third design panel session for this case study, it would be preferable to involve a panel of mostly visually impaired users to ensure that the context of the use scenario is well understood.

4. CONCLUSIONS

There is a clear structural analogy between the design of non-speech sounds in interactive systems and many other communication contexts, like music or language. The use of structural semiotics is therefore a natural way to conceptualise the design process. Such a conceptual framework can provide designers with the appropriate tools to communicate with each other about an otherwise obscure design practices.

The intention of this user panel design method is to trigger creativity within a design panel so that one designer does not choose sounds for an auditory interface based on personal preference or ad hoc choices. Involving a panel of designers that are removed from the system design process generates a level of objectivity that is more likely to create effective sound design solutions. The rich use scenario should generate create input rather that focusing discussion on the details of the system. The level of detail included in the description of character environment in the use scenario in this method can

help to contextualise sounds as well as inspiring creative design.

There were a few occasions, particularly in the second user panel where users were confused as to what the sound was actually supposed to signify or did not fully understand the correct context of the sound. Directing the users back to the visually-impaired character and the tasks in the use scenario was helpful to focus the sighted panellists on the purpose and the context of the sounds. By constantly directing the panellists to consider the overall syntagma or user scenario they were better able to consider the role of individual sounds. The application of this holistic approach to sound design for auditory display can provide both a theoretical design framework and a realistic practical approach.

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Task Description	Sound Description Suggestions
Opening a web page	- short sound success sound - bell "you won" - tv programme "ta da" sound
Sound to indicate page loading	-a background sound to know whether a page is downloading - 80 percent etc. to hear what's happening - could be mapped to pitch or a sound filling
"Magnetic" sound to draw users towards hyperlinks	-Sound of a spinning lid falling - the closer you are to the centre the faster and more intense it sounds -Metallic sound
"Magnetic"sound to draw users towards images	Participants did not consider that this location cue was as significant considering that the use scenario character was visually impaired images should have a sound
Sound for cursor over link	-Either an unobtrusive swelling sound or speech audio with link text
Web Form	Keyboard typing - Sound of a pen on paper

Table 1. Tasks described in the use scenario and subsequent sound suggested by the first panel

Implemented Sound Description	Reaction of Panel
pop.wav – short sharp pitched sound	Negative response to this sound; Too high pitched, Ambiguous meaning Thought this sound should be related to a continuous loading sound Sounded artificial -suggestion of using a woodwind instrument instead Acknowledgment that this is subjective, similar to visual design – one participant recognised that a short sharp sound like this could be effective
progressbar.wav – rhythmic sound, increasing in pace to signify page loading	Positive –reaction to the timbre of this sound Suggestion of a strong sound that fades as the page loads so that if it takes a long time for the page to load, the user can continue to use the page with a faint background sound.
swirl.wav – implementation of the link location sound suggested by user panel 1 – a synthesised sound imitating the sound of a spinning plate or object	Positive reaction to the timbre of the sound Could work for one link but would be confusing for a cluster of links
metallic.wav – implementation of a metallic link location sound suggested by user panel 1 – metallic sound, like a metal plate moving or being struck	Strong reaction against this sound, participants described the timbre as "frightening"
image.wav – existing sound implemented in auditory interface prototype – sound of a camera shutter	Positive reaction participants liked the camera metaphor
link.wav - existing sound implemented in auditory interface prototype – short clicking metallic sound	Positive reaction – hitting action, "sounds like a link" Alternative suggestion of a more subtle ticking/clicking sound
typing.wav – implementation of environmental sound described by the first panel to signify a web form	Positive reaction Participants liked the metaphor as they could make an association between typing and filling in a form
pen.wav - alternative implementation of environmental sound described by the first panel to signify a web form	Strong reaction against this sound – particularly for participants who related it to a scratching sound Participants didn't feel this metaphor would be relevant to a visually-impaired user

Table 2. Sounds implemented based on suggestions from first user panel and taken from auditory interface prototype and reactions of the second panel to these sounds

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