LOWERING THE BARRIERS TO THE CREATION OF INTERACTIVE AUDITORY DISPLAYS: AN EXPERIMENTAL INVESTIGATION

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ABSTRACT

What can the practice of Soundtrack Composition bring to the design of auditory displays? Previous research has highlighted the lack of knowledge in the wider human-computer-interaction (HCI) community about the practice of auditory display (AD) design, providing evidence that there is a need to capture the rationale for AD design more effectively, disseminate good AD practice more widely and in general lower the barriers to AD creation. This paper describes an experimental approach to address these questions. The approach and principle aims of the method (SoundTrAD) outlined in this paper is to bring together ideas from soundtrack composition and design stages for interface creation to produce a systematic and creative approach to AD design. The instantiation of SoundTrAD reported here takes the form of an interactive tool that is programmed in Max/MSP, Processing and Open-Sound Control. This tool serves to guide the development of an interactive auditory display from the point of view of an end-user. The instantiation of the tool is specific to a particular scenario to be used in the experimental evaluation of the approach; however, in principle the method supports the creation of a display for a wide range of scenarios and applications and is argued to be a particularly good match for monitoring systems. 11 novice designers took part in a study examining their use of the tool to create an interactive auditory display. The results demonstrated that all participants were able to complete the tasks and were therefore successful in creating interactive ADs. Qualitative results from the study indicated that they found the tool and the approach it embodies very usable, engaging and enjoyable. Participants also said that their overall understanding of ADs was significantly improved, and suggested numerous ideas for further applications of the approach.

1. INTRODUCTION

The work described here was undertaken in the context of a wider project which explores the question 'what can the practice of Soundtrack composition bring to the design of ADs?'. The lack of knowledge in the wider human-computer-interaction (HCI) community about the practice of AD design was highlighted by [1]. This provides evidence that there is a need to capture the rationale for AD design more effectively, disseminate good AD practice more widely and in general lower the barriers to AD creation. It follows from the above that it is desirable to build into courses on Interaction Design, materials that motivate the need for auditory displays as well as approaches that are of practical value to a novice interaction designer (or designer with limited experience of applying audio to their designs) in illustrating how they might adopt a methodical approach to the design of auditory displays. This paper describes an experimental evaluation of an approach to introducing novice interaction designers to a methodical approach to AD creation.

2. BACKGROUND

2.0.1. Methods

The lack of methods to support novice designers has been argued by [1]. This motivated their design of PACO, a framework to support the design of ADs [2]. The main approach was to provide access to a design pattern space for novice designers. The patterns were contrived as a result of understanding and documenting existing approaches to AD design from designers with experience in HCI. Similarly, [3] argued that approaches to AD design tend to be ad-hoc. As a result, they formed a review of methods that addressed the early stages of AD design namely requirements gathering and conceptual design stages. Stephen Barrass's TADA method is widely reported and does utilise all stages of auditory interface design, supporting the design from the start to the production of a display [4]. Arguably, however, this remains the only method that supports the designer through all of the stages of interface development and there is still a lack of established and accessible methods to support a novice designer, in particular, through all stages of the design process.

2.0.2. Soundtrack Composition

The idea of using soundtrack composition as an influence for the design of ADs is not new. In chapter 7 of The Sonification Handbook, Barass and Vickers, compare visual design to sonic design by stating that, 'where graphical visualization draws on graphic design [it is possible to] draw on sound design for commercial products and film sound in the next generation of ubiquitous everyday sonification' [5, p.165]. They go on to compare composers with film composers, claiming that whilst composers do not have to focus on functionality and accessibility (unless they opt to do so), film composers have to be aware of the function of the audio and how listeners perceive it.

For her Ph.D, [6] explored the use of music in the interface. She compared the use of sound in film with its use in interfaces. She claimed that in a film setting music provides elements that could also prove useful within a computer interface setting. These included continuity, which could be useful when switching between windows in a desktop, for example. Motifs for reflecting characters, which could be useful for identifying which window is active or as a way to introduce a particular theme, algorithm or

principle. The use of audio to enhance action which could be used to emphasize something on a screen.

A direct insight into how the functions of film music could benefit computer-based design was explored by [8]. Cooley argued that, like a soundtrack, using music in interactive systems can help expand screen space, draw attention to both on and off screen events as well as provide characterisation and emotions in HCI.

When referring to the use of sound to enhance learning in 'computerised instructional environments', [9] argued that sound is somewhat under utilised. To overcome this, the authors recommend four approaches from the 'best practices' of film industry sound design. The recommendations are as follows:

1. Firstly, they propose that like sound design, the sound used in computerised instructional materials could be used to support storytelling in order to help learners 'acquire, organize and synthesize' the materials under study (p.7).

2. Secondly, they pointed out that when designing soundtracks, sound designers often begin their processes with an initial reading of the script. From this they 'listen out for' objects, actions, environments, emotions and physical or dramatic tensions that can be 'fleshed out auditorally' using the various sound types (which they describe as music, speech and sound effects). They then argued that the instructions for computerised learning environments can also be identified for these key 'storytelling elements'(p.8) through a collaborative process (between sound designer and media developer).

3. Thirdly, the authors argue that like sound designers, designers of audio for an instructional product should understand and utilise the way people listen to sounds. The authors reference the modes of listening presented by film theorist Michel Chion; reduced, causal and semantic [10].

4. Lastly, the authors argue that like sound design for films, designers should be systematic about how they incorporate sounds. Sound designers work within a framework and literally map out along a time line where particular sound groupings (voice, music, sound effects) will be placed as the story unfolds. They propose that humans learn through a process of 'selecting, analysing and synthesizing' which can be seen as analogous to a film's beginning, middle and end.

3. SOUNDTRACK COMPOSITION MEETS AUDITORY USER INTERFACE DESIGN

The design of our approach to AD design evaluated in this paper, called SoundTrAD, was inspired by a drawing together of approaches to user interface design and to soundtrack composition. In order to establish the background to this, what follows in this section is an overview of established stages employed in auditory interface design. This is followed by a summary of approaches to soundtrack composition. The section ends by drawing parallels between the two, which will be used to formulate the fundamental stages and framework of SoundTrAD.

3.1. Interface Design

3.1.1. Design Stages

Existing guidelines for interface design support several methodological stages. These have been utilised for interfaces with and without audio. The following stages are not derived from one source only, but from a reading of a range of sources on interface development, including, [11, 12, 13, 14, 15] and [16] and represent a summary of interface stages accounted in those references. The different sources vary to some degree in terminology and emphasis they place on each of the stages, however an overview is provided here representing a broad consensus of the stages of interface development.

3.1.2. Requirements gathering

The first of the stages is *the requirements gathering* stage. This stage often starts with the idea of a scenario which can be used to outline who the users of the interface are, what their context is and what their tasks are.

An analysis of the scenario, in order to inform the interface design, is known as a task analysis. The analysis of the tasks to be performed, the users or system that performs them and where the tasks (actions) take place is important in creating a user-centred design. Central to this is the user and their point-of-view of the system they are interacting with. Different users have different preferences, goals and expectations. Analysis of the context in which the interface will be deployed is also important. For example, in their study of office soundscapes [17], argued that auditory interface designers consider the different sounds in the display in combination with the sounds that exist externally to the display and within the context. They showed the importance of paying attention to how the different sounds combine and to the potential masking issues that could occur between sounds when it comes to sound design choices.

3.1.3. Conceptual design

The second stage, *the conceptual design stage*, involves considering the overall form of the interface including the modes of interaction to be supported and how communications between the users and the system is to be organised. Once more this stage is informed by the context in which the system is intended to be used, the capabilities, requirements and tasks of the users. Prototyping often plays an important role at this stage in helping to provide users with an overall impression of the interface and what it will be like to use, in order to obtain feedback on both its form and functionality.

3.1.4. Detailed design

The third stage is the *physical or detailed design stage* wherein the interface is designed at a detailed level and implemented in the form it will be deployed. Lower level prototyping is often employed in this stage to obtain more detailed feedback on specific lower level features of the interface. This iterative process of detailed design, implementation and feedback through prototyping results in a final realisation of the entire interface.

3.1.5. Summative evaluation

Finally, there is the *summative evaluation stage*, which involves final acceptance testing of the entire interface. This should involve the complete cycle of tasks required to be undertaken by users and should exercise all parts of the interface. Feedback from this final evaluation may lead to some changes being made to the interface,

as well as lessons being learned for future interface development projects.

The above stages provide a broad structure from which to approach the design of an interface, and were used to provide an overall framework for the development of SoundTrAD.

3.2. Soundtrack composition

The following section provides a review of the functions and principles of creating soundtracks. This review is based on [18, 19, 20, 21, 22] and [10]. The review given here draws on what is considered to be the most frequently utilised and widely held soundtrack composition principles. Within this, particular attention has been paid to concepts in soundtrack composition practice that could be seen to parallel practices in interface development.

3.2.1. Functions

Sound in film is used to anchor and engage us with meaning; smooth editing, enhance and create mood and emotion, illustrate geographical location and historical situation, focus attention on a specific action or object, determine speed and motion and to function as a leitmotif, associated with a specific character or theme [18, 21, 22].

3.2.2. Design Stages

Hollywood sound designer David Sonnenschein outlines a methodical approach to creating a soundtrack from the script to the final mix [18]. With this, Sonnenschein does not offer a technical account of suitable software, or specific hardware, or mixing or editing techniques, but rather a creative approach to analysing a script and conceptualising, designing and delivering ideas for a soundtrack to the technical team. This includes techniques and methods that can not only aid in the initial decision of where sounds should go, (formerly known as 'spotting') but also the categorisation, mapping, placement and initial arrangement of suitable sounds. Sonnenschein is clear to point out that the steps are subject to personal ordering and are not definitive. What is clear in this suggested approach is the importance of iteration as part of the creative process and the means by which the composer can be guided and supported at the same time.

3.2.3. Scenes and Spotting

Composers will analyse a scene by 'spotting' it for places that could be enhanced by audio. The elements that composers could 'listen out for' during this process have been described by Sonnenschein, who wrote that within every on-screen *character, object* and *action* there is potential to generate a sound that can enhance the narrative and story [18]. With the starting point of marking the script, in order to identify key storytelling elements that can be 'amplified by sound', Sonnenschein identifies the following 'voices' to listen out for; specifically by identifying and circling explicit words and phrases: *People, objects, actions, environments, emotions* and *transitions*.

At this stage the idea of a cue sheet is important. Cue sheets are the main means by which sound editors communicate the layout of their work to the human mixer [20]. They list changes throughout a performance. Cue sheets are organized with columns to include notes on important footage or time-code numbers corresponding to the occurrence of events. As, Yewdall observed, a cue sheet is 'simply a road map of intent'[23, p.23].

3.2.4. Fundamental sound classifications

Once the composer has annotated their ideas for sounds, the sounds are classified into categories of dialogue, music, sound effects (D-M-Es). What is important in a soundtrack is the consideration of how these sounds work together and how they form the bigger soundtrack by relating to one another and to the story being told. Within a film, the soundtrack contains not only the musical score, but ambient sound, dialogue, sound effects, and silence, [24, p.5].

To underline the importance of considering the soundtrack and all the sounds that make it up as a whole, Lipscomb and Tolchinsky argued for the 'analysis of the entire soundtrack, upon which musical sound, dialogue, sound effects, silence, and some sounds that fall in the cracks between traditional categories all exist for the purpose of enhancing the intended message of the motion picture'[24, p.5].

3.3. Bringing The Two Together

The above has very briefly outlined some of the fundamental processes in creating interfaces and soundtracks. Parallels between these activities are proposed in table 1 which starts with the idea of paralleling a scenario/scene. This table illustrates a parallel framework comprising the larger method stages involved in creating auditory interfaces and soundtracks. In these stages reside the steps that were developed and explored as a result of the iterative design approach that supported the development of SoundTrAD.

It is clear to see existing similarities between the analysis of scenarios and film scenes. More specifically, this illustrates the importance of identifying actions, objects, locations, as well as the relationship and transitions between events as a part of the *requirements gathering* and *conceptual design* stages. It is equally important to consider suitable audio that can map to the events alongside the need to evaluate and iterate the design process.

4. THE AIM OF SOUNDTRAD: WHAT CAN IT SUPPORT?

Below are listed the set of general aims of SoundTrAD.

1. To lower the barrier to creating ADs in order to enable novice designers to engage effectively in the AD design process.
2. To support the designer in executing accountable, repeatable steps toward producing a display.
3. To enable the designer to complete a prototype/model of their design.
4. To enable designers to document their ideas to enable them to reference and share the rationale for their designs.

The following study was performed to test whether SoundTrAD met the objectives, specifically that of lowering the barriers to novice designers and improving their understanding of ADs.

Auditory Interface Stages and Steps	**Soundtrack Stages and Steps**
Stage: Requirements Gathering - scenarios and task analysis with *users/actors, events (transition between them) objects, actions, context*	**Stage: Spotting the scene** - stories with *characters, actions, objects, transitions, locations* and *emotional feel*
Stage: Conceptual Design - thinking about interface arrangement, and what parts need sonifying and how it is laid out	**Stage: Arranging** ideas and cues, sketching, establishing and iterating ideas
Stage: Detailed Design - mapping events to audio	**Stage: Composing/Designing** original music and sourcing sound samples to map to the cues/events
Stage: Evaluation	**Stage: Evaluation**

Table 1: Parallel between audio interface design and soundtrack composition

5. SUMMARY OF THE DEVELOPMENT OF SOUNDTRAD

The stages of SoundTrAD were developed out of the parallels drawn between the stages of soundtrack composition and AD design. Each stage was refined, changed, and developed as a result of 3 user studies that took place before the final study reported here. The following provides a heavily summarised description of how the SoundTrAD approach was developed.

Firstly, the idea of a cue sheet was introduced to help the designer map out events in a scenario by identifying actions, objects and subsequent ideas for sound. The study utilised ideas from how scenarios are mapped out in HCI practices [13, 12, 26] and explored how these can parallel the traditional cue sheet as used in soundtrack composition [18]. A database was created in order to store details of sounds and sound mappings and to facilitate audition of sounds from an early stage in the design process. Ideas for the database came from the previously referenced soundtrack literature. The database of sound examples was populated with sound samples and supported navigation in relation to the requirements, sound types or soundtrack composition categories. A basic time-line was created to represent the sequence of events as they unfold during the interaction. Sound ideas were placed on the time-line in order to start to consider event layout. As the studies developed events on the time-line could be reordered to allow users to examine alternate interaction scenarios, check for masking and audition early prototypes of their ADs.

6. THE STUDY

The aim of the study was to represent the potential of the database and principle behind the mapping. To demonstrate a set of mappings that draw on some principle of soundtrack composition in order that integration of different sound types and aesthetics could be considered. The aim was that aesthetics and sound categories were made accessible, understood and it is clear how they relate to requirements of the AD events. Listed below are the details of the mappings that were implemented for the study:

1. A user-entered data set was mapped to pitch to create rhythm and melody. The designer could change the instrumentation and speed of playback in order to give them a sense of control and change the rhythm. The pitches that the data was mapped to were scaled to a major scale as inspired by Vickers [28] who argued that tonal music should be preferred over direct mappings to frequencies. The numbers were scaled (0-10 = c/MIDI note 60, 11-20= d/MIDI note 62, 21-30, e/MIDI note 64, f/MIDI note 65, g/MIDI note 67, and so on through to MIDI note 72). In principle these scaled numbers could be mapped to any major, minor scales and modes. The idea was that the data set is scaled to a western scale. There were 10 options for the instrumentation from drum to strings through to tuned percussion. The data could be represented using musical pitches or rhythmic beats and could come together to create melody and/or rhythmic sequences as a result of the playback.
2. Background: the designers were presented with 5 options from natural to musical drones (wind, sea, calm, electricity, strings). In order to enhance the display and perception of the data, as inspired by [29] who argued, convincingly that drones can be used to show lengths of processes, the aim was to map a continuous sound to a drone to clearly illustrate the length of the scenario. The parallel with soundtrack composition is that it can be used to establish place, enhance action, give sense of a size and create mood. The designers were told what to consider when picking their sound: who the users are, where the display is heard, how it alters perception of the events and data.
3. The events could be mapped to Foley/SFX or music. There were 12 options for the SFX and 7 for the motifs. Designers were told that these sounds can be used to represent everyday things or that if events do not have a real-world association, then motifs can be chosen as an option. The motifs were presented in the form of minor and major piano chords. In theory this could be any chords or instrument but the idea was that the sounds should be short and can be major (positive), minor (negative) or neutral. Motifs that have the same instrumentation, yet are altered in key helped narrate story and represent data points (character) or events. From a system and design principle point of view (even if the user is not aware), it is necessary that the chords for the motifs, the melody for the dataset and the constant drone for background should all be associated with the same musical key.

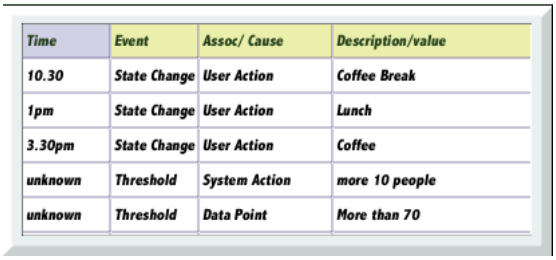
6.1. Participants

11 participants took part in the evaluation. All participants had little or no experience of creating ADs.

6.2. Tasks

The participants were presented with a hypothetical scenario/scene involving someone using an AD to monitor footfall and staff activities in a work-place environment. They were then presented with a series of 7 tasks and help files that supported them in applying SoundTrAD to create an AD for the scenario. If the information

Figure 1: Task 1: Add footfall numbers in the number entry boxes provided



Time	Event	Assoc/ Cause	Description/value
10.30	State Change	User Action	Coffee Break
1pm	State Change	User Action	Lunch
3.30pm	State Change	User Action	Coffee
unknown	Threshold	System Action	more 10 people
unknown	Threshold	Data Point	More than 70

Figure 2: Task 2: The cue sheet where events were documented

icon was clicked then this opened up a separate window with the help files. The content of each outlined further rationale behind the mapping options. The 7 tasks are briefly summarised below:

Task 1: Enter footfall data to provide the data set for the scenario. Figure 1 illustrates the screen participants could interact with. Participants could enter numbers between 0-100 in each number box.

Task 2: View the user, system and data point events on the cue sheet that are used to represent staff activity and significant points in the scenario that need to be represented in audio. Enter qualitative descriptions about the events in order to help with sound design choices. Figure 2 illustrates the cue sheet.

Task 3: View the time-line and load the entered dataset and event data from the cue sheet into it. Note how these are displayed in rows on the time-line, including a final row which can be used to represent a background sound. Explore interacting with the time-line by trying to move any of the user, system or data point events by placing the mouse cursor over them, left-clicking and dragging. Try pressing the play icon, notice the vertical moving line and how it loops through the scenario every ten seconds. Figure 6 demonstrates the time-line.

Task 4: Create melody, instrumentation and rhythm. Choose the instrument options and speed of playback that you feel best represents the data set in the shop scenario. Figure 3 illustrates the interface the participants could use to map their data (entered in task 1) to pitch, rhythm and speed parameters. The gauge on the right hand sound monitors the level of playback.

Task 5: Create background audio (choose a background sound that matches the context of the given scenario) . Figure 4 highlights the selections that participants could choose to create a background for their display.

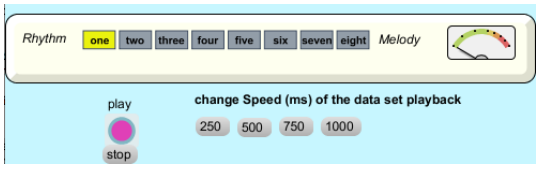


Figure 3: Task 4: Map the footfall to different instruments and change the speed of playback

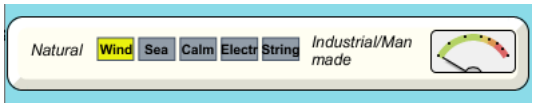


Figure 4: Task 5: Select a background

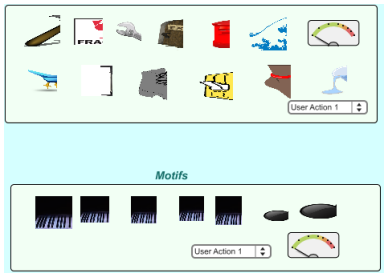


Figure 5: Task 6: Map events to different sound effects, Foley or musical motifs

Task 6: Add effects and music. Choose sounds from the database of sound effects and motifs that are good representations of the events on the time-line. Figure 5 shows the interface participants could use to select sound effects, Foley sounds and motifs that they felt best matched their design.

Task 7: Adjust and mix the sounds: Explore re-arranging the events, adjusting the length of the time-line, the balance of the sounds, adding/removing events, adding/removing effects. See figures 6 and 7 for the screens participants could use to audition and design their final display.

7. FINDINGS

Participants were presented with a questionnaire pre-study to gather their level of experience and rate their understanding of data sonification and auditory display (as outlined above). After the study, the participants were asked to complete the questionnaire by rating and giving their immediate feedback regarding how they felt the method and tool had supported their understanding of data sonification and auditory display. The aim was to compare the participants reactions before and after the study.

The participants were then sent a link to an on-line survey containing 6 questions to gather ratings and their open-ended responses regarding the usability, enjoyability and usefulness of the system. The ratings scaled from 1-7 and included semantic markers. For example, the question on usability ranged from 1: extremely unusable to 7; extremely usable. The survey was also designed to gain insight into whether the participants would use SoundTrAD again and what scenarios they thought it could cater for.

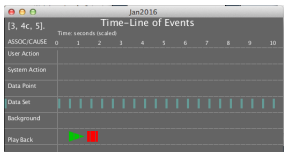


Figure 6: Task 3 and Task 7-Time-line

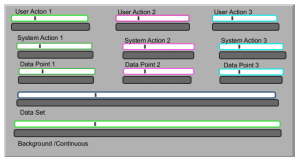


Figure 7: Task7-levels

Part.	AD (before)	Son.(before)	AD (after)	Son.(after)
1	Reasonable	Little	Little	A Lot
2	Little	Little	Little	Reasonable
3	Little	Little	Reasonable	Reasonable
4	Little	Little	A Lot	A Lot
5	Little	Little	Reasonable	Reasonable
6	Little	Reasonable	Reasonable	Reasonable
7	Little	Little	Reasonable	Reasonable
8	Little	Little	Little/Reas.	Little/Reas.
9	Little	Little	Reasonable	Reasonable
10	None	None	Reasonable	Reasonable
11	Little	Little	Little	Little

Table 2: Understanding of Auditory Display and Sonification Pre and Post Study

7.0.1. Question: Levels of experience and understanding pre and post study

Table 2 shows the participant ratings for their level of understanding of AD and sonification before and after the study. The ratings span from none, a little, a reasonable amount to a lot. One participant's (P1) understanding of what an AD was went down from reasonable to a little. Two participant's (P2 and P11) understanding stayed the same at 'A little'. Eight out of the eleven participants claimed their understanding of what an AD is had increased after the study with six responses changing from a little to reasonable, one response from a little to a lot and one from none to reasonable.

Nine out of the eleven participants claimed their understanding of what sonification is had increased after the study. Two (P1 and P4) had their understanding change from little to a lot, six from a little to reasonable, one (P10) from none to reasonable. One participant (P6) asserted that their understanding had stayed the same.

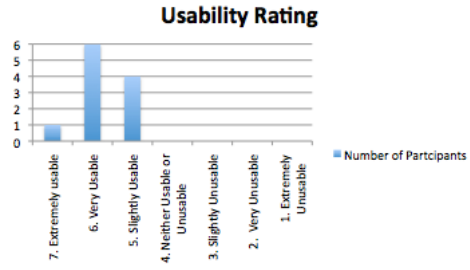


Figure 8: Usability Rating

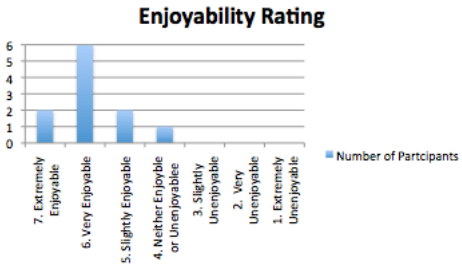


Figure 9: Enjoyability

7.1. *Question 1: Usability*

Figure 8 shows that the lowest rated usability was 5 out of 7 with 4 of the 11 putting this, and the highest score from 1 participant was 7. The mode was 6 - very usable, with 6 out of the 11 participants claiming this.

7.1.1. Summary of Question One

The lowest usability rating of 5 out of 7 came from P1, P6, P8 and P11. P1, P8 and P11 all commented on issues with the interface and implementation as somewhat limiting its potential and usability. P6, liked the interface but compared it to the interface from the previous studies they have taken part in. Arguably, this could demonstrate an improvement in the system but there was further potential to develop it. Audio levels gave a sense of control (P2) and the instructions and layout were seen to be accessible. As P5 noted, it is "Well explained and accessible without having much prior knowledge".

7.2. *Question 2: Enjoyability*

Figure 9 shows that the lowest rated enjoyability score was 4 (neutral) from one participant and the highest was 7 out of 7 with 2 participants putting this. The mode was 6 out of 7 with 6 out of the 11 participants stating this.

7.2.1. Summary of Question 2

The lowest enjoyability score was from P6 (neutral). P2 and P3 found it slightly enjoyable. They both thought there could be less steps, default settings (P2) and more user control (with ability to input their own sounds). Enjoyability was clearly related to being able to listen to sounds and work with audio straight away, as P2 observed: *"It is nice to be able to change the volume of the sounds that associated to the events. In this way, I can make important events more noticeable. In general, I feel in good control and is able to change all the aspects of the sound"*. The sense of personalisation and control also supported enjoyability as did being able to visualise the events and work with graphic representations.

7.3. *Question 3: usefulness for designing AD's for real world scenarios*

Figure 10 shows that the lowest rated usefulness was 5 out of 7, with 2 participants putting this, and the highest score being 7 with 4 participants putting this. The mode was 6 out of 7 with 5 out of the 11 participants putting this.

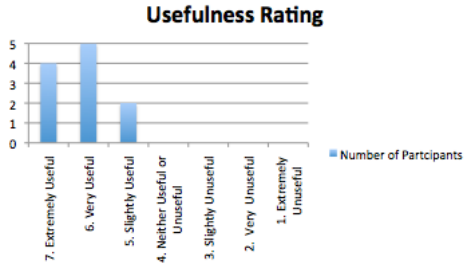


Figure 10: Usefulness

7.3.1. Summary of question 3

2 participants scored the usefulness as 5 out of 7 (P6 and P8), however P6 gave positive comments when stating how useful they thought the system could be. P8 showed some confusion regarding the target users. The usefulness was related to its potential and the wide range of scenarios it can be applied to. P9's observation about using it for historical data is specific and related to their specialism and so this reflects the potential for SoundTrAD to be adaptable and, as P4 stated, customizable to suit the users needs.

7.4. *Question 4: Use again and Any changes?*

Yes=54.55%(6)
Maybe=27.27%(3)
Do not know=9.09%(1)
Unlikely=9.09%(1)

7.4.1. Summary of question 4

It is clear that most participants would use this again given changes or a specific need. P11 is a novice to interaction design and music composition and observed that they did not know of any other system that could do this. There are no commercially available systems in the everyday world.

7.5. *Question 5: Other Scenarios*

The responses demonstrate the wide-range of scenarios and applications that participants felt the system could be used for.
P1: *"Sport events, data sonification, live data performance tool"*.
P2: *"I would like if it can respond to real time events. Then it can be used in public areas such as cafeterias. The system can be related to the play list the cafe is using. When there are more customers in the shop, play some pop music or music with a quick tempo, customer might eat faster and leave quicker. When there are only few people in the cafe, play some classic music to ease the pressure of customers."*
This response shows confusion on behalf of P2 regarding the method and the displays it is intended to help create.
P3: *"Analysis of any complex system e.g. scientific research"*
P4: *"For tasks or cases that need constant monitoring and need to fire alerts if changes happen, while users are occupied doing something else. Almost like a background monitor."*
P5: *"Petrol consumption. When client payments made to bank account (might be too complex but would be really helpful) Metered water consumption. When I need coffee!"*
P6: *"I think it can be applied to use with any storyline/events that needs auditory display"*
P7: *"Music education, aiding system for sensory-impaired people,mobile application, animal monitoring, and so on."*
P8: *"Transport hubs like railways stations and airports, either for people (queues building up, need more staff on check in desks etc) or for the logistics of moving bags (airports) or rolling stock (sending in more carriages) or even having an alert for a problem with trains and getting rail replacement busses."*
P9: *"Digital archives. Revision aids. Teaching aids especially for students with special educational needs'. I would really like to use with historical data being archived online. I think this kind of audio display would be great for a variety of students needs and could make education more accessible for all. There are endless possibilities here I think'*
P10: *"To help workers 'keep an ear' on their work. To help supervisors monitor staff activity. To help managers review data and plan accordingly. To add auditory and notification to already existing IT systems (in vehicles/computers/classroom environments). Hugely beneficial to people with impairments."*
P11: *"in vehicles for optimum performance and monitoring. For use in medical and sporting monitoring equipment. for monitoring energy use in the home/business. for use in extreme locations for monitoring yourself/the environment. to aid a person with disability/medical condition. For anyone that is multitasking any situation and needs to monitor and respond to situations while engaged in another activity"*
To summarise the possible applications:
Monitoring, data review and trends, real-time scenarios, multitasking, alerts and alarms, sports, medicine, health, environment, performance, education, transport, special educational needs and business.

7.5.1. Question 6: Any Other Comments

There were no negative comments received for this question. P9 said it was *"impressive stuff*. P10 commented that the system has *"endless potential"*. P7 made suggestions for updates to interface could be include "adding more samples". P4, P8 and P5 said they thought it was *"enjoyable"*, with P4 adding that it was *"easy to learn"*.

7.6. Summary of Findings

The aim of the study was to explore the accessibility of SoundTrAD to novice AD designers, to examine whether it improved their understanding of ADs and sonification, and the usability of the tools employed to implement the approach. Out of usability, enjoyability and usefulness it was the usefulness that received the highest number of the maximum score 7 (extremely useful). The next most successful in scoring highest numbers was enjoyability, followed by usability. This outcome could reflect that the method potential was realised for this sample of participants new to AD design, and despite some remaining issues with usability, it is clear that given professional development that it would be a useful system. The enjoyability was also an important part of the system, in particular how this related to the use of audio throughout the design process. Particularly, iterating ideas, exploring options and subsequent aesthetics of the final display.

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