

EVALUATING A VEHICLE AUDITORY DISPLAY : COMPARING A DESIGNER’S EXPECTATIONS WITH LISTENERS’ EXPERIENCES

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ABSTRACT

This paper illustrates a method for the early evaluation of auditory displays in context. A designer was questioned about his expectations of an auditory display for Heavy Goods Vehicles, and the results were compared to the experiences of 10 listeners. Sound design is essentially an isolated practice and by involving listeners the process can become collaborative. A review of the level of agreement allowed the identification of attributes that might be meaningful for the design of future auditory displays. Results suggest that traditional auditory display design guidelines that focus on the acoustical properties of sound might not be suitable.

Keywords

Auditory Display, vehicle, evaluation, listeners’ experiences, designer’s expectations

INTRODUCTION

Sound is one of the easiest ways to augment any environment and has always been used as a method of communicating information (Delage, 1998). Yet the use of sound in human-computer interaction remains problematic. Brewster (2008) raised this issue, despite successful research into the use of non-speech sounds going back to the early 1990s. Sound design is not an expertise easily conveyed (James, 1998). Robare and Forlizzi (2009) highlight the lack computing sound design guidelines, despite the number of sound enabled products having increased dramatically since 2000.

Auditory displays have been defined by Kramer (1994) as an interface between users and computer systems using sound. Displays differ from interfaces in that they are mono-directional (McGookin & Brewster, 2004). Sound has long been used to convey information in vehicles, and researchers have emphasized the suitability of auditory displays (Hirst & Johnson, 1992, Graham, 1999, McKeown, 2005, Fagerlönn & Alm, 2010). Barrass and Frauenberger (2009) argue that designers need to consider the context of use, particularly given that the conditions in vehicles can be ‘complex and dynamic’ (Cao *et al.*, 2010 p. 109).

SOUNDSCAPE MAPPING TOOL

Watson and Sanderson (2007) tell us that an auditory display’s effectiveness at communicating information should be evaluated according to its *context of use*. By context we mean the ambient auditory environment or soundscape (Schafer, 1977). The *soundscape mapping tool* (SMT) is a way of abstracting and visualising sound events that allows designers to represent designs, and listeners to record experiences (McGregor *et al.*, 2010). The SMT was developed and validated with groups of audio professionals and listeners (McGregor *et al.* 2006, 2007).

The SMT has three distinct phases, identification, classification and visualisation. The sound designer identifies sound events within a sound design, and/or soundscape. Both the designer and listeners classify the sound events according to a list of attributes (see Table 1). The results are then visualised by the researcher for ease of comparison by the designer.

Awareness	Aware/Unaware
Spatial cues	x/y axis
Type	Speech/Music/Sound effect
Material	Gas/Liquid/Solid
Interaction	Impulsive/Intermittent/Continuous
Temporal	Short/Medium/Long
Spectral	High/Mid/Low
Dynamics	Loud/Medium/Soft
Content	Informative/Neutral/Uninformative
Aesthetics	Pleasing/Neutral/Displeasing
Clarity	Clear/Neutral/Unclear
Emotions	Positive/Neutral/Negative

Table 1: Sound event classification

The visualisation takes the form of a “map”, the key of which is shown in Figure 1. Each sound event is given a code and is represented by a combination of shapes, colours and symbols that are overlaid onto a grid that captures where the listener heard the sound. If a sound event is heard to move during the recording, then the start and end points are both marked and joined.

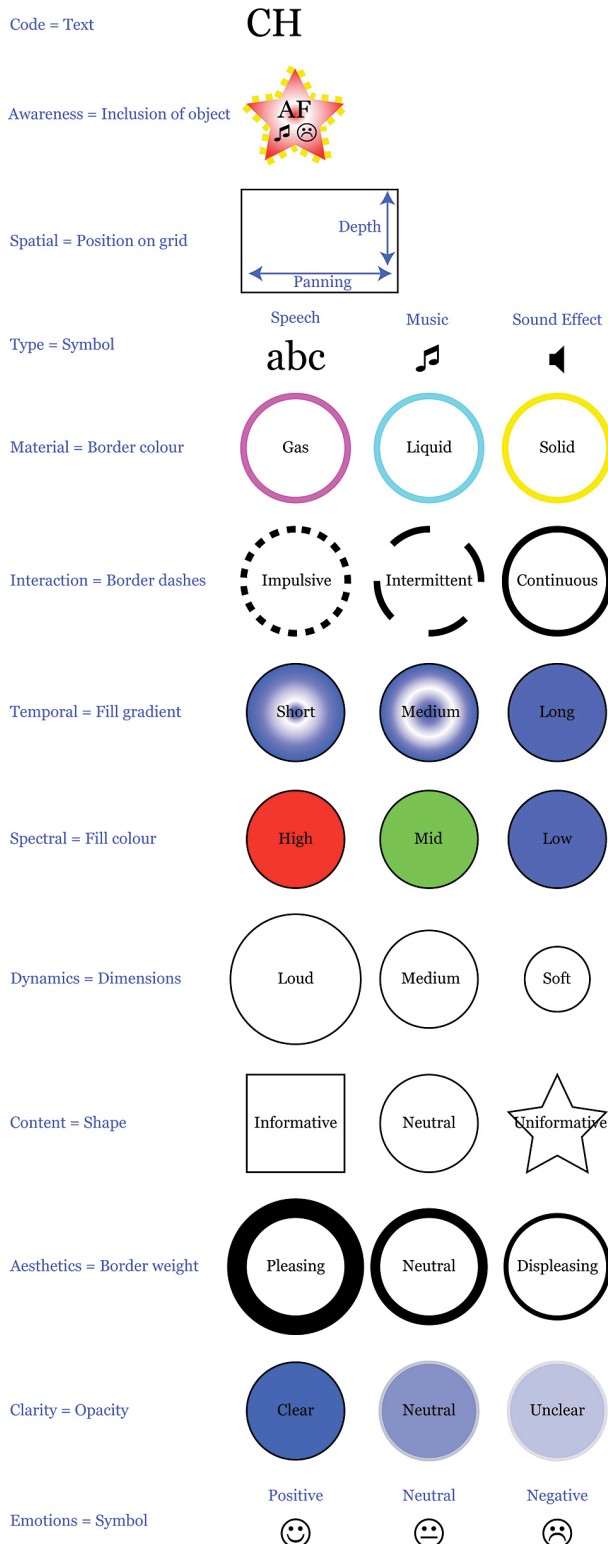


Figure 1: Visualisation key

Method

Participants

The designer (second author) and 10 listeners took part in this study. The 10 listeners were a sample of convenience made up from staff and students at Edinburgh Napier University.

Materials

The designer made an 11 minute 41 second stereo recording of the auditory display within a moving Heavy Goods Vehicle (HGV). A professional driver was driving the truck with a co-driver, the designer was sitting in the centre on the back seat/bunk bed. The recording was made with a pair of electret microphones attached to the designers' spectacles. This near-ear microphone technique creates a partial binaural effect, improving distance perception and reducing *inside-head-locatedness* for listeners (Blauert, 1996).

Procedure

The designer supplied a list all of the sound events in the recording. The designer then classified what he had heard. Listener tests were conducted in a quiet office. The listeners were provided with fully enclosed stereo headphones. Listeners were asked to listen to an audio recording and answer questions about what they heard. The first author translated the tabulated information into soundscape maps.

Results

The designer identified 20 different sound events within the recording (see Table 2). Seven of the sound events were part of the auditory display (AD). The 13 remaining ambient sound events were either vehicle related (10) or people related (3).

Code	Description
AA	windshield wiper
AB	engine
AC	tapping sound, "tick tick... tick tick" (non-imminent message, e.g. new sms message)
AD	warbling warning (p-brake)
AE	Mech. of sound handbrake release or similar
AF	Continuous ticking (tachograph)
AG	Female speech (driver)
AH	Male speech (co-driver 1)
AI	Male speech (co-driver 2)(laughter)
AJ	Four fast beeps (telling driver that they are not attending to the driving task appropriately)
AK	windshield wiper loud scraping
AL	"Beep beep..... Beep beep" (urgent warning, you need to go to the workshop within x km, or fix something with the vehicle)
AM	Turn signal
AN	Turn signal off
AO	Car passing
AP	Four sharp, fast beeps (lane keeping support, the vehicle is drifting out of lane)
AQ	Fast turn signal sound 3x 2 ticks (is it broken?)
AS	Beep beep-beep beep (driver is not attending to driving task appropriately)
AT	Seatbelt fastening

Table 2: Sound events

When the sound designer listened to the recording he did not identify four of the sound events but still classified them so that the results could be compared to the listeners experiences. The listeners were *aware* of

Discussion

Fagerlönner & Liljedahl (2009) warn that end users may not feel confident enough to provide informed feedback about sound designs. Coleman (2008) highlighted the distrust that sound designers have for non-experts' descriptions. There are a number of issues to address. Accurate measurements of sound are difficult to achieve (Moore, 1997). Stopping and listening takes sound events out of context. Individual perceptions vary, making classification difficult (Porteous and Mastin, 1985). Perception includes 'stuff around the edges', context, background, history, common knowledge and social resources (Brown & Duguid, 2000)

Any method to capture the experience of inhabiting a soundscape will have issues with granularity. Balance must be achieved with gathering sufficient data, and overwhelming participants. Only limited time periods can be studied, as there are necessary time constraints for listeners' availability and fatigue.

The physical properties of sounds have been used for the stylised designs of sonifications and earcons. The finding of a low level of agreement of the physical properties of sound challenges the use of conventions in this area of sound design. Specifically, the wisdom of the use of guidelines to aid the design process of auditory displays should be investigated further.

This work demonstrated that the SMT was suitable for capturing the intentions of a sound designer and the experiences of 10 listeners. The trial also provided information about how the SMT could be developed further. This paper contributes evidence that auditory environments can be abstracted and visualised in a manner that allows designers to represent their designs, and listeners to record their experiences.

REFERENCES

- Barrass, S., & Frauenberger, C. (2009). A communal map of design in auditory display. *ICAD, 2009*.
- Blauert, J. (1996). *Spatial Hearing: The Psychophysics of Human Sound Localization*. Cambridge, MA: MIT Press.
- Brewster, S. A. (2008). Nonspeech auditory output. In A. Sears & J. Jacko (Eds.), *The Human Computer Interaction Handbook* (2nd ed., pp. 247-264).
- Brown, J. S., & Duguid, P. (2000). *The Social Life of Information*. Boston, MA: Harvard Business School Press.
- Cao, Y., van der Sluis, F., Theune, M., op den Akker, R., & Nijholt, A. (2010). Evaluating Informative Auditory and Tactile Cues for In-Vehicle Information Systems. *AutomotiveUI 2010*.
- Coleman, G. W. (2008). *The Sonic Mapping Tool*. PhD, University of Dundee.
- Delage, B. (1998). On sound design. In H. Karlsson (Ed.), *Stockholm, Hey Listen!* (pp. 67-73). Stockholm: The Royal Swedish Academy of Music.
- Fagerlönner, J., & Alm, H. (2010). Auditory signs to support traffic awareness. *IET Intelligent Transport Systems, 4*(4), 262-269.
- Fagerlönner, J., & Liljedahl, M. (2009). AWESOME Sound Design Tool: A Web Based Utility that invites End Users into the Audio Design Process. *ICAD 09*.
- Graham, R. (1999). Use of auditory icons as emergency warnings: evaluation within a vehicle collision avoidance application. *Ergonomics, 42*, 1233-1248.
- Hirst, S., & Johnson, C. (1992). Auditory displays for in-vehicle systems, CED3 Report Number 1. Loughborough: HUSAT, Loughborough University of Technology.
- James, F. (1998). Lessons from developing audio HTML interfaces *Proceedings of the third international ACM conference on Assistive technologies* (pp. 27-34). New York: ACM.
- Kramer, G. (1994). An Introduction to Auditory Display. In G. Kramer (Ed.), *Auditory Display: Sonification, Audification, and Auditory Interfaces* (pp. 1-77). Reading, MA: Addison-Wesley.
- McGookin, D. K., & Brewster, S. A. (2004). Understanding concurrent earcons: applying auditory scene analysis principles to concurrent earcon recognition. *ACM Transactions on Applied Perception, 1*(2), 130-155.
- McGregor, I., Crerar, A., Benyon, D., & Leplatre, G. (2007). Establishing Key Dimensions for Reifying Soundfields and Soundscapes from Auditory Professionals *ICAD 2007*.
- McGregor, I., Leplatre, G., Crerar, A., & Benyon, D. (2006). Sound and Soundscape Classification: Establishing Key Auditory Dimensions and their Relative Importance *ICAD 2006*.
- McGregor, I., Leplatre, G., Turner, P., & Flint, T. (2010). Soundscape Mapping: a tool for evaluating sounds and auditory environments *ICAD-2010*.
- McKeown, D. (2005). Candidates for within-vehicle auditory displays. *ICAD 05*.
- Moore, B. C. J. (1997). *An Introduction to the Psychology of Hearing* (4th ed.). London: Academic Press.
- Porteous, J. D., & Mastin, J. F. (1985). Soundscape. *Journal of Architectural Planning Research, 2*(3), 169-186.
- Robare, P., & Forlizzi, J. (2009). Sound in Computing: A Short History. *Interactions, XVI*(1), 62-65.
- Schafer, R. M. (1977). *The Tuning of the World*. Toronto: McClelland and Stewart Limited.
- Watson, M. O., & Sanderson, P. (2007). Designing for Attention With Sound: Challenges and Extensions to Ecological Interface Design. *Human Factors, 49*(2), 331-346.