SOUNDSCAPES AND REPERTORY GRIDS: COMPARING LISTENERS' AND A DESIGNER'S EXPERIENCES

Iain McGregor
Edinburgh Napier University
School of Computing
Edinburgh
United Kingdom
i.mcgregor@napier.ac.uk

Phil Turner
Edinburgh Napier University
School of Computing
Edinburgh
United Kingdom
p.turner@napier.ac.uk

ABSTRACT
This paper reports on establishing whether listeners have the same listening experience as the person who designed the sound. Surprisingly, there is little or no evidence as to whether what is designed to be heard is what is actually heard. The study reported here is a qualitative study into these two experiences.

Research approach – A repertory grid technique was adopted using listener and designer generated constructs. One designer and 20 listeners rated 25 elements within a surround sound recording created by a soundscape generative system. The listeners' modal response was compared to the designer's.

Findings/Design – The results suggest that it is perfectly feasible to compare designers and listeners experiences and to establish points of agreement and disagreement.

Research limitations/Implications – Only UK-based university students and staff participated in the study, which limited generalisation of the findings.

Originality/Value – Demonstrates an ontology of sound based on user experience rather than designer's whim. This approach is based upon long-term experiences and our conceptualisation of sound

Take away message – Comparing listeners' experiences could allow designers to be confident with their sound designs.

Keywords
Soundscape, repertory grid, listeners, designers, listening

INTRODUCTION
While sound designers can guide listeners by providing clues about what they should be attending to (e.g. Kerins, 2011, Sonnenschein, 2001), there has been relatively little work on directly comparing listener and designer experiences. Listening tests have been conducted within product design for the last 50 years or more and involve experienced listeners (e.g. Soderholm, 1998, Engelen, 1998).

Rumsey (1998) tells us that there are high levels of agreement when participants are experts, whereas non-experts' responses are likely to vary more. Bech (1992) suggests that increasing the number of participants can improve the level of confidence in the findings. Yang and Kang (2005) highlight the differences between measurements and evaluations and how much they can vary, especially when it comes to different types of sound sources and levels of pleasantness. Listener testing is limited to products such as audio reproduction equipment and vacuum cleaners, and has not migrated into mainstream media, and only partially into computing (Bech and Zacharov, 2006). Tardieu *et al.* (2009) found that laboratory tests of sound signals (earcons), do not fully correspond with tests conducted under real world conditions.

Soundscapes
The term soundscape is analogous with landscape in that it represents an individual's unique experience of inhabiting an auditory environment (Schafer, 1977). Brown, Kang and Gjestland, (2011) propose that due to the number of alternative definitions, which they list as 10, that soundscape studies should address both a listener's experience of the acoustic environment of a place, as well as the sounds present in an environment. The proviso being that the ear conducts all identification and measurements. This broad definition allows the inclusion of memories of places as well as compositions/constructions.

Traditional methods for measuring auditory environments revolve around descriptions of the quantifiable loudness, pitch and timbre as well as sound events' duration and spatiality (Altman, 1992). Attempts have been made to communicate the experience of inhabiting soundscapes, most notably through maps, the first instance being by Granö in 1929. There is little evidence of adoption of these methods by professional audio practitioners, who concentrate on a sound's physical manifestation rather than its perception by a unique listener, which, Augoyard (1998) points out, is a laboratory abstraction.

Interest in the concept of the inhabited soundscape, and how this can be used within the traditional field of acoustics has gradually increased. The Positive Soundscapes Project was funded by the Engineering and Physical Research Council (EPSRC) and began in 2006 (EPSRC, 2006). This multidisciplinary approach incorporated both scientific and artistic practices and aimed to re-evaluate environmental sound from the listener's perspective. It further sought to extend the paradigm of noise control, as well as engender positive sound design (Davies *et al.*, 2009). The European Cooperation in the field of Scientific and Technical Research (COST) set up an action plan, TD0804: Soundscape of European Cities and Landscapes, in 2008 to create 'soundscape assessment and indicators' as well as 'tools to support designers and decision makers in planning and reshaping urban/rural spaces' (COST, 2008). Schiewe and Kornfield (2009) stated that TD0804 was not sufficiently ambitious and should include 'the geography of sounds', as the field is currently 'highly neglected'. There is also work being conducted on an international standard for the Perceptual assessment of soundscape quality (ISO, 2010).

There is some consistency across methods such as breaking down soundscapes into individual identifiable sound events. Recurring attributes have been identified such as spatial, dynamics, temporal, spectral, aesthetics, clarity, material and interaction (McGregor, 2011). Brown, Kiang and Gjestland (2011) proposed a standardized taxonomy for places and sound sources, but highlighted the wide variety of variables for soundscape preference measurements and how all of these will be affected by the experimenter effect (Kintz *et al*., 1965). Jennings and Cain (in-press) developed a three part framework for improving urban soundscapes based on the Kano model for product quality control (Kano *et al.*, 1984). All of the elements within a soundscape are described, considered in terms of whether they are positive to the activies be carried out, and any suitable interventions identified. Jenning's and Kains framework could be adopted for the evaluation of a broader range soundscapes if additonal attributes of sound were considered, and the interventions were to refine a design in order to bring the listeners' experiences closer to a designer's intentions. Cain, Jennings and Poxon (in-press) believe that more tools are required to be created for the design of soundscapes. This paper proposes a new tool for the design of soundscapes using the repertory grid technique.

Repertory Grid Technique

The repertory grid technique (RGT) is a proven method of elicitation based on Personal Construct Theory (PCT). Kelly (1955) first developed the technique in order to study personality, as constructivism relates to how interactions and experiences contribute to individuals' understanding of the world. Fransella and Bannister (1977) were the first to formalise the repertory grid technique. RGT has been used for sound studies such as establishing audio quality attributes (Berg, 2005), auditory display design (Brazil and Fernstrom, 2005, Garner, 2004), sound design for video (Cunningham, 2010), and generating a common terminology for describing sounds (Grill, Flexer and Cunningham, 2011). Grill, Flexer and Cunningham (2011) found that existing audio descriptors were mostly timbre related, and suggested that the RGT would be suitable for establishing constructs for a broader range of attributes such as temporal and dynamics. Within their study all of the 10 constructs had a Krippendorff alpha (agreement) below 0.6.

A common approach for repertory grid analyses involves four stages: element elicitation, construct elicitation, rating and analysis. All of the stages except for the analysis are normally conducted during a repertory grid interview. Elements are exemplars of the chosen research topic. Elements are used to identify constructs, which are polar opposite descriptions of the way in which individuals compare the elements. Elements are then rated using the constructs, typically using a three, five or seven point scale (Jankowicz, 2004). Two of the more common forms of analyses are hierarchical cluster analysis (dendogram/focus graph) and a non-hierarchical cluster analysis (pringrid) (Fransella, Bell and Bannister, 2004).

The technique used in this study has fixed elements and fixed constructs. The constructs were user and designer generated categories (see Table 1) (McGregor *et al.* 2006, 2007). Fixing the elements and the constructs allows comparisons and therefore matches to be calculated for the Soundscape Generative System (Gaines and Shaw, 1993).

Soundscape Generative System

Schirosa *et al.* (2010) developed a system where interactive soundscapes can be generated in real-time and streamed over the web. The Soundscape Generative System (SGT) extends Valle, Lombardo and Schirosa's GeoGraphy (2009), and can be used on its own or within a virtual reality engine. A soundscape is broken down into *sound zones*. Each sound zone contains *sound concept classes*, which are made up of either *atmosphere* or *sound events*. An atmosphere is a series of complex sounds that cannot normally be broken down into sound events. A sound event represents an individual, isolated sound. The generative sequencing of the sound concept is part of a *graph object*, which controls all of the replay parameters in real-time according to participants actions. The system was created using an audio programming language called SuperCollider (SC) (Wilson, Cottle and Collins, 2008). The stereo output of the SGT includes an HRTF model (Head Related Transfer Functions) so that listeners can experience 3D sound using stereo headphones, reducing the effect of inside the head locatedness (IHL). The sound designer records all of the original samples (concept class) and composes, or creates, a set of rules and parameters for the soundscape generation.

METHOD

Participants

One designer and 20 listeners took part in this study. The designer is an interaction sound design researcher, specialising in soundscape exploration and composition. The 20 listeners were a sample of convenience made up from staff and students at Edinburgh Napier University.

Materials

The designer provided a 4 minute and 4 second stereo audio recording created by the soundscape generative system. The 3D (HRTF) recording allowed listeners to experience sounds in a full 360º field. A recording was chosen rather than real-time generation to ensure consistency for each participant. The soundscape was an interpretation of the Plaza de Santa Ana in Las Palmas, Gran Canaria, Spain. The designer recorded the sound concept classes on location in Las Palmas. The designer was also responsible for creating the rules and parameters for the KML score.

Procedure

The designer supplied a list all of the sound events in the recording, this list became the elements (see Table 1). The designer then rated, on a 3 point scale, all of the elements while listening to the recording, using the supplied constructs (see Table 2).

Code	Description
AA	Pigeon
AB	Steps
AC	Children
AD	Fountain
AE	Footsteps
AF	Toll
AG	Cyclist
AH	Square Atmosphere
AI	Toll
AJ	Toll
AK	Toll
AL	Toll
AM	Footsteps
AN	Toll
AO	Bells Melody
AP	Fountain
AQ	Fountain
AR	Footsteps
AS	Steps
AT	Cyclist
AU	Fountain
AV	Fountain
AW	Fountain
AX	Fountain
AY	Pigeon

Table 1: Elements

Listener tests were conducted in a quiet office. Listeners were provided with fully enclosed stereo headphones connected to a laptop. Listeners were asked to listen to the audio recording and rate the elements using the supplied constructs. After listening to the entire recording listeners were played the relevant sections in order to rate the elements, the section was repeated as often as the listener required, repetition was infrequently requested.

Aware	Unaware
Left	Right
Back	Front
Speech	Sound effect
Gas	Solid
Impulsive	Continuous
Short	Long
High	Low
Loud	Soft
Informative	Uninformative
Pleasing	Displeasing
Clear	Unclear
Positive	Negative

Table 2: Constructs

After the listeners' responses were captured the first author calculated the mode for each element and construct using Microsoft's *Excel* 14.1.4, and then transferred the data to Centre for Person Studies' *Rep 5* v. 1.04. The designer's responses were inputted exactly as reported, and then RepSocio (part of Repgrid) was used to compare the grids.

RESULTS

The results can be split into four sections: designer, listeners, comparison and constructs. The designer's response can provide information about the intentions for a design. The listeners' responses can tell us something about what listeners are attending to. Comparing the grids can indicate the extent to which the listeners' and designer's responses match. Finally the suitability of the constructs can be explored for rating soundscapes such as the one included in this study.

Designer

The designer identified 25 elements (see Table 1), which were rated according to the 13 constructs (see Table 2). The elements fall into seven broad groups: bells (8), fountains (8), footsteps (5), pigeons (2), cyclist (2), children (1) and atmosphere (1).

All of the constructs were applied by the designer, although a single rating was used for 3 of the 13 constructs (see Figure 1). The designer was *aware* of all the elements so rated them all as 1. The designer considered all of the elements to be neither *pleasing* nor *displeasing* so the rating was a consistent 2. All of the elements were also rated as neither positive nor negative with a rating of 2. This meant that *pleasing* and *positive*, as well as *displeasing* and *negative* had a match of 100 (see Figure 1). The ratings of the elements was for the most part consistent, with the bell tolls (AF, AI, AJ, AL, AL, AN) having a match of 100. There were the same high levels of matches for the steps (AB, AS). The outlier of the elements was the square atmosphere which was the only element rated as *soft*.

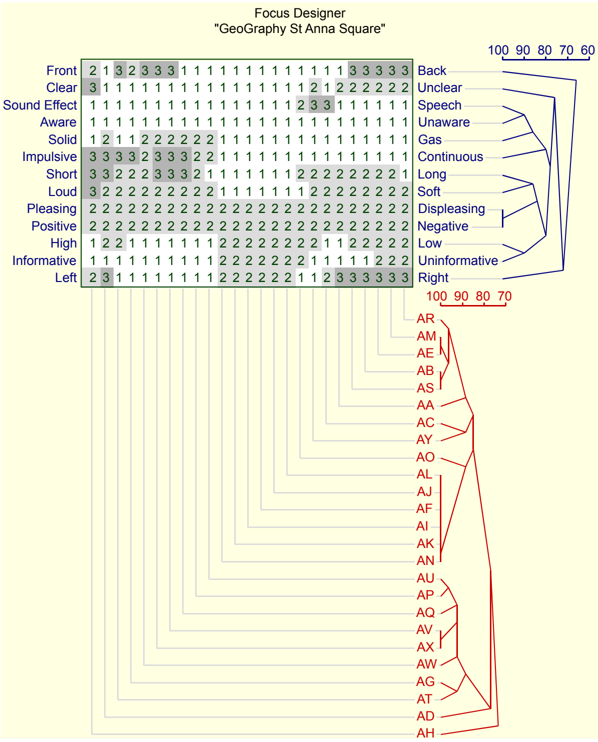

Figure 1: Focus graph for Designer

The Pringrid for the designer (Figure 2) confirms the clustering for the toll (AN, AL, AK, AJ, AI, AF). The steps (AR, AE, AB, AM, AS) are also clustered together. There is a wider range of variance for the fountains, but they are still within adjacent sectors.

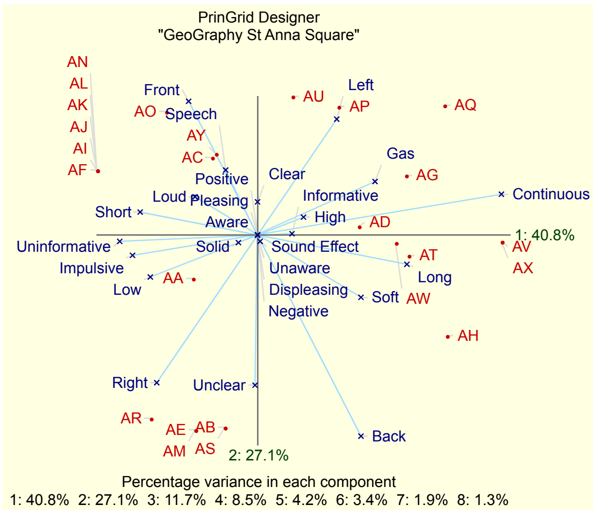

Figure 2: Pringrid for Designer

Listeners

The listeners' responses were aggregated to identify the mode for each element and construct. It was not possible to establish the mode for all of the constructs as insufficient responses were obtained for AT (Cyclist). The missing values are represented as question marks in Figure 3. The listeners' were predominantly unaware of AA, AS, AT and AY which were the pigeons, some steps and a cyclist.

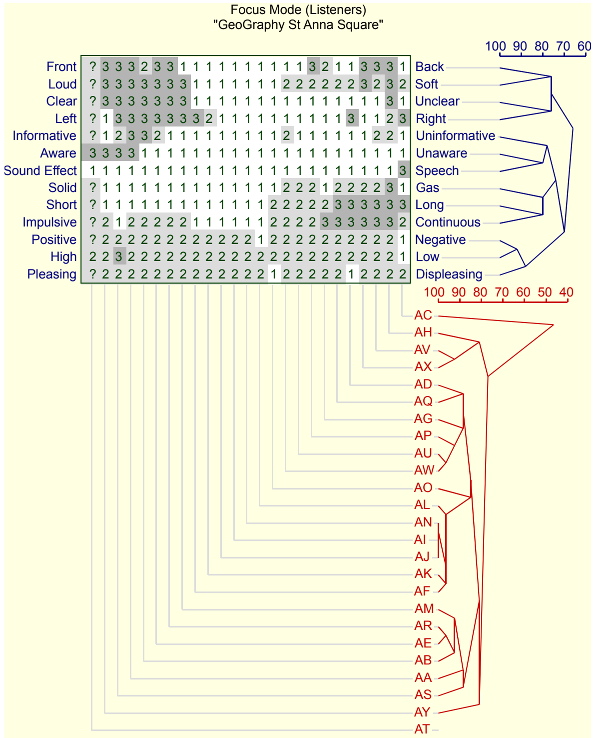

Figure 3: Focus graph for listeners

Listeners did experience the sound as surrounding them, with 12 of the elements being rated as in front of the listeners and 9 elements rated as coming from behind, only 2 were elements were rated as being neither in front of or behind. There is only a small amount of variation between the two. Only 2 of the elements were rated as being neither left or right with 13 being left and 9 right, showing a slight bias towards the left.

All of the elements except for the children (AC) were rated as a sound effect. Only a single element was considered to be a gas, the atmosphere (AH). All of the fountains (AD, AP, AQ, AU, AV, AW, AX) were neither gas nor solid and the remaining 16 elements were solid. The elements were more equally rated for the temporal construct with 7 being impulsive, 6 were continuous and 11 were neither. More of the elements (13) were rated as short, with 6 being long, 5 of which were also rated as continuous.

There was little variation in the spectral construct with 23 elements rated as neither high nor low. Only the children (AC) were rated as low, and 1 instance of the steps (AS) was high. In terms of dynamics the ratings were more evenly spread suggesting that this was an easier attribute to interpret. The majority of the elements (17) were rated as informative, with only 2 being uninformative (AA, AB). All but 2 of the elements (AD, AO) were neither pleasing nor displeasing. The bells melody and one of the fountains were positive. A similar bias towards the mid value was also the case with positive and negative, with all but 2 being neither positive nor negative. One of the bell tolls (AL) and the children (AC) were positive. The ratings for clarity were either clear (16) or unclear (8) with no mid values.

In the listeners' pringrid (see Figure 4) it is possible to see that AH (square atmosphere) is an outlier. All of the bell tolls are clustered together with a match of 88.5 or higher. The two pigeons had a match of 84.6 differing on location and level of information. All of the steps matched with 73.1 or above. The fountains had a lower level of match with only 57.7 or above. The two cyclists differed greatly with only a 15.4 match. The difference is mostly due to incomplete data as only two constructs were rated for AT compared to all 13 for AG.

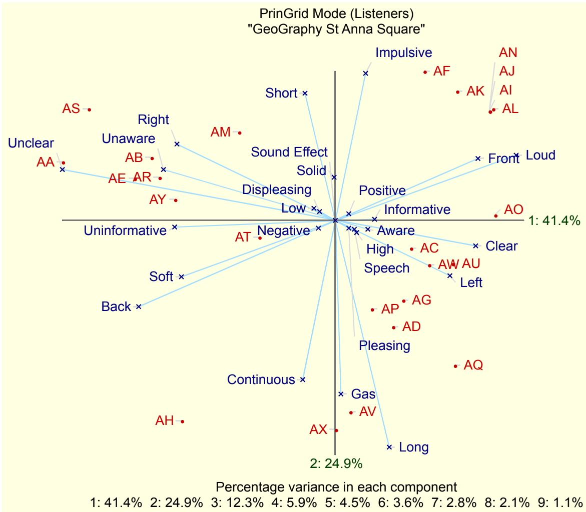

Figure 4: Pringrid for listeners

Comparison

When comparing the modal response for the listeners with the designer's response an overall match of 82.62 was achieved (see Figure 5). In the rectangle in figure 5 the white spaces represent a match, the numbers denote how much the responses differ. All but 6 (AA, AB, AM, AS, AT, AY) of the elements had a match of 80.8 or above. Both the pigeons 3 of the steps and 1 of the cyclists differed by more than 20. All of the constructs except for 2 had a match of 80 or above. The 2 exceptions (front/back, informative/uninformative) had matches of 72 and 62 respectively. Sound effect/Speech had the highest match at 94. Three additional constructs also had a match of 92 (pleasing/displeasing, positive/negative, solid/gas).

The designer was aware of all of the elements but the listeners were unaware of 4 (AA, AS, AT, AY). The designer rated left/right more evenly than the listeners who rated 2 as being neither left nor right, the designer rated 8 as being in the centre. With the front/back construct 6 of the elements were reversed by the listeners (AA, AM, AP, AT, AW, AY). There was little difference for the speech/sound effect construct with the only differences being that the designer rated one of the pigeons (AY) as speech, and the bell melody as music (AO) in contrast to the listeners who rated them both as sound effects. Solid and gas were similarly close, with the variation being that the designer thought that the square atmosphere (AH) was solid and listeners rated it as a gas. The ratings were incomplete for AT (cyclist).

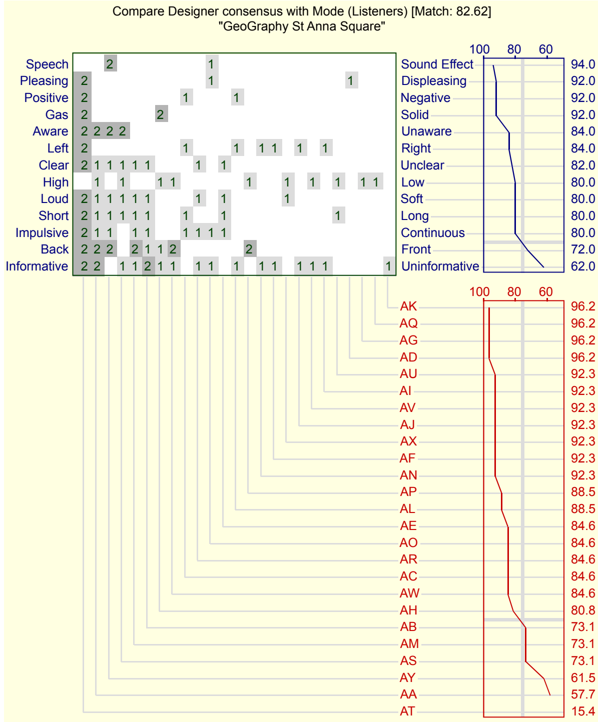

Figure 5: Comparison of designer's and listeners' grids

The designer rated more elements as impulsive than the listeners (designer = 13, listeners = 7). Elements such as the children, pigeons and footsteps were rated as neither impulsive nor continuous by the listeners, whereas the designer rated them as impulsive. The number of elements rated for continuous only differed by 1 element, which was again the missing data for AT. The listeners considered the majority of the elements (13) to be short, in contrast the designer rated the majority (12) as neither short nor long. The number for long differed by only 1 element (AC = children), which the designer rated as neither short nor long.

The listeners rated almost all of the elements as neither high nor low, in contrast the designer rated an additional 10 elements as high. Only a single element was rated as low, the steps (AS) were rated as neither high nor low by the designer. In terms of loud and soft the designer rated the majority of elements (17) loud nor soft, in contrast the listeners responses were more evenly spread. Only a single element (AH = square atmosphere) was rated as soft by the designer, which the listeners also rated as soft. The ratings for loud were identical for both the designer and listeners.

The greatest difference between the designer's and listeners' responses was in the ratings for informative and uninformative. The designer rated all of the elements as either informative (15) or neither informative nor uninformative (10). The listeners rated AA and AB as uninformative. The designer rated the fountains as informative in contrast to the listeners who rated the bell tolls as informative. The designer and listeners were predominantly consistent for pleasing and displeasing with only 3 elements not matching (AT, AO, AD). No elements were rated as displeasing, the designer rated all of the elements as neither pleasing nor displeasing. The listeners rated the first fountain (AO) and the bell melody (AD) as pleasing.

With regards to clarity the designer's and listeners' responses matched for clear elements. The ratings for the footsteps differed (AB, AE, AM, AR, AS) with the designer rating the elements as neither clear nor unclear, the listeners rated the elements as unclear. The listeners did not rate any elements as being neither clear nor unclear. The designer rated all of the elements as being neither positive nor negative, the listeners did the same, except for AC (children) and AL (toll).

Constructs

In the composite pringrid showing only the constructs, it is possible to illustrate patterns of similarity and the amount of variance for a construct (see Figure 6). The angle between construct lines denotes the correlation, and the length represents the variation in ratings (Jankowicz, 2004). In order to identify constructs that are essentially identical it is necessary to establish the level of match (see Table 3). There are four measures to calculate for each pair of constructs: designer (D); listeners (L); designer's construct A and listeners' construct B (DL); listeners' construct A and designer's construct B (LD).

Construct A	Construct B	D	L	D L	L D
Pleasing/ Displeasing	Negative/ Positive	100	88	92	92
Pleasing/ Displeasing	Positive/ Negative	100	88	92	92
Aware/ Unaware	Sound effect/ Speech	90	80	96	82

Table 3: Construct matches (≥ 80), D = Designer L = Listeners, DL = designer construct A, listener construct B, LD = listener construct A, designer construct B

If a threshold of 80% match is set, which is the default setting in RepGrid 5, then only three pairs of constructs are identified out of a potential 156. The first is pleasing/displeasing, which has a mean match of 93 with both negative/positive and positive/negative. This very high level of match is partly due to the designer rating all of the elements as neither pleasing nor displeasing as well as neither positive nor negative. In addition the listeners rated 20 out of the 25 elements as neither pleasing nor displeasing. The second pair of constructs with a high level of match (average = 87) was aware/unaware and sound effect/speech. The designer was aware of all of the elements, and all but 3 elements were speech. The listeners were aware of all but 4 elements, and all but 1 were speech. There were a number of other pairs of constructs that had a match

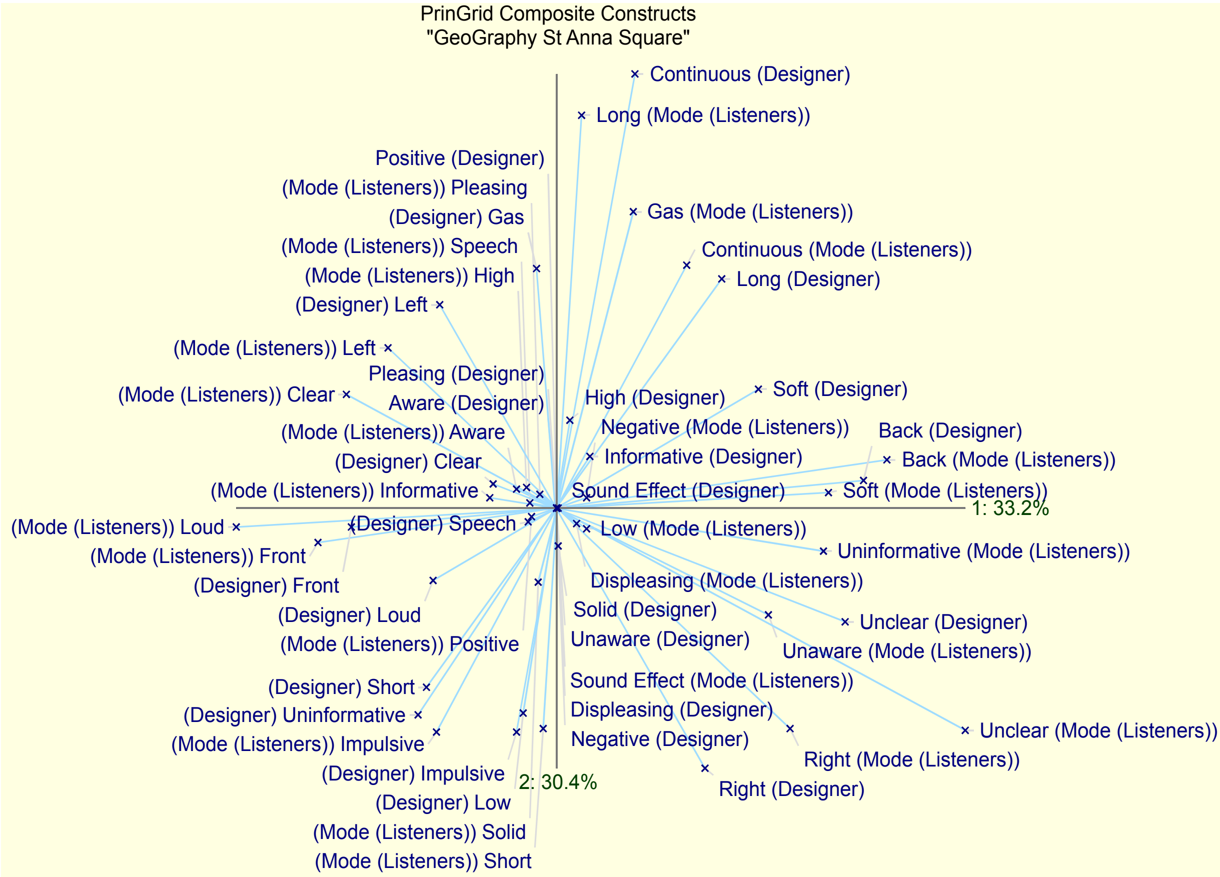

Figure 6: Composite pringrid of components for designer and listeners

above 80, such as high/low and pleasing/displeasing, but when the designer's and listeners' ratings were compared, the match fell below the 80% threshold.

DISCUSSION AND CONCLUSIONS

The aim of this study was to continue on-going work into establishing whether listeners have the same experience as designers and what the consequences are. With a match of 82.62 it could be argued that in this study the designer and the 20 listeners had a similar, but not identical, experience. The main differences were in terms of whether an element was informative or uninformative and if an element was in front or behind the listener. All of the other constructs had a match of 80 or higher, when comparing the designer's and listeners' ratings. Informative/uninformative had a match of 62 and front/back was 72, suggesting that there was a different listening experience.

The nature of whether an element was informative or uninformative could be part of the nature of design. All of the elements were included in the design in order to convey information about the soundscape that the listener was inhabiting, hence the designer not rating any elements as uninformative. Listeners found the elements that were uninformative to also be soft and unclear, but other elements with this combination were rated as informative, so it is not possible to establish the reason for the difference from the current data.

Problems with front and back confusion have been well documented (Wightman and Kistler, 1989, Schnupp, Nelkin and King, 2011). The issue can be partially resolved through head movement, but this was not possible due to the lack of head tracking hardware in this study. Head-tracking hardware has been shown to be effective with only some participants (Wersenyi, 2009). The lack of head tracking meant that the positions of elements remained constant in relation to the listening position. Even allowing for technical constraints Raimbault, Lavandier and Berengier (2003) experienced problems with spatial qualities and ambient sound assessment, citing Berg and Rumsey (1999) experiments with recordings, which also used RGT.

Two pairs of constructs were strongly associated pleasing/displeasing and negative/positive, which suggests that the constructs were interpreted similarly. Further work will be required to establish which construct remains or if a new pair is required. Awareness could be considered redundant, as it was always a binary response and a lack of awareness could be conveyed through absent data. If the awareness construct were removed then the close association would no longer be of concern.

The high match level for the remaining 11 constructs suggest that it is possible to compare designers' and listeners' experiences in order to check specific instances and the consensus. The high level of match is confirmed by the rating of the elements with 19 out of 25 elements having a match greater than 80. Five of the remaining elements had a match greater than 50, with only a single element below 50 (15.7).

Comparing listeners' experiences could allow designers to be confident with their designs. Specific instances as well as the consensus can be established, and the number of participants can be easily scaled up. Kang and Zhang (2010) suggest that 100-150 would be an appropriate sample size for soundscape evaluations. The level of granularity can also be varied, as it is common to use 5 or 7 point scales for rating when using the repertory grid technique.

ACKNOWLEDGMENTS

We thank the 20 volunteers from Edinburgh Napier University who took part in this study. We would also like to thank the designer, Mattia Schirosa for providing the sound design and taking part.

REFERENCES

Altman, R. (1992). The Material Heterogeneity of Recorded Sound. In R. Altman (Ed.), *Sound Theory/Sound Practice* (pp. 15-31). New York: Routledge.

Augoyard, J.-F. (1998). The Cricket Effect: Which tools for research on sonic urban ambiences? In H. Karlsson (Ed.), *Stockholm, Hey Listen!* (pp. 116-125). Stockholm: KMA.

Bech, S. (1992). Selection and Training of Subjects for Listening Tests on Sound-Reproducing Equipment. *Journal of the Audio Engineering Society, 40*(7/8), 590 - 610.

Bech, S., & Zacharov, N. (2006). *Perceptual Audio Evaluation*. Chichester, West Sussex: Wiley.

Berg, J. (2005). *OPAQUE – a tool for the elicitation and grading of audio quality attributes.* Paper presented at the 118th AES Convention.

Berg, J., & Rumsey, F. (1999). Identification of Perceived Spatial Attributes of Recordings by Repertory Grid Technique and Other Methods. Paper presented at the 106th AES Convention.

Brazil, E., & Fernström, M. (2009). Subjective experience methods for early conceptual design of auditory display. Paper presented at ICAD2009.

Brown, A. L., Kang, J., & Gjestland (2011). Towards standardisation in soundscape preference assessment. *Applied Acoustics*(72), 387-392.

Cain, R., Jennings, P., & Poxon, J. (in-press). The development and application of the emotional dimensions of a soundscape. *Applied Acoustics*.

COST (2008). *Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action TD0804: Soundscape of European Cities and Landscapes* Brussels: European Cooperation in the field of Scientific and Technical Research

Cunningham, S. (2010). *Applying personal construct psychology in sound design using a repertory grid*. Paper presented at the Proceedings of the 5th Audio Mostly Conference.

Davies, W. J., Cain, R., Carlyle, A., Hall, D. A., Hume, K. I., & Plack, C. J. (2009). The positive soundscape project: a synthesis of results from many disciplines *Internoise 2009, 23-26 August 2009,* . Ottawa, Canada: Internoise.

Engelen, H. (1998). Sounds in Consumer Products. In H. Karlsson (Ed.), *Stockholm, Hey Listen!* (pp. 65-66). Stockholm: The Royal Swedish Academy of Music.

EPSRC (2006). The Positive Soundscape Project: A re-evaluation of environmental sound Retrieved February, 27, 2010, from http://gow.epsrc.ac.uk/ViewGrant.aspx?GrantRef=EP/E011624/1

Fransella, F., & Bannister, D. (1977). *A manual for repertory grid technique*. New York: Academic Press.

Fransella, F., Bell, R., & Bannister, D. (2004). *A Manual for Repertory Grid Technique* (2nd ed.). Chichester, UK: John Wiley & Sons.

Gaines, B. R., & Shaw, M. L. G. (1993). Knowledge Acquisition Tools based on Personal Construct Psychology. *The Knowledge Engineering Review, 8*(1), 49-85.

Garner, S. C. (2004). *Data set selection for a constrained simple sonification.* Paper presented at ICAD2004.

Granö, J. G. (1929). Reine Geographie. *Acta Geographica, 2*, 1-202.

Grill, T., Flexer, A., & Cunningham, S. (2011). *Identification of perceptual qualities in textural sounds using the repertory grid method.* Paper presented at the 6th Audio Mostly Conference.

ISO (2010). TC43/SC1: Noise Retrieved February, 27, 2010, from http://www.iso.org/iso/standards_development/technical_committees/other_bodies/iso_technical_committee.htm?commid=48474

Jankowicz, D. (2004). *The Easy Guide to Repertory Grids*. Chichester, UK: John Wiley & Sons.

Jennings, P., & Cain, R. (in-press). A framework for improving urban soundscapes. *Applied Acoustics*.

Kang, J., & Zhang, M. (2010). Semantic differential analysis of the soundscape in urban open public spaces. Building and Environment, 45(1), 150-157.

Kano, N., Seraku, N., Takahashi, F., & Tsuji, S. (1984). Attractive Quality and Must-be Quality. *Quality: The Journal of the Japanese Society for Quality Control, 14*(2), 39-48.

Kelly, G. (1955). *The Psychology of Personal Constructs*. New York: W W Norton.

Kerins, M. (2011). *Beyond Dolby (stereo): cinema in the digital sound age*. Bloomington, IN: Indiana University Press.

Kintz, B. L., Delprato, D. J., Mettee, D. R., Persons, C. E., & Schappe, R. H. (1965). The experimenter effect. *Psychological Bulletin, 63*(4), 223-232.

McGregor, I. (2011). *Soundscape Mapping: Comparing Listening Experiences*. Saarbrücken, DE: LAP.

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., Crerar, A., Benyon, D., & Leplatre, G. (2007). Establishing Key Dimensions for Reifying Soundfields and Soundcapes from Auditory Professionals *ICAD 2007*.

Raimbault, M., Lavandier, C., & Berengier, M. (2003). Ambient sound assessment of urban environments: field studies in two French cities. *Applied Acoustics, 64*(12), 1241-1256.

Rumsey, F. (1998). *Subjective Assessment of the Spatial Attributes of Reproduced Sound.* Paper presented at the AES 15th International Conference.

Schafer, R. M. (1977). *The Tuning of the World*. Toronto: McClelland and Stewart Limited.

Schiewe, J., & Kornfeld, A.-L. (2009). Framework and Potential Implementations of Urban Sound Cartography *12th AGILE International Conference on Geographic Information Science*.

Schirosa, M., Janer, J., Kersten, S., & Roma, G. (2010). *A system for soundscape generation, composition and streaming*. Paper presented at the XVII CIM - Colloquium of Musical Informatics.

Schnupp, J., Nelken, I., & King, A. (2011). *Auditory Neuroscience: Making Sense of Sound*. London: MIT Press.

Soderholm, M. (1998). *Listening Test as a Tool in Sound Quality Work: Applied to Vacuum Cleaners* (MSc). Stockholm: KTH.

Sonnenschein, D. (2001). *Sound Design: The Expressive Power of Music, Voice and Sound Effects in Cinema*. Studio City, CA: Michael Wise Productions.

Tardieu, J., Susini, P., Poisson, F., Kawakami, H., & McAdams, S. (2009). The design and evaluation of an auditory way-finding system in a train station. *Applied Acoustics, 70*(9), 1183-1193.

Valle, A., Lombardo, V., & Schirosa, M. (2009). A Graph-based System for the Dynamic Generation of Soundscapes. In M. Aramaki, R. Kronland-Martinet, S. Ystad & K. Jensen (Eds.), *Proceedings of ICAD 2009*.

Wersenyi, G. (2009). Effect of Emulated Head-Tracking for Reducing Localization Errors in Virtual Audio Simulation. *IEEE Transactions on Audio, Speech, and Language Processing, 17*(2), 247-252.

Wilson, S., Cottle, D., & Collins, N. (2008). *The SuperCollider Book*. Cambridge, MA: The MIT Press.

Yang, W., & Kang, J. (2005). Acoustic comfort evaluation in urban open public spaces. *Applied Acoustics, 66*(2), 211-229.