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Comparative Evaluation of Radio and Audio Logo Sound Designs

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The testing of sound designs often involves only expert evaluations; training is commonly required when non-experts participate, which can alter the listening experience. This paper presents a method of evaluating sound designs for radio and audio logos that avoids listener training. Sound designs incorporating sound effects, music or dialogue can be broken down into discrete sound events that can then be rated using attributes of sound meaningful to both designers and listeners. Two examples are discussed, a radio drama, and a set of audio logos. Both of which were tested using a repertory grid approach. The paper shows that the method can highlight similarities and differences between designer and participant listening experiences. Comparing listening experiences could allow designers to be more confident about the reception of their sound designs.

0 INTRODUCTION

Sound can be designed for a wide variety of purposes from media through to products. Sound designers working in radio and audio logos routinely manipulate the attributes of music, sound effects and dialogue as part of their everyday practice. In order to work effectively, audio professionals have to spend a considerable amount of time learning to listen critically [1]. Listening is an active process that is dependent on previous experiences and training, amongst other factors such as context and emotional state. In contrast, hearing is a passive process where an individual is exposed to a sensation, which is not necessarily perceived [2]. Critical listening is when an assessment of a sound's spectral, dynamics and spatial characteristics is made so that changes could be applied to an audio signal. The translation of the perceived aspects of a sound into parameters that can be technically manipulated is termed isomorphic mapping, and is an essential skill for any audio professional [3].

In order to establish listeners' experiences of sound designs it is important to elicit responses from non trained listeners. Coleman [4], whilst developing a sonic mapping tool to aid interaction designers, highlighted the distrust that some sound designers have for non experts' descriptions of auditory environments, instead preferring to rely on their own experiences as "expert listeners" (p.264). This mistrust may be due to non-experts typically requiring training to describe what they are listening to in terms that are meaningful to designers, but Coleman does suggest that the reasoning behind this might be design-centric industries, like video games, that have yet to fully embrace user centred design approaches.

When the quality of audio reproduction is addressed, Rumsey [5] tells us that there are high levels of agreement between experts, whereas non-experts show greater variability. There can often be dispartities between measurements and evaluations, Yang and Kang [6] attribute much of this variability in listeners' experiences to the different types of sound sources and levels of perceived pleasantness. Tardieu *et al.* [7] warn that laboratory tests of sound signals do not fully correspond with tests conducted under real world conditions.

One approach to eliciting listener responses is through the use of audio taxonomies; methods of describing sounds using readily identifiable concepts and terms [8]. To a limited extent, the taxonomies of auditory experiences have been explored for sound design purposes [9-11]. The intent has mostly been upon communication between auditory professionals, rather than as a mechanism for comparing listener and designer experiences [12, 13]. This work takes into account end-user listening experiences, in a manner that is conducive to design work, by comparing designers' and listeners' experiences of sound designs using repertory grids.

Radio is unique among the other forms of media in that it relies on sound in isolation to communicate information, atmosphere and emotion. Radio has often been referred to as theatre of the mind for the reason that sounds are designed to create images [14]. Crook [15] defined the listener's imagination as the fifth dimension within radio drama, the first four being dialogue, music, sound effects, and post-modernist inclusion of pre-existing recordings. Like theatre, radio from its

mainstream inception in the 1920's through to the late 1950's, was produced live, and borrowed much from the theatrical world, using sound to involve the listener [14].

Sieveking [16] states that radio sound effects can be realistic, symbolic or impressionistic. Signposts contained within dialogue, such as a reference to rain, can be confirmed by the sound of heavy rain falling onto a tiled roof. This is similar to anchorage [17], where captions provide links between images and their context [15]. Sound effects can also be used as signifiers, with the sound itself being the signpost. For example, a train whistle might suggest to the listener that a train is nearby. When the sound of multiple footsteps in a reverberant environment is added, the listener is transported to a train station with the suggestion of travel and parting. Abstract rhythmic non-musical sound can be used to symbolise emotions, for example, the almost inaudible sound of thunder suggests a character's internal unrest. Altered states of consciousness can be denoted by dreamlike sounds that indicate a character's inner fantasy world, such as gentle wind suggesting they are dreaming. One of the most influential sound effects is silence; durations of up to five seconds can be effective [18]. However, dramatic pauses can be perceived as dead air, implying a technical fault [19].

In radio drama, sound design is extensively applied through the use of signposts. If this is done successfully then there is no need to describe the setting in the script, as listeners have extensive experience of polysonic environments [20]. Signposts only work if the sounds are readily recognisable [19]. The amount of reverberation applied, for example, provides information about whether the scene is set indoors or outdoors, as well as the size and type of room [21]. Certain sounds are associated with location or time of day, by way of example, a cockcrow indicates daybreak in the countryside [22]. A pragmatic approach is often adopted in drama where sound effects are mixed unnaturally low to aid dialogue clarity as well as to help prevent audience fatigue and disengagement [23]. Radio, more than any other medium, generates remarkable interest by listeners in the accuracy of sound effects. A simple mistake of a bird that is heard to sing in the wrong month can generate a number of letters of complaint [21, 24].

Audio or sonic logos (sogos) are commonly short (0.5 to 3 second) musical phrases played on a single instrument, occasionally with sound effects (sound icons) and/or dialogue. Sound icons are sounds strongly associated with the product or brand, such as a cereal crunch or a bottle top popping open [25]. Audio logos were first identified in the 1980's as a method of increasing the effectiveness of radio advertising, and stem from advertising jingles, but sound marks have been trademarked since 1950. Treasure [26] argues that they have been in use for centuries by artisans calling out their services or wares in public. Audio logos are a form audio mnemonic and are used across a wide variety of media to provide a strong association with a brand or company [27]. It is paramount that they are recognised and remembered without requiring repeated exposure. Surprisingly, the more irritating an audio logo is the more memorable it is [28]. However, this irritation can be detrimental, as in the case of Nokia, where the company utilised their most recognisable ringtone as an audio logo. This decision led to adverse associations with the brand due to over exposure as part of normal mobile phone use [29].

Audio logos can direct listeners towards an advertising opportunity and effective design can potentially create a strong psychological bond with patrons and a brand [26]. Using audio as a logo can aid differentiation between brands in a crowded market, especially with preoccupied audiences, whilst you can easily choose not to watch, it is more difficult to choose not to hear [30]. A logo is often made up of components that can be used beyond advertising such as: call management, tele-sales and customer services, or even shopping centres and offices [28]. Krishnan *et al.* [31] suggest that the number of tones in an audio logo affects the "willingness to pay" for a product and that in-depth studies are required in order to create effective audio logos. Most of what is heard relies on memory and psychological state to efficiently convey meaning, context is a key factor if an audience is going to understand and recognise an audio logo, especially if they are going to be iconically coupled [32, 33].

Listening tests are (and have been since at least 1956) commonplace in the field of product design, where experienced listeners (those who have previous experience with listening tests) are preferred. It is believed that expert listeners provide more consistent responses, which improves a test's reliability [34, 35]. When expert listeners are not available, it is accepted practice practice to train listeners to become experts [36]. However, there is a high risk of prejudicing results when this approach is adopted [37]. Listener testing has so far been limited to products such as audio reproduction equipment, audio codecs, vehicles, and vacuum cleaners, and has not migrated into mainstream media, and only partially into computing [38]. In addition, consumers who utilize these products are not necessarily 'expert' listeners, therefore, there might be a need to develop more ecological approaches to conducting listening tests.

In work that deals with assisting in sound design tasks for non-experts, in the field of video game development, Alves and Roque [39, 40] advocate design patterns, in the form of physical tokens that are representative of sound. These tokens are a deck of cards that are used to assist in the task of designing sound, with a focus on allowing game developers to produce effective sound without having to recruit, or become audio, specialists. Similar to the work presented here, their system attempts to bridge the gap between the expert and non-expert through the form of common vocabulary and media based upon background research in the literature as well as input from game industry professionals. However, a notable difference is that their work is predominantly concerned with empowering non-experts to obtain a sound design goal, rather than to mediate between the expert and non-expert. Their work demonstrates the feasibility and effectiveness of mediated vocabulary in sound design. A notable aspect that separates it from the investigation

presented here, is that they employ a vocabulary predominantly, though not exclusively, concerned with describing the function of sound within the game environment, rather than describing audio qualities or features of sound.

Ramsgaard [41] suggests that profiling logos according to their emotions can provide insight about their impact. Treasure [26] agrees, stating that the Geneva Emotional Musical Scale (GEMs) can help prove whether an audio logo works, but it's commercial use is prohibited [42]. Vocal attributes, such as clarity and volume have been considered for choosing vocal talent for sonic logos, but not for evaluating its effectiveness with listeners [28]. Beckerman and Gray [43] point out that when questioning focus groups about what they are listening to the results are prejudiced to such an extent that they are pointless, as the experience should be unconscious.

The method that we present here uses repertory grids in order to connect designers' and end users' listening experiences without the need for specialized training. The repertory grid technique (RGT) is a proven method of information elicitation based on Personal Construct Theory (PCT). Kelly [44] 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 [45] were the first to formalise the repertory grid technique. Based upon the principles of constructivism, described in the work of Piaget [46], the RGT effectively becomes akin to a projective test in the discipline of psychology, such as that of the Thematic Apperception Test (TAT), where participants are provided with an ambiguous stimulus, commonly an image in the case of TAT, and required to describe and interpret the stimulus using their own words [47]. This process necessitates drawing upon their own experiences and constructing a description of the stimulus. As far as the RGT is concerned, this feature can be restricted, by providing participants with pre-defined constructs, rather than requiring participants to develop them. One notable difference from the use of RGT in sound and the TAT is that in a TAT experiment subjects are typically required to construct a narrative around the stimulus, whereas RGT seeks short, descriptive constructs.

The RGT has been used for a number of sound studies purposes such as establishing spatial audio quality attributes [48, 49], auditory display design [50, 51], video sound design [52], as well as generating a common terminology for describing sounds [53]. Kjeldsen first poposed the RGT for measuring personal preferences for listening tests in 1998, arguing that it could capture the reasoning behind individuals' choices through elicitation personal reflections [54]. Berg and Rumsey [55] were concerned with the vagueness of descriptors often used to describe listening experiences of reproduced sound, as well as inherent bias where trained participants only provide responses they were "trained to provide" (p. 53). They utilised RGT to develop a method for capturing listeners' experiences of spatial attributes, and were able to successfully elicit shared constructs for reproduced sound. Grill, Flexer and Cunningham [53] 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 parameters and dynamics. All of the stages except for the analysis are normally conducted during a repertory grid interview. Elements are exemplars of the chosen subject of study. Elements are used to identify constructs, polar opposite descriptions of the way in which individuals compare elements. Elements are then rated using the constructs, typically using a 3, 5 or 7 point scale [56]. Two of the more common forms of analyses are hierarchical cluster analysis (dendogram/ focus graph) and non-hierarchical cluster analysis (pringrid) [57].

This study aims to explore the suitability of capturing designers' and listeners' experiences of a sound design for a radio drama and audio logos using repertory grids.

1 METHOD

Two designers and 40 listeners took part in this study. The first designer is a sound effects artist who specialises in radio drama. The second designer creates sound identities for company brands. The 40 listeners were a sample of convenience made up from staff and students at Edinburgh Napier University. The participants all considered themselves to be without hearing difficulties, and ranged in age from early twenties through to early fifties. Both male and female participants took part with a ratio of approximately 2:1. There was an almost equal mix of UK native, mainland european and rest of world participants, all of whom were fluent in English. Educational background ranged from secondary school, through to undergraduate and postgraduate. None of the participants had studied media, music, design or a similar field, so could be considered untrained listeners. Recruitment was conducted face-to-face by approaching a wide variety of indivduals on campus, with approximately 20% of those approached agreeing to take part. There were no financial incentives in accordance with Edinburgh Napier University ethical guidelines. The first twenty participants listened to the radio drama, and the remaining twenty listened to the audio logos. Participants were able to complete all tasks without prompting, no requests for clarification were made during the sessions by any of the participants, who all anecdotally found the questions easy to answer.

1.1 Materials

For the radio drama case the designer created all of the sound effects using physical props, which he layered on top of a previously recorded 42 second section of a dialogue track for a radio drama (see Table 1). Manual sound effects are a popular way of creating radio sound effects as they are easily synchronised with actions and dialogue [58]. The scene covers the arrival of a safecracker to a home run by crooks posing as aristocrats. The criminals need some papers that have been locked in a desk safe in their house. The action includes a crook sending off a henchman (AB), a doorbell ringing (AA), a butler answering a door (AE & AF), a safecracker

coming in (AF & AH), trying the safe (AI), and then being greeted by the crooks/aristocrats (AL & AN).

The files were recorded and mixed in mono, so there were no panning cues and the designer considered there to be no depth cues. Mono compatibility is an important issue for broadcast listeners, as summing stereo signals can mean that sounds are artificially loud if they are panned to the centre compared to left or right [59].

Table 1: Radio drama sound events by code

Code	Description	Code	Description
AA	Ringing bell (doorbell)	AH	Sid's footsteps
AB	Butler's Voice	AI	Safe Door jiggled
AC	Girl's voice	AJ	Tools put down
AD	Butler Footsteps	AK	Woman's footsteps enters
AE	Door opens	AL	Woman's voice
AF	Sid's voice	AM	Chetwood enters
AG	Door closes	AN	Chetwood's voice

The second design consisted of a series of Audio logos. Four different Audio logos were trialled, varying in length from 4 to 6 seconds (see Table 2). *Speech* and *music* were present in all four audio logos, but *sound effects* were only included in three. The first audio logo was named *Classico* and consisted of a discordant door (AA), some plucked strings (AB) and the company's name (AC). The second audio logo was called *Folcklore* and had 'birds' (AD), a 'classical guitar' (AE), a drum (AF) and the company's name (AG). The third audio logo (*Piano*) was the simplest containing only a 'piano' (AH) and the company name (AI). The last audio logo (*Piano2*) was the most complicated with a 'door' (AJ), 'voice' (AK), 'wood knocks' (AL), 'drum' (AM), and 'piano' (AN).

Table 2: Sound effects design sound events by code

Code	Description	Code	Description
AA	Wooden Country side door (Audio Logo 1/Classico)	AH	Piano (Audio Logo 3/Piano)
AB	Plucked Strings (Audio Logo 1/Classico)	AI	Voice "xxxxx" (Audio Logo 3/Piano)
AC	Voice (Audio Logo 1/Classico)	AJ	Door (Audio Logo 4/Piano2)
AD	Birds (Audio Logo 2/Folcklore)	AK	Voice "xxxxx" (Audio Logo 4/Piano2)
AE	Classical guitar (Audio Logo 2/Folcklore)	AL	Wood knocks (Audio Logo 4/Piano2)
AF	Leather bass drum (Audio Logo 2/Folcklore)	AM	Leather bass drum (Audio Logo 4/Piano2)
AG	Voice "xxxxx" (Audio Logo 2/Folcklore)	AN	Piano (Audio Logo 4/Piano2)

The designer supplied mono files, which is common for this industry. Audio logos typically form part of an advert or some other promotional material, where listeners are often at a great distance from the reproduction source, which means that any stereo output is summed to mono by the time it reaches the listeners ears [60]. Designing the logos in mono prevents any phase issues being introduced, which can affect clarity, and therefore the impact of the audio logo.

1.2 Design

The repertory grid technique used in this study has fixed elements and fixed constructs. Fixing the elements and the constructs allows comparisons, and therefore matches to be calculated for both the designers and the listeners [61]. The elements were the individual sound events which made up the design, and were provided by the respective designers. The constructs used in this study were user and designer generated categories taken from two earlier studies (see Table 3).

Table 3: Constructs used in the study on a rating system 1-2-3

Left (1)	Neither left nor right (2)	Right (3)
Front (1)	Neither front nor back (2)	Back (3)
Speech (1)	Neither speech nor sound effect (2)	Sound effect (3)
Impulsive (1)	Neither impulsive nor continuous (2)	Continuous (3)
Short (1)	Neither short nor long (2)	Long (3)
High (1)	Neither high nor low (2)	Low (3)
Loud (1)	Neither loud nor soft (2)	Soft (3)
Informative (1)	Neither informative nor uninformative (2)	Uninformative (3)
Pleasing (1)	Neither pleasing nor displeasing (2)	Displeasing (3)
Clear (1)	Neither clear nor unclear (2)	Unclear (3)

The constructs were based on the principle of a common language, having been derived from a lexicon generated from descriptions used by 40 listeners to describe what they were listening to [62] and a questionnaire where 75 audio professionals were asked for terms that they used to describe sounds [63]. This meant that the resultant terms should ideally be

meaningful to both groups. The listeners were an entiely different group from the participants who took part in this study, but like the listeners in this study none of the participants had studied media, music, design or a similar field, and so could also be considered untrained listeners [60]. Similarly the 75 audio professionals were a separate group, all of whom had extensive professional audio experience in either acoustics or sound design [63], neither of the sound designers from this study were part of the audio professionals study. The audio professionals represent a wider group than sound designers of Radio Drama or Audio Logos, but as all of the audio professionals regularly utilise critical listening, and are therefore trained listeners, the constructs should be appropriate for this experiment. Providing constructs does not affect the importance of the results as long the constructs are relevant to the elements and the participant [57]. Listeners and designers were not asked to identify their level of agreement about how well a construct applied to a given sound, and therefore did not take part in validating the constructs.

1.3 Procedure

To begin with, each designer supplied a list of all the sound events in the sound design to be tested, and classified each sound according to the rating system of constructs. Listener tests for both the radio drama and audio logos were conducted in an auralisation suite using fully enclosed stereo headphones. Listeners were asked to listen to an audio recording and verbally rate the elements using the supplied constructs. Each construct allowed three choices for rating, e.g. pan (*left/right*) could have a value of 1 (left), 2 (neither left nor right) or 3 (right). Listeners could replay the files as often as they wished, and were made fully aware of the context of use for the two designs. As suggested by Fransella *et al.* [57] all of the particpants were questioned verbally, with the construct values being entered into each grid within the Rep 5 software by the first author (see Figure 1). This approach prevents participants from visually comparing ratings for previous elements during the study.

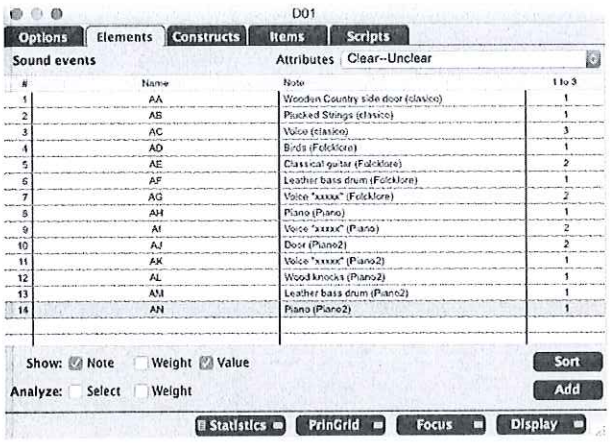

Figure 1: Rep 5 Elements window for inputting Designer's construct values (Radio Drama)

Rep 5 software can be used to build and analyse repertory grids [64]. A common technique of analysing repertory grids is through focus graphs, which brings elements and constructs together according to how closely they are matched and displays the similarity in terms of percentage, utilizing algorithms originally published by Shaw in 1980 [65]. The technique can be extended using RepSocio in order to compare grids from different participants, which calculates the percentage match between grids for elements (red), constructs (blue) and overall, normally displaying the results heirarchically (see Figures 2 and 4).

According to Fransella *et al.* [57], citing the work of Metzler *et al.* [66], the number of points on the rating scale only have a limited impact upon the results, except for the number of 0 ratings, which increase in an evaluative 3 point scale. It is also suggested that the order in which ratings are made does not affect the results, so listeners were asked to classify an element using all of the constructs, rather than to rate all of the elements using one construct before moving on. Working in this direction allowed listeners to concentrate on a single sound event (element) rather than have to repeat elements (sound events) in order to become familiar with them again. Following the advice of Fransella *et al.* [57] a non-evaluative scale (1 - 3) was chosen over an evaluative scale (+1 0 -1) as specifying which pole is considered positive (+) and which is negative (-) might bias results. Whereas using a scale of 1 – 3 gives no indication about whether a pole is considered beneficial or detrimental to the sound design. RepSocio (part of Repgrid) was used to compare the designers' and listeners' grids.

2 RESULTS

The results are presented by test condition: radio drama and audio logo. For each condition we discuss designer-listener evaluations with regard to both individual sound events and constructs. Statistical significance was not calculated since the RGT is an exploratory technique and the aim of this study is predominantly concerned with the efficacy of RGT as an evaluative approach that does not require listener training. As such, this investigation is primarily concerned with the relative ordering of elements and constructs, rather than determining which ones meet or exceed a specific confidence interval and respond to a prescribed, testable hypothesis. To this extent, a match between elements or constructs of 75% or above can be considered close and is of interest. More importantly, below this threshold the results are too dissimilar to be considered effective, and are therefore not considered reliable [57]. However Jankowicz warns that any figure is relative, and that to improve reliability the % similarity should also be thought of in terms of High, Intermediate and Low (H-I-L), based upon the range of responses [56]. For each condition we consider both between-participant matches for sound events and constructs, and the modal listener response. In order to establish the level of consensus between the designer's and listeners' responses, each listener's repertory grid had

to be combined into a single grid (L01, L02). The mode was calculated for the listeners' construct ratings for each element in order to create a single grid. The most typical participant rating for each sound event according to each construct represented the between-participants agreement more accurately than the mean of individual responses, and is a more appropriate representation of central tendency, since the data being examined is ordinal.

2.1 Radio Drama

The designer produced 14 elements (see Table 1), which were rated according to all of the constructs. The radio drama had an overall match between listeners and designer of 86% (see Figure 2). The matrix at the top left of the figure represents a listener-designer perspective by rating match. White (blank) spaces represent a match, and the numbers denote by how much the responses differ between the designer and the listeners. The figure makes it possible to identify the match for each construct and each sound event. Construct matches are denoted in blue at the top right of the matrix and we can see that 80% of the constructs had a match of 75% or greater. Sound events or *elements* are denoted in red at the bottom right of the figure. All of the sound events (100%) had a match of 75% or greater, with the lowest match being 75% for two of the sound events (AL and AC).

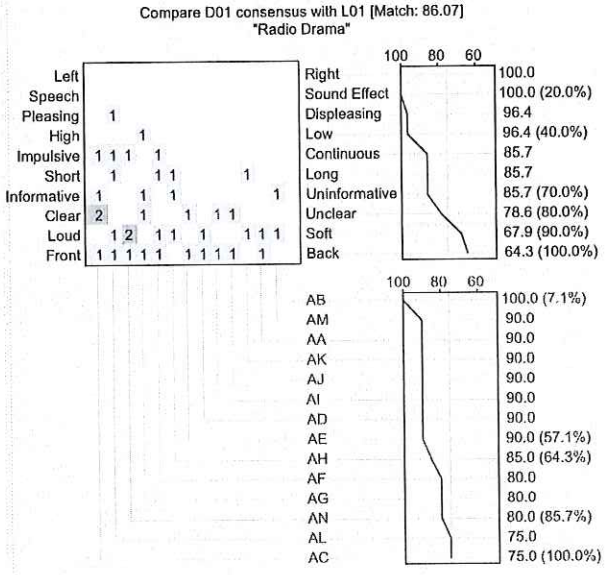

Figure 2: Comparison of the designer's and the listeners' application of constructs (Radio Drama)

Only a single sound event (AB, Butler's Voice) had a match of 100%. The lowest level of match was 75% (AL, woman's voice and AC, girl's voice). The designer considered all of the sound events to be neither *front* nor *back*, in contrast the listeners considered the sound events to be more evenly spaced from *front* to *back*, with a slight emphasis on *front*. The designer classified the sound events equally as neither *loud* nor *soft* (7/14), or *soft* while the listeners classified the majority (8/14) as neither *loud* nor *soft*. In terms of the temporal constructs the designer considered more of the sound events to be more *impulsive* and *short* than the listeners. The majority of sound events were rated by both the listeners and designer as: neither *left* nor *right, sound effect*, neither *high* nor *low*, neither *loud* nor *soft*, *informative*, neither *pleasing* nor *displeasing*, and *clear* (see Figure 3).

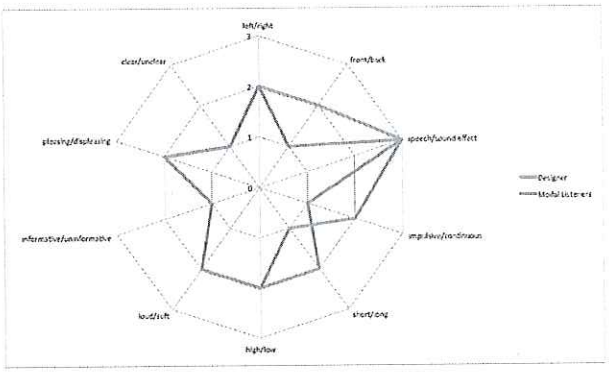

Figure 3: Comparison of the designer's and the listeners' application of constructs (Radio Drama)

The two sound events with the lowest level of match (75%) were the "woman's voice" (AL) and the "girl's voice" (AC). The most prominent differences between the designer's and listeners' rating of AL were that the designer rated the sound event as neither *front* nor *back*, neither *impulsive* nor *continuous*, *short*, neither *loud* nor *soft*, neither *pleasing* nor *displeasing*, whereas the listeners rated AL as *front*, *continuous*, neither *short* nor *long, loud,* and *pleasing*. With AC the designer classified 5 out of 10 constructs as neutral as well as being *uninformative* and *unclear*, in contrast the listeners classified 4 out of 10 constructs as neutral, as well as neither *informative* nor *uninformative* and *clear*. It might be argued that for a radio drama the *informative/ uninformative* and *clear/unclear* constructs were two of the most important. The two constructs had a match 86% and 79% respectively, suggesting that the design could be considered successful in terms of content and clarity.

2.2 Audio Logos

The designer rated 14 elements (see Table 2) according to all of the 10 constructs. The audio logos had an overall match between listeners and designer of 80%. Ten of the sound events had a match of 75% or greater (see Figure 4). The lowest level of match was 45% (AA), which was the "wooden countryside door". The designer rated 12 out of 14 sound events as *informative*, whereas the listeners only rated 4 out of 14 as *informative*. The majority of sound events were rated by both the listeners and designer as: neither *left* nor *right, front*, neither *loud* nor *soft*, neither *pleasing* and *clear* (see Figure 5).

When the audio logos are considered separately the matches, based on the responses to the events within each logo category, are respectively 72%, 82%, 88% and 80%, which suggests that the third audio logo most closely matches the designer's descriptions, and might be the most suitable candidate for dissemination (see Figure 6). The only construct that fell below 75% was *front/back*,

which was due to the listeners finding both sound events closer than the designer did.

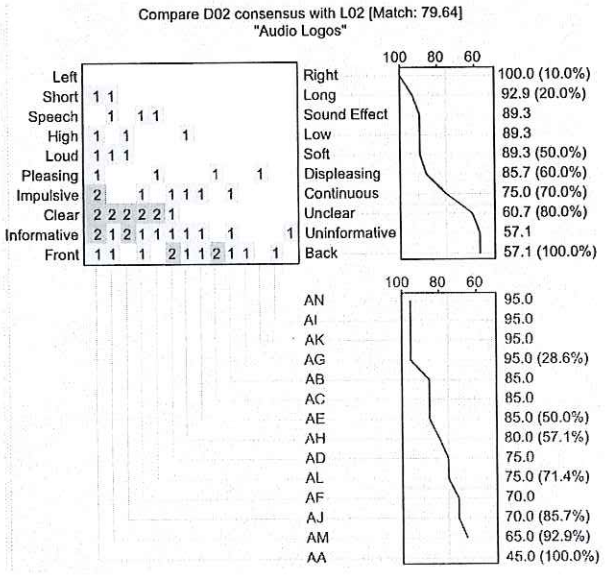

Figure 4: Comparison of the designer's and the listeners' application of constructs (Audio Logos)

The sound event with the lowest level of match (45%) was the "wooden countryside door" (AA). The most prominent difference between the designer's and the listeners' rating was that the designer rated the sound event as *impulsive*, informative and *unclear*, whereas listeners rated AA as *continuous*, *uninformative* and *clear*. As with the radio drama, it might be argued that for audio logos the *clear/unclear* and *informative/uninformative* constructs are two of the most important. The two constructs had a match 61% and 57% respectively, suggesting that the overall designs could not be considered successful in terms of content and clarity. However, when the design with the highest level of match is considered on its own (3/Piano) the matches for the *clear/unclear* and *informative/uninformative* constructs are 100% and 75% which could be successful (see Figure 6).

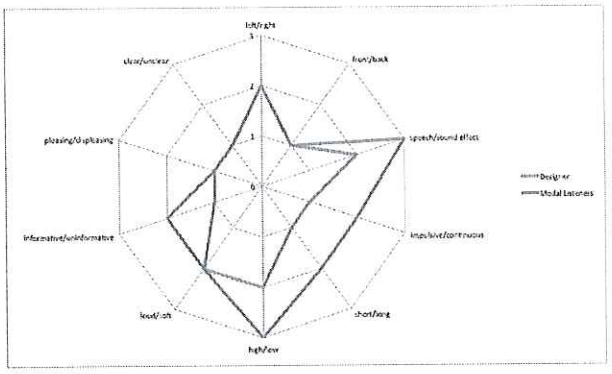

Figure 5: Comparison of the designer's and the listeners' application of constructs (Audio Logos)

Unlike figures 2 and 4, where only the difference between responses are shown, in Figure 6 both sets of responses are shown, with the upper values representing the Designer and the lower the Listeners (i.e. the first and third rows of the grid refer to responses from the Designer and the second and fourth row of responses are from the Listeners). This method of display is due to an artefact within the Rep 5 software when only displaying a small number of elements. When the responses match the numbers are against a white background, where there is a difference the numbers are against a grey background. Figure 6 provides an example of how the RGT technique can be used on a more focused basis to interrogate a particular subset of sound designs, rather than dealing with the entire set of elements used in a study.

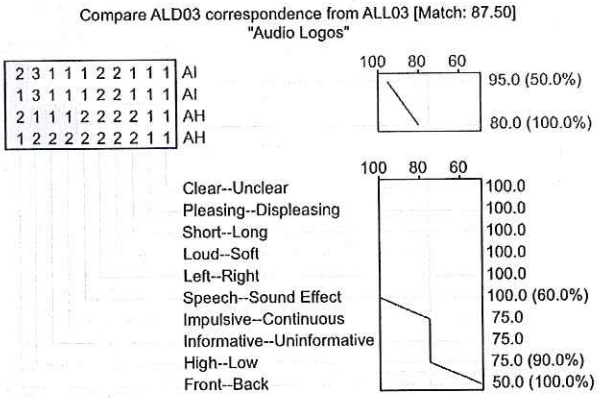

Figure 6: Comparison of the designer's and the listeners' application of constructs (Audio Logo 3/Piano)

2.3 Initial Findings

Results from both experimental conditions show promise. A number of the constructs that have been used show strong matches between the sound designers and listeners, indicating that these constructs have value as a common vocabulary and therefore can be used to mediate and articulate audio features between the two. Over both experiment conditions, the following constructs are shown to be effective and rating highly similarly (see Table 4). These have been established by comparing the construct percentage matches for both the Radio Drama and the Audio Logos (see Figures 2 and 4).

Table 4: Strongest matching Constructs over both Experiments

Construct		Radio Drama	Audio Logos
Left	Right	100%	100%
Speech	Sound effect	100%	89.3%
Short	Long	85.7%	92.9%
Pleasing	Displeasing	96.4%	85.7%

Aside from the *pleasing/displeasing* construct, the strongest matching constructs are ones that describe the sound's physical characteristics and purpose. The

presence of *left/right* as strongly matching constructs may be explained by both sets of sounds being presented to listeners in mono format. As such, it would be unusual to expect a result indicating any significant difference between the designer and listener groups. In the case of this particular study there is an argument that this construct is not necessary, but may be useful in other studies where stereo sounds are present.

It is surprising that both groups did not entirely arrive at the same conclusions regarding constructs such as *front/back* and *loud/soft*. In terms of those constructs that vary in their amount of matching between the two types of listener, we propose a secondary set of constructs, worthy of further investigation (see Table 5), though perhaps these are more suited to focused application areas of sound design, such as is suggested by their respective experimental condition.

Table 5: Additional strongest matching Constructs within Experiments

Construct		Experiment
Loud	Soft	Radio Drama
Front	Back	Audio Logos
Informative	Uninformative	Radio Drama

As mentioned earlier, we now see that constructs relating to physical description of the sounds are present. An argument for these not appearing more strongly across the experimental conditions relates to the type of sound used in each category. The radio drama sound set contains mainly human speech and sound effects of real-world objects whereas the audio logos set primarily consists of musical sounds. To this end, we arrive at a finding that 7 of the 10 constructs show sufficient efficacy, at this stage, to warrant future investigation.

In terms of the *loud/soft* construct, there is high matching with regard to the audio logos and less so with the radio drama. This may partly be explained by the lack of a range of soft and loud sounds in the audio logos set, and such variety may have provided a better test of the range of this construct and, as such, whether or not the Designer and Listeners would be in agreement. To this extent the construct is tentatively presented, whilst acknowledging that further work is necessary to ensure it is robust

It is worth noting a philosophical issue related to the testing scenario. The work is concerned with determining the efficacy of the constructs and the RGT approach in empowering listeners to make judgments. As such, we present results that compare the response of these listeners to the original sound designer, with the intention that valid solutions will produce results in the listeners sample that shows no significant difference from that of the sound designer. However, this approach needs to take account of the fact that the perceptions of everyday listeners may fundamentally vary from those of an expert precisely because of the training they have and their involvement in the production of sound. To this extent, it is worthwhile considering the consistency with which constructs are applied by the general listening sample, as an indicator of their ability and effectively rate sounds presented to them. This issue produces some interesting avenues for future work. To explore this further, the following tables (6, 7) consider all general listeners' responses and indicate dispersion of values across each sound, by experimental condition, using the range.

Similarly, there are constructs where the level of agreement between designers and listeners varied more than expected. In particular, the *clear/unclear* construct is effective in the case of the radio drama evaluation, but less so in the audio logos. It is difficult to attribute this to any particular cause, however, this may be due to the process of deriving constructs, as described in section 1.2, where non-expert listeners were used, and the construct is open to interpretation and a group norm not achieved. For example, *clear/unclear* might be perceived by listeners are referring to any distortion present in the sound, whilst designers may consider this as referring to the clarity of metaphor or message within the an audio logo. Likewise, the absence of voices in audio logos may lead the listeners to struggle to determine the message that is being conveyed due to the lack of linguistic clues. This phenomenon would be an area for some future research.

Although range is a crude indicator, with a short measurement scale of 1 to 3, the tables indicate a degree of consistency within the results obtained. For example, this view of the data supports the outcome that the *speech/sound effect* construct was well understood and utilized consistently by each of the listeners. The mode analysis of each construct, across each condition, is only an indicator, since it is the mode of ranges, and a very high-level overview of the underlying data.

3 DISCUSSION

With regards to the aim of this study, which was to explore the suitability of capturing designers' and listeners' experiences of a sound design for a radio drama and audio logos using repertory grids, it can be shown that it is possible to compare trained and untrained experiences of both a radio drama and audio logos using the provided constructs. The main construct that needs to be investigated is *front/back*, which only had an average match of 61% between the sound designers and the listeners. This was not a case of listeners confusing *loud/soft* with *front/back*, as the most common listener response for both designs was *front* and *neither loud nor soft*, whereas the most common response for the designers was neither *front nor back* and *neither loud nor soft*. The most obvious answer might be the use of headphones. Blauert [67] states that when headphones are utilised the pinnae of the ears, which help in estimating distance, are effectively bypassed and, as such, could make it more difficult for untrained listeners to estimate depth cues. Trained listeners are possibly more familiar with the effect of Inside-the-Head Locatedness, and are therefore better at interpreting depth cues.

Table 6: Range of Listeners' Reponses by Sound in Radio Drama Experiment

Code	Le/ Ri	Fr/ Ba	Sp/ SE	Im/ Co	Sh/ Lo	Hi/ Lo	Lo/ So	In/ Un	Pl/ Di	Cl/ Un
AA	2	2	1	1	2	2	1	2	0	2
AB	1	2	0	2	2	2	1	1	1	1
AC	2	2	2	1	1	2	2	2	2	2
AD	1	2	0	2	2	2	2	1	1	1
AE	2	2	1	1	2	2	2	1	2	2
AF	1	2	0	2	2	1	0	2	2	1
AG	1	2	1	1	2	1	2	1	2	1
AH	2	2	0	2	2	2	2	2	2	2
AI	1	1	1	1	2	2	2	1	1	1
AJ	1	1	0	1	2	2	2	1	2	1
AK	2	2	0	1	2	2	2	1	2	2
AL	2	1	0	1	1	2	1	2	1	2
AM	2	2	2	1	2	2	2	2	2	2
AN	2	1	0	2	2	2	0	2	1	2
Mode	2	2	0	1	2	2	2	2	2	2

Both the audio logos and the radio drama were mono audio files, but listeners experienced the radio drama as if it included panning. Similarly the listeners experienced a wider dynamic range and depth than the designers, which might suggest that the listeners are actively trying to interpret what they are hearing and creating a internal spatial construct beyond the mono file that they are presented with. This is of potential interest to sound designers, in that mono files do not necessarily sound mono to the listeners. A similar approach is followed in cinema where the dialogue is predominantly replayed in mono through the centre front channel, even when a character is far right or left of the screen [68]. One of the main reasons behind this is clarity; as it might be difficult for an audience member to clearly hear dialogue panned to the far side of the cinema if they happen to be seated on the far opposite side.

A notable observation comes when examining the level of matches between elements in the radio drama and audio logos. In terms of the radio drama, all elements have matches of 75% to 100%, whilst in the audio logo element matches range from 45% to 95%. In the case of the radio drama, these high levels of match could suggest a limitation in the constructs applied, since they have not been able to delineate any notable differences between the radio drama elements. This might be symptomatic of the presence of a homogeneity, or narrative running through the radio drama sounds, which is not replicated in the case of the audio logos, where the constructs do appear to allow differentiation between the elements. This presents an area for future work, where a closer analysis of constructs in narrative sounds could be undertaken.

3.1 Limitations

There are several recognized constraints in the comparison between the listeners and sound designer, both of which relate to the nature of the problem being addressed. First, the sound designer's views, and therefore ratings, of the sounds being evaluated are likely to be skewed. They are significantly more familiar with each of the stimuli, and, it may be argued, that they will listen to the sounds in different ways than the general listening group. This familiarity, depending upon the sound designer, is likely to colour the ratings assigned to each sound. Second, there is the inherent limitation in comparing the results of 20 general listeners against the single rating of the sound designer. This issue is also intrinsic to the problem scenario, since we can never foresee a scenario where there would be more than a few sound designers working in any practical application scenario. Nevertheless, for the purposes of research, a greater number of expert listeners to compare against the general listeners would add weight to any analysis.

Table 7: Range of Listeners' Reponses by Sound in Radio Drama Experiment

Code	Le/ Ri	Fr/ Ba	Sp/ SE	Im/ Co	Sh/ Lo	Hi/ Lo	Lo/ So	In/ Un	Pl/ Di	Cl/ Un
AA	2	2	1	2	2	2	2	2	2	2
AB	2	1	1	2	1	2	2	1	1	2
AC	2	2	0	2	2	2	2	2	2	2
AD	2	2	1	1	2	2	2	2	2	2
AE	2	2	1	2	2	2	2	2	2	2
AF	1	1	1	2	2	2	2	1	0	1
AG	2	2	1	2	2	2	2	1	0	2
AH	2	2	1	2	2	2	2	1	0	2
AI	2	1	0	1	2	2	2	2	2	2
AJ	2	1	2	1	2	2	2	2	1	2
AK	2	1	2	1	2	2	2	1	1	2
AL	1	1	1	1	1	2	2	2	2	1
AM	2	2	1	2	2	2	1	2	2	2
AN	2	2	0	1	2	1	2	2	1	2
Mode	2	2	1	2	2	2	2	2	2	2

Use of the RGT approach is an efficient and effective choice at this level of investigation. However, it might be useful to have explored with listeners the reasons behind their choices and scoring of the sounds; particularly around their use of the constructs, which pertain to the more physical properties, rather than the content. Whilst the RGT approach would allow participants to define their own constructs, this was deliberately avoided so as to afford a systematic comparison. However, doing so somewhat diminishes the ability to fully understand each listener's perception and interpretation of a sound.

3.2 Future Work

A natural extension of this work is to repeat the experimental process over an additional number of scenarios. For example, similar processes may be applied that involves sounds that have been designed for inclusion in video games, TV, film, or sonic icons for use in user interfaces and/or mobile devices. This would build-up a larger set of data from which to further determine the effectiveness of the approach, and focus on the particularly useful constructs. A logical extension would then be to determine if the resultant list of constructs is sufficient to describe the pertinent features of sound and whether or not another approach needs to be followed to formulate the additional ones required. Such research could also encompass a range of sounds that have greater spatial range, such as stereo and surround sound sources, which would be pertinent particularly when considering sound for computer games, film, and television.

Another piece of work would be to undertake a deeper investigation into the fundamental differences between sound designers and listeners, which could help to explain the less effective constructs encountered in this work. One solution might be to reverse the process of enquiry and to present sound designers and general listeners with a series of scored audio constructs and ask them to create, play or describe sounds that meet these criteria. An initial criticism of this approach is that the sound designers are at an advantage. However, if the principles of construct theory and negotiated vocabulary hold true, then this should not be the case.

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