

# EVALUATION OF MULTICHANNEL REPRODUCTION FORMATS INFLUENCED BY THE REPERTORY GRID TECHNIQUE

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## ABSTRACT

This is a report on the evaluation of multichannel reproduction formats. With the ever increasing knowledge of new technology at present new multichannel formats are derived, encoded or decoded, and in use in surround sound systems. The sense of immersion and envelopment are just a couple of many sensations felt by multichannel reproduction (such as greater than 2 channel stereo speaker setups) and will be spoken about in this paper.

This paper also touches on the ways and methods that multi channel sound reproduction formats could be evaluated, such as by implementing the repertory grid technique.

## 1. INTRODUCTION

The general view on multichannel sound reproduction is that there is a possibility and it has the capability of creating a sense of immersion, and realism whilst being involved in the whole enveloping experience. Most current multichannel surround sound formats consisting of the five or higher speaker set up have the ability to recreate this experience. In a four channel (square) layout, it is found that the front stage images are unstable and suffer from a hole in the middle between left and right front speakers and an elevation effect. [1]

There are many methods that assess the spacial attributes of sound reproducing systems, Repertory Grid technique is one of them which Berg and Rumsey have studied and experimented with and will be touched upon in this paper.

An issue when speaking about the evaluation of multi channel reproduction formats or any form of reproduced sound is the choice of descriptive language we use. Is it enough to say that the sound source is "spacious", or is describing it to have a "sense of realism" just ok.

### 1.1. What is surround sound?

Surround Sound refers to the envelopment watching and listening experience created by the use of multiple audio tracks, making the audience feel as if they are in the action. Allowing the audience to hear sounds coming from all around them creates the sense of realism, what is known as "Suspended disbelief". This is where the audience is no longer aware of their real world surroundings and completely immersed in the movie experience [2].

#### 1.1.1. *Dolby Surround or Stereo*

Dolby Stereo is a four channel system that is most commonly used for TV and cinema. The soundtrack could be printed at high speed along with the picture, which made it less time consuming and less expensive to produce than earlier multichannel formats. Dolby Surround was introduced to emulate the effects of Dolby Stereo in the consumer environment, sound from the cinema to your home. It comprises of left, centre, right and surround channels. [3]

#### 1.1.2. *5.1 Formats*

The current standard 5.1 format is Dolby Digital, there is also an optional one, DTS. Both of these formats are capable of creating a surround sound experience that envelops the listener.

Dolby Digital also known as AC-3 encoding was developed to produce 5.1 channel surround sound to cinemas and the home using six discrete separate audio channels, it replaces Dolby Surround a matrix format. [2]

DTS is another digital signal coding format, more common on a number of surround cds and is an optional audio track on DVD. It uses low bit rate data coding techniques to reduce the rate of the audio information. DTS systems are able to accommodate a wide range of data rates (32 kbit/s up to 4.096 Mbit/s) and sampling rates up to 196 kHz. [3]

### 1.1.3. *Encoding/Decoding Process*

To process the 5 audio channels that produce surround sound, systems use either matrix technology or separate individual discrete channels.

Matrix technology is very impressive as it decodes the 5.1 mix from the cinema down to two tracks, so that when played in a consumer's home theatre system (using Pro Logic) it is encoded and played back in 4 channel surround, (Left, Centre, Right, and Mono surround channels). It can also extract a surround mix from a stereo track, i.e.; a stereo CD track that was meant for stereo playback.

Discrete audio channels simply means that the 6 audio channels used for 5.1 in the cinema mix are the same 6 audio channels used for 5.1 that will be played back through your home theatre system.

### 1.1.4. *6.1 & 7.1 and higher Formats*

The latest formats in surround sound have a greater amount of channels than 5.1. 6.1 has an added rear centre speaker for accurate localisation of surround effects where as 7.1 has left & right side and rear surround channels. Both offer a sense of envelopment and spaciousness.

The main benefit for formats with greater than 5 channels is the added centre surround channel which allows for rear imaging and improvements in listener envelopment. [4]

## 1.2. **Immersion & Envelopment**

In surround sound Immersion is the aim for multichannel formats in film, cinema and most music pieces, which results in a truly enveloping experience. The primary goal of a surround sound system is to produce in the ears and brain of the listener the illusion of an intended pattern of directional sound, and produce the illusion of sounds from any distance from the listener [1].

The minimum number of channels to produce the feeling of envelopment in a diffuse sound field has been debated on, research shows that 5 channels of direct sound is the minimum. [4].

Envelopment is used to describe the sense of immersion and involvement in a soundfield, with the sound appearing to come from all around the listener. Defining the term envelopment with regards to reproduced sound, difficulties are bound to occur. i.e.; an

unnatural sound stage caused by artificial balance in level, placing source sounds in the surrounds which envelope the listener rather than the reverberant sound. [3]

## 1.3. **Realism**

Creating the sense of realism is definitely a hard task for a surround sound format to achieve. Making the audience believe that what they are hearing is real, lifelike and completely and accurately true. Surround microphone techniques and mixing procedures has great effect on the overall outcome in creating a sense of realism.

## 1.4. **Methods for Evaluating Spatial attributes**

In searching for methods to assess spacial performance of sound reproducing systems a number of problems arise in finding the right way to grade/rank spacial attributes. There has Only been a limited number of experiments to do with reproduced sound, where the researcher has asked the listener to grade very vague expressions such as 'sound stage', spaciousness', 'spacial impression', which has led to a need for more accurate terms and methods to become clearer. [5]

The use of scaling methods such as The Repertory Grid technique are considered in psychology and behavioural science fields and are used as research methods. Rumsey and Berg[6] have experimented and looked into this method and come out with some promising results for the evaluation of sound reproducing systems.

### 1.4.1. *Repertory Grid Technique*

The Repertory Grid Technique is a method used for eliciting information from the subject, introduced in the 1950's by G. Kelly, see [7]. Basically it "encourages personal reflection upon the qualities of the stimuli under examination".[5]

#### 1.4.1.1 *Elicitation of Constructs*

It lets the subject use their own vocabulary to describe the characteristics in this case the spacial attributes of multi dimensional sound.

It's shown that subjects are more reliable when their own language is used to define a quality.

The table below shows an example of the language used by subjects in the experiment.

2. phase externalisation envelopment localisation	18 constructs
phase error	single
inside head	from outside
dispersion	directed
exists in the whole room	exists in the rear part of the room
undefined	comes from a central point
three-dimensional	two-dimensional
floating front	defined front
surrounded by sound	sound from front
can not determine direction	easy defined direction

Figure 1. One Example of constructs used in spacial attribute analysis.

#### 1.4.1.2 Rating of constructs

The method relies on the comparison of triads, subjects are each asked to describe ways in which two of the stimuli are alike and different from the third. A new triad is then presented and same question asked. This process continues until no more constructs are provided by the subject. A grid can then be constructed upon which the subjects rate each of the stimuli according to each of the constructs provided earlier.

#### 1.4.1.3 Verbal Protocol Analysis

Verbal protocol analysis (VPA)[9] is used to analyse verbalisations produced when comparing musical timbres. Method using three levels of analysis considering its 1. logical sense, 2. stimulus-relatedness, 3. semantic aspects. Take the term “naturalness” for example, if all subjects stated the term naturalness, to investigate more precise attributes VPA would be used. The descriptive verbalisation can be categorised as either a descriptive or attitudinal feature. The descriptive features can further be divided into unimodal or polymodal (sensory modalities). The attitudinal features into artificiality of naturalness (emotional-evaluative attitudes).

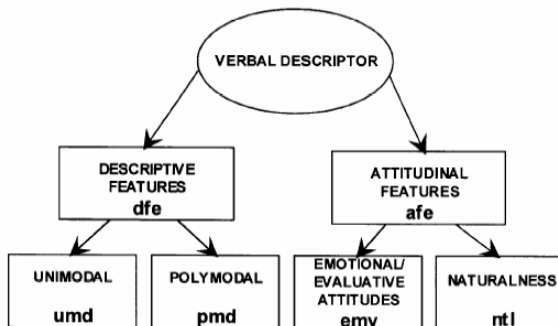


Figure 2. The feature of Verbal protocol Analysis and the separation of similar qualities.

#### 1.4.1.4 Cluster Analysis

Cluster analysis groups together variables with similar features reducing the original data to allow hidden structures to be discovered in the data. The result of a cluster analysis is often presented as a dendrogram, figure 3. where similar variables are branched together.

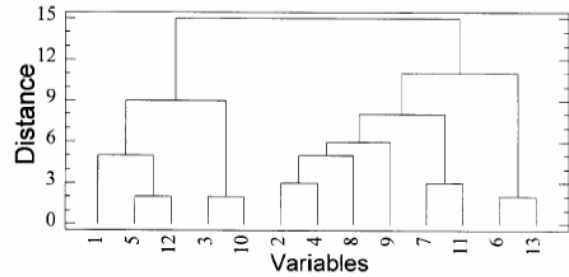


Figure 3. the results from the cluster analysis placed on a dendrogram.

### 1.5. Repertory Grid Technique Experiment[5] & [6]

The most important task was to find what people perceive of different modes of reproduced sound in regards to the spacial features, eg, envelopment, naturalness, width and depth.

Berg & Rumsey’s[6] Repertory Grid technique analysis contains the following parts previously spoken about:

- Elicitation of constructs
- Rating of stimuli
- Verbal protocol analysis
- Cluster analysis

#### 1.5.1. Subjects and Sound Stimuli

In the experiment nine audio engineering students and seven music/media students participated, which produced sixteen complete sets of data. These subjects can be classed as expert listeners as they are likely to reflect more on what they perceive.

Stimuli that has a comparison between reproduction techniques using a different number of reproduced channels to give different sensations of spacial impression were used, eg, from mono to 2-channel

stereo, or from 2-channel stereo to 6 channels for 5.1 surround.

Recordings chosen were made of six different sources, each with different variations of microphone arrangement or processing, see [5] and reproduced through a five channel system.

The sound sources were; a male speaker, solo saxophone, forest environment, symphony orchestra big band and a pop artist.

### 1.5.2. Summary of Results

Of the extracted attributes one of the most pre dominant ones is localisation. Subjects gave many expressions for the ability to pin point sounds both left and right, and front and back. Two indicators of envelopment, to be surrounded by sound or to be within the sound came up as attributes. Externalisation and distance were other attributes that were brought out. A sound that has no externalisation as if it were located within the head is said to be at zero distance from the listener, and when externalisation occurs there is a perceived distance to the source.

The following are the attributes extracted from the cluster analysis;

- Localisation
- Depth/distance
- Envelopment
- Width
- Room perception
- Externalisation
- Phase
- Source width & depth
- Detection of background noise
- Frequency spectrum

### 1.5.3. Comments about the results

The use of 5 channel recording reproduction made in acoustical spaces seem to excite any sensations. Subjects are making distinctions between recorded rooms reproduced through a sound system and the experience of being in the same room as the recorded sound source, this can be expressed as “presence”. “feeling of a real room”, the source is in the room”, etc. Other attributes are supporting the natural feel through localisation of sound sources that have width and depth, and are at certain distances from the listener in a room where the sound envelops the listener.

There was a lack of consistency of the attributes defined by the listener which is due to each listener using different terminology for different attributes, some listeners don't perceive some attributes, the stimuli are too complex and excite many dimensions simultaneously.

More consistent responses could be recorded by using less complex and more simple sound stimuli. Since the main purpose of sound reproduction systems is to reproduce complex sources, such as music, drama and environment, its important that experiments aimed at investigating the perception generated by such systems contain these complex sources even though they may cause complications in the experiment.

However complex an experiment like this can be it is still worth using the same analysis techniques to convey results, and it is definitely a starting point in evaluating multi channel sound system reproduction.

## 2. CONCLUSION

Evaluation in terms of surround sound formats is something that needs more clarification with regards to what is actually being evaluated, the format itself, spacial attributes, reproducing systems using the formats, or the quality of the overall sound.

The Repertory Grid Technique is one of many effective methods of assessing the spacial attributes of reproduced sound especially surround sound and should be worth considering when evaluating this topic.

## 3. REFERENCES

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