The Development of a Combinational Model for the Analysis of Acousmatic Music

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Introduction

Since the publication of Pierre Schaeffer's *Solfège* in 1966 there have been many conflicting arguments with regard to both perception-based analysis theories and computational analytical methods.[1] Debate has ensued regarding the problem of representation of information in acousmatic music and the development of a universal method of notation, where a score-format is paramount to the analysis of a work.

In essence, acousmatic music exists as work for tape, created by the composer without a score or the employment of traditional instruments, and experienced by the listener through loudspeakers. Taking into account existing methods of scoring and the question of the use of traditional notation, this article will suggest that a written score is both unnecessary for the successful analysis of acousmatic music and invalid due to the exclusivity of its content and the relationship of its author to the actual work. It will argue that the search for a universal method of notation along with one absolute method of analysis is unattainable due to certain restraining factors. In examining the theory of perception, the article will demonstrate that human perception is an important basis for analysis and supersedes any notational concept. It will suggest, however, that a more inclusive consideration of all approaches is necessary. In conclusion, a combinational model which draws upon and develops existing analysis methodology (perceptual and computational) will be proposed.

Representation: Score and Notation

The French composer and theorist Pierre Schaeffer first introduced the term 'acousmatique' in his 1966 publication *Traité des Objets Musicaux*. The term originates from the Pythagorian epoch, where Pythagoras

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[1] Schaeffer's *Solfège* is a programme of musical research centred on the act of listening more so than the act of notating. It is descriptive rather than operational. The central focus is on the actual sound material itself and not its causation.

conducted all his teaching from behind a screen, thereby ensuring that his students focussed on the intrinsic elements of what was being taught and not on his physical gestures or corporal presence. This acousmatic situation was manipulated and developed by Schaeffer as a tool for the composing of music which permits the use of any sound, natural or otherwise, in any combination or juxtaposition, for its creation. Schaeffer's aim was to direct the listener's attention to the sound material itself (which he called sound objects (*objets sonores*)) and not that to which it referred. He considered the actual meaning of a sound to be of more importance than its causal origin. Consequently, he proposed a new form of concentrated listening, 'Reduced Listening' (*écoute réduite*), which focused the listener's attention on the acoustic attributes of the sound rather than the cause.

Acousmatic music is structured by acquiring sound material and manipulating it utilising technology available in the studio. The finished work is then presented to the listener via loudspeakers. The loudspeakers resemble Pythagoras's screen, automatically separating the listener from the visual context of the work's individual sound sources. In acousmatic music listening becomes a creative act. Due to the nature of its presentation, the provision of a score is not necessary; the work does not need a score to be realised.

The score is, in fact, only one piece of information about the work. In most cases it is constructed by the composer and serves to exclusively narrate the work from his/her own personal viewpoint. The study of a score may lead to an inconclusive analysis having perhaps created prejudices in the mind of the analyst. The score may also influence the analyst's experience of the work by pre-informing his/her listening. Knowing the concept(s) behind a work or how the work was constructed would most certainly distract, if not influence, the analyst's focus.

The Canadian psychologist Albert S. Bregman has suggested that the human brain possesses the ability to organise complex combinations of sound by grouping similar sound material considered to have originated from the same source. This process is based upon grouping principles which are contained within what he termed Auditory Scene Analysis (ASA).[2] An integral part of ASA is the concept that sight and

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[2] Albert S. Bregman: *Auditory Scene Analysis – The Perceptual Organization of Sound* (Cambridge, MA: MIT Press, 1990).

sound are inseparable. This underlies the aural analysis of traditional Western art music, as a score is almost always provided. Bregman suggests that what we see (vision) influences what we hear (audition) and vice versa. This impacts on our subsequent interpretation of what we actually heard, i.e. what we then focus our listening upon. This further compounds the view that a visual score (graphic, notational, symbolic or otherwise) would most certainly influence the results of an analysis, drawing attention to certain elements prescribed by the composer and not the elements naturally perceived by the listener. As the composer directs our ears with a visual score, s/he imposes an un-natural mode of listening upon us, which may be seen as being 'directed'. This mode of listening would be better served firstly, by adapting it to incorporate specific characteristics of sound material, and secondly, by implementing it as a practical method of analysis. It may also be said that the composer is in some way 'performing' the piece through the score, by conducting our perception of the work.

The analyst needs to be able to draw his/her own conclusions from what s/he hears in a non-biased environment. Graphic representations and score formats do not represent the reactions, impressions and sensations of the listener – they express the actions and intentions of the composer. The following is an example of this:

If a listener receives a score with the words 'LOUD CRASH' printed at a specific time point, s/he will automatically focus his/her listening just before that point in time in order to hear the loud crash. Instead of the listener reacting naturally to the loud crash and drawing his/her own conclusions from their sensations or impressions, the listener is pre-informed about the action and intention of the composer. This creates repercussions for the analysis. As the listener is apprehensive of the loud crash, the musical content just before it and, more than likely, just after it will be lost or misinterpreted. This leads to an unbalanced listening approach where the sound is taken out of its musical context and highlighted, and the listening process is automatically pre-focussed. Such score representations are also specific to the work itself (or a set of works by the same composer) and cannot be employed in a variety of cases. This begs the question: if the issue of loyalty to the acousmatic tradition was overlooked, could one method of notation for acousmatic music really be developed?

Universal Notation

It has in the past been suggested that a universal form of notation be established.[3] Communication is the exchange of information through a specified idiom. In order for a message to be communicated thoroughly, both the contributor and the recipient must retain a basic understanding of the language of expression being used. In the case of a universal expression of acousmatic music, this would first require the analyst to gain a sufficient grasp of the language, and secondly, to adapt their knowledge and experience to every instance in which a composer deviated from the notation due to the implementation of new technologies or compositional ideas and styles.[4] The success of such a universal notation is uncertain. What is certain is that only those actively participating in the production of such music would possess the essential knowledge and experience to be fully equipped to conduct an exhaustive analysis.

Exchange requires feedback and analysis may be considered a form of such feedback. This is why efficient and honest analysis is required. The sender (i.e. the composer) becomes the recipient. Feedback strengthens the communications link between the composer and the listener, which can only serve to inform upon both the composer and the listener's knowledge and experience of the music being created. The listening process is part of this communication between composer and listener.

A universal method of notating acousmatic music would first require an agreement on a dedicated syntax to govern the method of notation. This would also require a pragmatic approach to the establishment of the notation or set of symbols. Finally, the semantics of the language would need clarification so as not to be misconstrued by the composer or analyst.

In the foreward to Thomas Licata's *Electroacoustic Music – Analytical Perspectives* Jean-Claude Risset argues that 'the lack of an objective representation makes it difficult to study' works created without

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[3] For example, Bruno Bossis: 'The Analysis of Electroacoustic Music: from sources to invariants', *Organised Sound* 11/2 (8/2006), 109–110.

[4] This would be a continuous process as technology is constantly being upgraded and developed and compositional styles are changing alongside technological developments.

some form of notational guidelines for the listener/analyst.[5] However, the majority of analyses contained within this book are conducted by experienced composers and not by uninfluenced, unbiased analysts. Each analysis displays at least one notational or graphical representation of information, from sonograms, mathematical equations and symbols to graphical renditions of the music, traditional western music notation and computer music application languages, all individually chosen by the 'analysts', if not already produced by the actual composer. Unless the reader has a basic knowledge or understanding of all of the above, it may be impossible for them to comprehend exactly what message each writer is trying to convey or to make comparisons between the analyses of certain works. This is the case with Licata's book where, for example, the analyses of two of Stockhausen's works, *Gesang der Jünglinge* (1955-1956) and *Telemusik* (1966) contain completely different scoring and entirely opposing analysis methods – *Gesang der Jünglinge* uses letters to denote noise (*N*), impulse (*I*), vocal (*V*) and sine tone (*S*) alongside graphic illustrations for pitch, time and dynamics and mathematical permutations for other elements. *Telemusik*, on the other hand, uses tables to document durations and the number of instances of certain sounds, arrays to display serial structure and the mathematical Fibonnaci series. A comparison of the analysis of both pieces could not occur without some awareness of the notation used by the composer or the exploration method(s) of the analyst. So too, if a listener does not possess an understanding of the integral elements of the work, s/he will be obliged to conduct the analysis, drawing upon his/her own natural skills of perception and not relying on the score.

An additional problem with the establishment of a universal notation stems from the heterogeneity of individual compositional styles; for example, almost every work presented by Stockhausen contains new graphical information or symbolic notation. This alongside technology's constant advancement would force a recurring review of such notation. The advancement of traditional notation was documented as it developed over centuries, however in the case of acousmatic music the notation would surely be obsolete almost as soon as it was documented.[6]

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[5] Jean-Claude Risset: Foreward, *Electroacoustic Music – Analytical Perspectives* ed. Thomas Licata (Connecticut: Greenwood Press, 2002), xiii.
[6] Such development of traditional notation mainly corresponded with historical events, most notably the introduction of music in print in 1473.

Whatever the solution, any method of notation may be considered as compromising the analysis of acousmatic music, as the awareness of specific content of a work before listening to it may influence the results. Therefore, an independent analysis based upon natural human perception and specific computer applications based on spectral analysis would dispel all concerns and provide the basis for the implementation and development of a widespread analytical methodology, uninfluenced or governed by scoring or notational formats.

Human Perception

Our natural auditory system, i.e. our ears and our brain, allows us to perceive, interpret and analyse sound. The human ear detects all sound around it and converts this sound into nerve impulses. The brain then interprets these impulses and translates them into some form of understandable information. The range of possible frequencies (pitches) that the normal human ear may detect lies between 20Hz and 20kHz, although this range narrows with age, gender and over-exposure to extreme intensities (loudness) and/or frequencies resulting in ear damage and hearing-loss. Across this audible range the ear can distinguish between small and large shifts in intensity and frequency. The two ears together can determine where a sound is coming from (its direction). This is called 'sound localisation' and is dependent on the individual hearing ability of both ears and the actual quality of the sound being heard.

Hearing does not require any specific concentration or focus of attention. It is an unconscious act that occurs naturally and is analogous to our sense of sight. When we open our eyes, we automatically see what is in front of us or around us. Listening, on the other hand, is a conscious action by the listener, requiring varying levels of concentration so that the brain may interpret information correctly. If what is being sent to the brain is in some way scrambled, lost or only partially delivered, due to a distraction of attention and subsequent loss of concentration, the message being transmitted to the listener will be unclear or entirely misunderstood. During the entire auditory process, humans naturally attempt to uncover the causes and meanings of sound: What *caused* the sound? What does the sound *mean* – musically, sensually or visually? Repeated exposure to sonic environments (cultural, social, industrial, agricultural, etc.) influences our auditory palette. Therefore, when we perceive sound, we instinctively react to it by constructing mental representations of the sounds we hear. These representations may be linked to one or several of the four remaining senses (sight, taste, smell and touch), resulting in images or representations that are visual, sensory or both.

Bregman termed this process 'Auditory Streaming'. The representations we create alongside the reactions we experience (be they emotional, physical or sensual) are governed by our past musical memories. These are housed in our subconscious and relate to emotional experiences, musical moments, circumstances and environments. This associative listening process coupled with our natural need for clarification, results in the construction of analogous relationships between sounds. We intuitively present the unknown in terms of the known in order to clarify its meaning for ourselves. We impose our own musical sense on what we hear by naturally grouping sound according to similar factors such as pitch, timbre, rhythm, tempo, placement in time and context (Bregman's grouping principles). This aids the clarification process. The manner in which the music is structured as a whole alongside the actual material content may have an impact on our emotions and reactions, for example, music that seems to accelerate may infuse a sense of excitement or tension depending on the content; low-pitched drones accompanied by sparse sonic events may un-nerve the listener and evoke emotions of anxiety or fear, again depending on the content.

With regard to acousmatic music, when attributable and non-attributable sounds (be they natural or synthetic) are mixed together in the same space the former will positively influence the latter. If we cannot find an internal link between the sound material we automatically find an external one. The brain parallels the causal origin of a synthetic sound with that of a recognisable natural sound. The placement of such sound material within both known and unknown spaces will also determine different results, different levels of relationship and analogousness. The process of creating mental representations from the sounds we perceive may be defined as being somewhat 'programmatic' and the results may certainly be an appropriate starting point for an analysis of acousmatic music. It may be said that although perception-based analysis is influenced to some extent by our previous perceptual experiences, it is still the truest account of what we hear and subsequently decide to listen to. This can only serve the analysis of acousmatic music in the best possible way. Thus, perception-based analysis must take place first. Practically-based analytical applications (e.g. sonogram) may be used afterwards to aid us with our decision as to the relevance of the results we have arrived at. They may also display information misinterpreted or simply unheard by the ear. In a basic sense such applications return a concrete description of some of our perceptions. An opposing argument might align applications such as spectral analysis or sonogram tools with a form of graphic notation. Perhaps this would be the case if implemented before the listening has taken place. However, due to the objectivity of their calculations, their results would not demonstrate the same level of influence on the analyst as a score specifically crafted by a composer.

Proposed Model of Analysis

A solution to the problem of the most effective way to analyse acousmatic music may be found in the development and re-implementation of conscious listening practices and the marrying of such practices with practical computational applications. Human perception (uninfluenced by visual notation) coupled with existing practical applications has resulted in the equation and proposed model below:

(Human Perception) + (Practical Computation)

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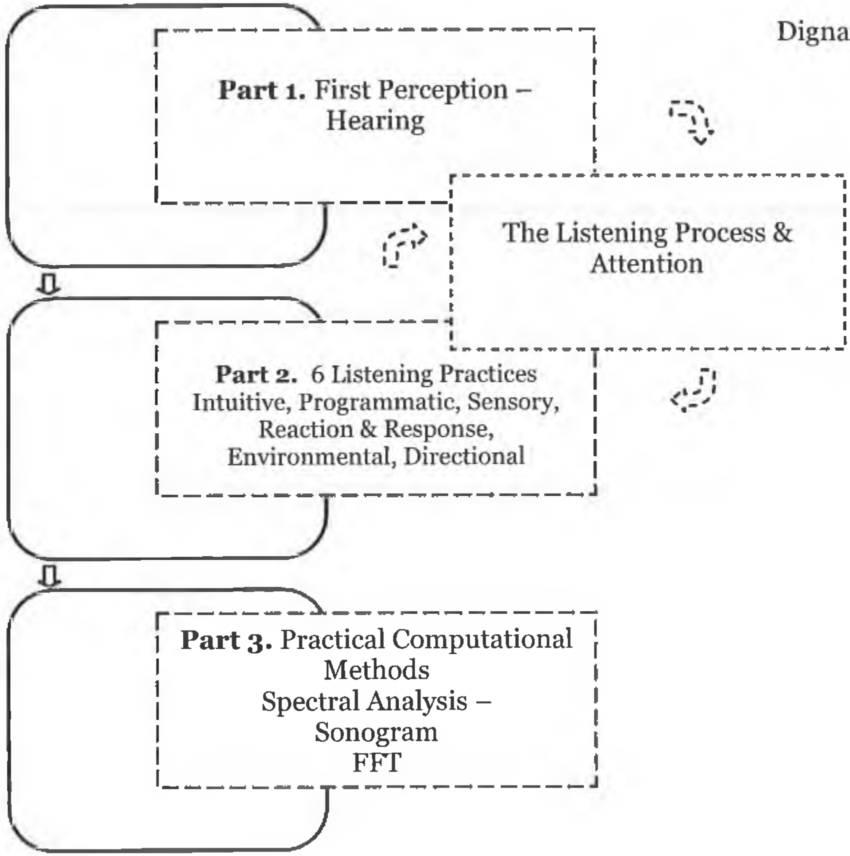
Overall Analysis

Figure 1. Combinational Model of Analysis



This is an inclusive model in three parts, which draws upon aspects of perception, psychology and mathematical computation.

Part 1. First Perception - Hearing

Hearing is an unconscious act. Humans hear continuously without regard to specific content. A bustling city street will fill our ears with many varieties of sound material such as cars, buses, people chatting on mobile phones, laughter, children crying, car doors, etc. A conscious decision must be made in order to listen to one or more specific elements of the cacophony. Having made this decision to listen, a person must then focus his/her attention so as to fully assimilate the sound material and distinguish it from all other sounds.

When conducting an analysis of acousmatic music we must choose to listen and then proceed to focus our attention. There must also be an awareness of our individual levels of attention, as this will determine how many presentations of the work will be necessary for a comprehensive analysis to be completed.

a) The Listening Process & Attention

After the initial perception of sound occurs (hearing) the listener makes a conscious decision to 'listen'. Central to this process of listening (and ultimately, the process of analysis) is the listener's individual ability to primarily focus their attention and subsequently maintain a high level of such focus. If a lessening or distraction of focus occurs over a period of time (whether long or short), this will result in a reduction of the information being absorbed, and consequently a less accurate response will be returned from the listener. The conscious decision to listen may be termed 'covert' attention.[7] This is a psychological term used to denote the act of mentally focusing on one of the many human senses, in this case the sense of audition.[8] Once this decision has been made, the listener directs this sense towards the source of stimulation. This is 'overt' attention and the source here is sound being emitted from loudspeakers.[9] Finally, the listener focuses his/her attention so as to concentrate his/her listening. Having directed attention towards the sound, the listener now actively concentrate on the sound in order to interpret its meaning or cause.

Two American psychologists, McKay Moore Sohlberg and Catherine A. Mateer, have developed a clinical model of attention.[10] This hierarchic model is universally used to test the attention processes of patients recovering from brain damage following a coma. As it is

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[7] For more information, see Bruce Goldstein: *Sensation and Perception* 6th edn (California: Wadsworth Publishing Company, 2002). Hereafter referred to as Goldstein: *Sensation and Perception*.

[8] Audition is a more widely used term to describe the sense of hearing and listening. Here, it is used in relation to listening, having previously been distinguished as being separate from hearing.

[9] For more information, see Goldstein: *Sensation and Perception*. Overt attention is another psychological term used in opposition to covert attention. It may be argued that the source of stimulation is actually the set of loudspeakers (in particular, their cones) from which the sound is emitted. This would most certainly be the case if the human sense chosen was that of vision and not audition.

[10] McKay Moore Sohlberg and Catherine A. Mateer: *Introduction to cognitive rehabilitation: theory and practice* (New York: Guilford Press, 1989).

neurologically-based it can be applied to any mode of perception and will be discussed in this article in relation to audition and the awareness of an individual listener's ability to focus attention. This will aid the analysis process when collating and cross-referencing results of several analyses of one work. The model deals with five specific levels of attention, each one increasing in difficulty. The levels of attention are as follows: Focused, Sustained, Selective, Alternating and Divided.

i) Focused attention is the ability to respond to specific visual, auditory or tactile stimuli. This relates to the listener's capacity to listen to specific sound material.

ii) Sustained attention refers to the ability to remain consistently focused during repetitive and continuous activity. In the case of listening, repetitive sound material, like repeated pitches or rhythmic patterns, or continuous sound material, drones for instance, are examples of such activity.

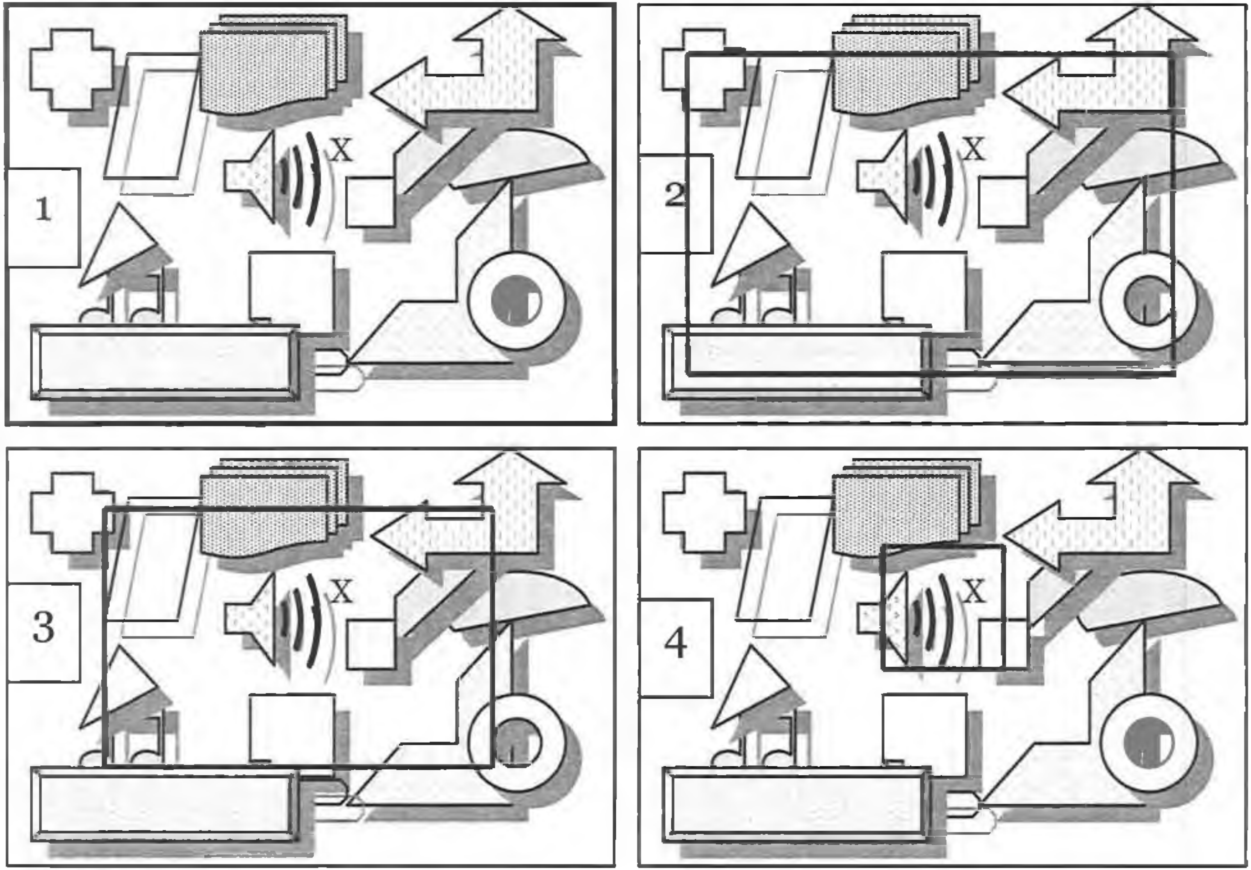
iii) Selective attention is the ability to remain focused when distractive impulses are present. This results in attention being fixed on one specific sound. The sound is therefore perceived as more prominent within the work because it is more recognisable. Each time it returns its prominence is strengthened. The level of our selective attention is influenced by emotional arousal and our individual disposition (See Reaction & Response Listening below).

iv) Alternating attention refers to mental flexibility and the listener's capacity to shift his/her focus between audibly differing sound material contained within the same texture, for example, opposing spectral material, i.e. high and low frequencies. In traditional musical terms, this might be considered analogous to shifting visual focus from a treble clef to a bass clef in a piano work.

v) Divided attention is considered the highest and most difficult level of attention. Here, the listener must possess the ability to multi-task. The focus of attention should vary constantly from one individual sound to another. The listener must also absorb information about each discrete sound within the context of the entire work.

The illustrations below have been devised to demonstrate some of the concepts described in the clinical model above. The viewer is requested to generally observe the overall illustration without concentrating or focusing on any particular object. The next illustration requires them to focus their attention away from peripheral objects and concentrate more towards central objects. When the viewer observes the third illustration, their attention needs to be focused even more towards central objects. Finally, the observer is requested to focus their attention solely on the 'X' in the centre of the illustration without becoming distracted by any of the other objects.

Figure 2. Demonstration of the varying levels of attention devised by Sohlberg and Mateer in their clinical model of attention.



Part 2. Listening Practices

Six Listening Practices have been devised: Intuitive, Programmatic, Sensory, Reaction & Response, Environmental and Directional. All reactions, responses, thoughts and feelings should be continually documented and should not altered or cross-referenced in any way until all three parts of the analysis have concluded. A record sheet (Figure 3) has been provided in order to record the analysis as it progresses. The collation of information should occur last so as not to distract levels of attention or influence participation in listening practices. Each part should exist solely as a separate element of the analysis method. Some of the listening practices are closely related, therefore the exact same information (or similar) may be written into the separate sections of the sheet.

a) Intuitive Listening: Subjective

Intuitive listening deals with the ability to understand without any apparent conscious reasoning. It results in the acquiring of knowledge without any motivation for doing so. As humans, we possess a natural desire to gain knowledge, resulting in questions concerning causes and meanings. Such questions are the basis of any analysis. Observing the illustrations above, the viewer will begin by asking generalised questions because they are presented with a generalised overview of the entire illustration. As soon as they are required to focus their attention specifically the questions become more specific, pertaining to the precise elements they are focusing on. Since intuition is primarily concerned with causes and meanings, the analyst will commence his/her analysis of an acousmatic work with intuitive questions such as: What may have produced the sounds I am listening to? What meaning do they have in the work? The analyst will instinctively know before initiating listening to the work that an analysis must be conducted and this heightens his/her basic levels of attention. The questions raised should be documented under this listening practice and added to as the analysis progresses.

b) Programmatic listening: Subjective

Programmatic listening involves the creation of descriptive representations of what is thought to be the cause of the perceived sound material. These representations may be of landscapes, of urban, industrial or agricultural scenery or even individual objects. They are solely descriptive, without any reference to personal involvement, and do not contain any physical, emotional or spiritual content – they are not memories, simply objective representations. For example: a sound is perceived to resemble the sea. The listener may have never personally experienced the visual or tactile qualities of the sea. However, even though s/he have not had that experience s/he can still describe the sea and what it sounds like from its portrayal (both visual and sound) by other sources such as the media. This listening practice is directly related to the questions posed in Intuitive listening. Repeated listening may alter the initial representations created in the analyst's mind and each set of representations should be documented, for example: Programmatic Listening 1 – landscape, cliffs, sea, etc; Programmatic Listening 2 – landscape, hills, seaside, beach; Programmatic Listening 3 – Not seaside, more like country landscape with a lake or a stream, etc.

c) Sensory listening: Subjective

Sensory listening is directly related to the more prominent human senses of sight, taste, smell and touch. Each sense is perception-based and works by responding to stimuli and then sending impulse signals to the brain for interpretation. During this listening process, representations involving these senses are created. In comparison to those formed during the programmatic listening process, the representations here are personal to the listener. They relate to the experiences of the listener, what was actually seen, tasted, smelled or touched. A representation can contain one sense or multiple senses depending on the content. Not unlike programmatic listening, sensory listening does not involve physical, emotional or spiritual content, apart from the basic tactility of touch.

Cultural, social and environmental experiences influence the development of the senses and the hierarchic importance placed upon them. This is especially evident in Russia where 'touch' is considered the proto-sense, existing as a reduction of all five senses: the tongue and taste buds touch or sense food; matter is sensed by the skin; the ear touches sound waves; the eye touches light; scents touch the nose.[11] In Western culture sight (also referred to as the sense of vision) is generally

[11] Anon. from Margaret Head and Rhóda Métraux, ed.: *The Study of Culture at a Distance* (Chicago: University of Chicago Press), 162–169.

considered the primary sense.[12] Age also has an impact on the senses. The quality of individual senses and overall perceptual ability is depleted as physicality alters and declines over time. The senses become less precise; for example, an older person will become less aware of subtle changes in sound or light or taste. The volume of past musical memories retained alongside the current level of perceptual ability will influence the representations created during sensory listening.

Having concluded the analysis, the listener will find that the outline of the representations described in this section may be similar to, if not the same as, those documented in the programmatic listening stage. However, subtle differences will appear. The representations related to sensory listening will be more descriptive and accurate.

d) Reaction & Response listening: Subjective

A reaction is any response to an event. An emotion is a complex reaction which draws on human behaviour, disposition, experiences and physical composition. An emotion occurs unconsciously and usually corresponds to a personally significant event. It is established internally and displayed externally. This external display of emotion is linked to physical reaction, which will always be expressed positively or negatively. Human disposition, i.e. one's individual tendency to react, influences attention by heightening arousal. This will affect the emotions expressed: a highly emotionally charged individual will express much stronger reactions and responses than their less aroused counterpart. Mood also governs how humans react emotionally, since it is a temporary state of mind. Reactions and responses described in this listening practice will be the most accurate and clearly defined, as they are highly personal and vivid within the listener's mind and take into account many more of the individual aspects of human make-up.

Reaction & Response listening may be broken down into three separate categories: Physical, Emotional and Spiritual.

i) Physical

Apart from the four senses discussed in Sensory listening above, there are many other human senses. Two such senses that fit into the category of

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[12] For example, David Howes: *Sensual Relations: Engaging the Senses in Culture and Social Theory* (Michigan: University of Michigan Press), 12–13. Bregman's ASA theory alludes to the close relationship and influence that exists between sight and sound.

physical reaction are thermoception and nociception. Thermoception refers to the physical feeling of temperature change experienced through internal or external skin cells: the sun was warm on my face; my hands felt cold having touched the snow with no gloves on. Nociception is the feeling of physical pain. It is the perception of damage to the body's skin, joints, bones and internal body organs.

ii) Emotional

Emotions have an impact on our memories. Vivid memories tend to correspond with emotional events that have taken place throughout out lives. The memories of such events may also be linked to physical reactions or sensual actions. A feeling of anger, sadness, embarrassment, etc. is closely related to the physical reaction of thermoception. Anger and sadness are also expressed during physical pain. Therefore, the more vivid memories will be recalled more often than unemotional, sober events. As discussed earlier, selective attention will be influenced by heightened arousal or emotion as we focus more clearly on specific sound material. This will result in the inclusion of intricate details in descriptions of such material.

iii) Spiritual

Spirituality concerns itself to some extent with personal experience, which in the case of Reaction & Response listening is very closely related to emotional response and physical reaction.[13] Spirituality also involves the perception of one's existence, being conscious and aware of one's place in the world and being a part of something bigger within the universe. In this listening practice, it comprises a sense of the listener being an integral and important part of the presentation of the work. Questions asked are: How am I involved in the presentation of this work? What affect does my presence have? Am I contributing anything to the presentation of this work? What change has occurred within me having had this experience? This is directly related to Environmental listening, which will be discussed later.

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[13] The subject of spirituality, and indeed, the term itself is very broad and widely used in different circumstances (religious studies, psychology, etc.). It is being implemented here in a generalised sense, without attaching any highly specific meaning to the term.

Reaction & Response listening is three-fold:
Representations are conjured up when we hear a sound. This causes a restoration of previous emotions, reactions and/or responses, which are coupled with that event. In many cases, the description will include elements of sensory listening: I saw the sea and touched the water. It felt warm and I was happy. 'Saw' and 'touched' refer to the main senses while 'warm' is thermoception and 'happy' is an emotional response.
We may also experience one or more new reactions, emotions and/or responses when we hear a sound which are not referenced to past memories. They are experienced for the first time during the listening to the work. This however occurs less often than 1.
The listener may experience a combination of 1 & 2, which is more likely to happen than 2.

e) Environmental Listening: Objective/Subjective

This listening practice involves the listener being aware of his/her surrounding environment and what affect this environment will have upon his/her listening and subsequent analysis. When a composer creates an acousmatic work, s/he would prefer the listener to experience it in a listening space as near as possible to that in which it was created, i.e. the studio. This is most likely impossible therefore the environment in which the work is presented will positively or negatively affect the perception of it. Questions posed during this listening practice will either relate to physical presence and reaction or the physical space in which the listener is present:

Physical Presence and Reaction:

Am I alone? Are there other people present? Is the composer present? How is the physical presence of others affecting me? Will this alter my perception of the work? Am I distracted by the physical movement of others? Are they displaying their emotional response(s)? Am I contributing anything (positively/negatively) to other people's experience of the work?

Physical Space:

Where am I? Is it a large or small space? How far away am I from the loudspeakers and will this have an affect on how much information I absorb? Is the floor carpeted or tiled? Is it acoustically suitable to the music – church, cathedral, concert hall, small theatre space, classroom, etc.?

Some of the above questions will exist already in the mind of the listener before commencing analysis of the work. Others will be formed during the presentation. All questions and responses should be documented as they are vital when drawing conclusions about the analysis.

f) Directional Listening: Objective

Directional listening is the most defined listening practice. It is concerned with the source of the sound material, its individual content and how it develops over the entire work. The parameters for this practice are fixed within five categories and relate to all aspects of sound from general elements such as pitch, to more complex elements such as texture. Directional listening is related to intuitive listening in that it involves questions relating to causes and meanings, be it on a higher level. The results of this listening practice may correspond frequently with the musical descriptions of objects (included in the representations) documented during other listening practices.

Categorisation of parameters:

The fixed parameters are categorised according to Basic Detection; Rhythm, Time & Tempo; Content, Typology, Morphology; Structure; Imitation Similarity, Difference.

Category I: Basic Detection

The basic characteristics of sound detected by the sense of audition are pitch, loudness and tone quality. Pitch corresponds to the frequency of a sound wave: the greater the frequency, the higher the perceived pitch will become.[14] Loudness is reliant on the amplitude or pressure intensity of the sound wave: the greater the intensity, the louder the sound will be. It is a physiological sensation experienced by the listener. Tone relates to the perceived quality of the sound, what is generally known as timbre, which is dependent on overtones or harmonics. Most sounds are complex and contain more than one frequency. Each sound contains one specific frequency called the fundamental, with all other frequencies being harmonics. If some of these frequencies are either stripped from a sound

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[14] Frequency is the number of times one cycle of the sound wave will be repeated in one second. Cycles per second related to Hertz, the value used to measure frequency. Therefore, 440Hz is equal to 440 cycles of a sound wave per second, which corresponds to A4 on a piano (i.e. A used to tune an orchestra).

or added to a sound it results in a change of the sound's overall perceived 'character'. This is an alteration of tone quality, or timbre. (The human ear also has the capacity to 'fill-in' the missing harmonic information). If three instruments such as an oboe, clarinet and flute were all playing the exact same note in unison (and in tune), they will not sound the same as a result of the different tone qualities produced by the instruments. The analyst should attempt to describe each of these characteristics in as much detail as necessary.

Category II: Rhythm, Time & Tempo

Rhythm, time and tempo are closely linked. Various psychologists and neurologists have indicated that the human brain possesses a system which governs the perception of time.[15] Two types of cells are in operation, the first type being responsible for what has been termed 'daily rhythm', or long-range timekeeping, and the second, short-range timekeeping.[16] The basic rhythm of life is the rate at which the human heart beats. This can influence our perception of rhythm and tempo due to fluctuations of the heart rate caused by the reactions and responses of the listener (listening practice d) to changes in the perceived quality or amplitude of sound, e.g. a very sudden loud, noisy sound may distract or unnerve the listener and cause them to react physically (moving) and/or emotionally (the feeling of being startled), which in turn raises the heart rate. The perception of time allows the listener to place events in logical sequence in order to quantify their individual durations and draw comparisons between their developments over that duration.

Category III: Content, Typology, Morphology

In this category, the analyst considers the sonic content of the work and how it develops over the piece.

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[15] This theory has been debated by various experts and has not been exclusively proven or quashed. Those who oppose the theory propose that time is an illusion of the mind. For example, see Richard S.J. Frackowiak: *Human Brain Function* (London: Academic Press, 2004), Yehuda Salu: *Understanding Brain and Mind: A Connectionist Perspective* (London:World Scientific Publishing Co., 2001) and the Institute for Advanced Science and Engineering, California, http://www.iase.info/.

[16] This is the reason why a young child considers an hour a very long period of time, while an adult will consider it quite short. The adult's cells are much more developed.

Content:
Does the work contain vast quantities of material in a rich texture, or less material in a sparse texture? Texture, in a general sense, refers to content and the grouping of such content either vertically or horizontally within the creation space. It also examines dynamic changes and panning values (automation). Texture may also refer to colour, where spectral content is assigned to a colour grid (as in Sonograms).

Typology:
During the analysis the listener will pose questions pertaining to the type of material they are listening to: Is the sound natural or synthetic? Was the sound originally produced naturally and manipulated so that it now resembles a synthetic sound? Typology is concerned with the classification of sound material into groups or types.

Morphology:
Morphology is based upon the examination of the internal shape and form of the sound material itself. Denis Smalley has established 'spectromorphology' to denote the exploration of available frequencies and how those frequencies have been developed over a period of time. The main aspects of morphology are texture and gesture. Musical gesture is related to the development of musical features as understood by the brain. Gesture is itself a conscious action, an articulation stemming from the intention to express emotion, thus linking it with the reaction and response listening practice.

Category IV: Structure
This category deals with the overall structure of the work, the Macro-Structure, and the individual sections or subsections of material contained within it, the Micro-Structure. In a traditional sense structure may be defined as sections of music which exists between cadence points, i.e. pauses, whether finite or not. In acousmatic music, this may not be the case. The composer may define the structure of the work more intricately, with sections and subsections of sound material being developed. It may also be determined by the creation of numerical, mathematical or serial relationships between sound material. Even if there is no apparent structure being presented, humans naturally group

sound according to Bregman's Grouping Principles (See Human Perception).

Category V: Imitation, Similarity, Difference
Imitation, similarity and difference can be applied to any of the above-mentioned parameters. It is proposed as a separate category in order to distinguish material of a different, similar or imitative nature, irrespective of which category it is contained within.

Part 3. Practical Computational Methods
There are several practical computational methods in existence, all of which return concrete results when implemented in this model, adding to the objective analysis of acousmatic music. They may be seen as the objective representation of our primarily subjective perceptual analysis.

Spectral Analysis:
Spectral Analysis is based on the FFT mathematical transform developed by Jean Baptiste Fourier (1786–1830). The theory states that any waveform, however complex, could be uniquely expressed as the sum of one or more sine waves. This allows for the deconstruction of a signal in the time domain into all of its individual frequency components. The results of such calculations can then be cross-referenced with the information obtained from the three listening modes. Sonogram software applications use the Fast Fourier Transform as a basis for their calculations. To fully interpret how sounds behave we need to look at how they change over time. Therefore, sonogram programs display both the spectral and temporal aspects of sound material as a visual plot. The horizontal axis represents time, the vertical axis represents frequency, and the intensity of the colour display represents amplitude.

The human ear forms a spectrum or many spectra from the sound material perceived. Sonogram software can further break down spectra and display detailed information corresponding to the parameters in the Directional Listening mode. Sonogram software may also be seen as some form of Reduced Listening as it draws its conclusions from the sonic material it is supplied irrespective of whether it is a natural or synthetic sound.

Figure 3. Record Sheet for documenting results of the 6 Listening Practices

6 Listening Practices: Record Sheet	
a) Intuitive Listening	
b) Programmatic Listening	
c) Sensory Listening Sight: Taste: Smell: Touch: Multiple:	

d) Reaction &Response Listening i) Physical ii) Emotional iii) Spiritual	
e) Environmental Listening Physical Presence and Reaction: Physical Space:	
f) Directional Listening Category I: Basic Detection Category II: Rhythm, Time & Tempo Category III: Content, Typology, Morphology Category IV: Structure Category V: Imitation, Similarity, Difference	

Conclusion

The fundamental objective of this article has been to propose a combinational model of analysis for acousmatic music, having examined existing perception theories, psychological concepts and practical computational methods of analysis. An investigation of the recommended establishment of a universal method of notation alongside a structured score format has proven that both the composer's relationship to the scored document and the visual nature of the document itself would result in a strongly weighted influence on the analyst. Bregman's theory of Auditory Scene Analysis has substantiated this view. The examination of human perception theory has illustrated the fundamental difference between hearing and listening and the role of cultural, social and environmental influences on our perception and comprehension of sound. An evaluation of Sohlberg and Mateer's clinical model of attention has demonstrated the existence of five levels of focused attention which determine the extent to which we concentrate our listening and our subsequent interpretation of the sound(s) perceived. In conclusion, an inclusive consideration of existing approaches, both conceptual and practical, has yielded the proposal of a combinational model which encompasses various aspects of previous research into the analysis of acousmatic music in order to sufficiently conduct a conclusive uninfluenced evaluation of an acousmatic work.

Select Bibliography

Anon. from Margaret Head and Rhóda Métraux, ed.: *The Study of Culture at a Distance* (Chicago: University of Chicago Press, 1958), 162–169.

Barrett, Natasha: 'Little Animals: Compositional Structuring Processes', *Computer Music Journal* 23/2 (Summer 1999), 11–18.

Bossis, Bruno: 'The Analysis of Electroacoustic Music: from sources to invariants', *Organised Sound* 11/2 (8/2006), 109–110.

Bregman, Albert S.: *Auditory Scene Analysis – The Perceptual Organization of Sound* (Cambridge, MA: MIT Press, 1990).

Goldstein, Bruce: *Sensation and Perception* 6th edn (California: Wadsworth Publishing Company, 2002).

Howes, David: *Sensual Relations: Engaging the Senses in Culture and Social Theory* (Michigan: University of Michigan Press).

Moore Sohlberg, McKay and Mateer, Catherine A.: *Introduction to cognitive rehabilitation: theory and practice* (New York: Guilford Press, 1989).

Risset, Jean-Claude: Foreward, *Electroacoustic Music – Analytical Perspectives* ed. Thomas Licata (Connecticut: Greenwood Press, 2002), xiii.

Smalley, Denis: 'The Listening Imagination: Listening in the Electroacoustic Era', *Companion to Contemporary Musical Thought* ed. John Paynter, Tim Howell, Richard Orton and Peter Seymour (London: Routledge, 1922), 514–554.