STIMULUS COMPLEXITY AND TIME JUDGMENTS

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ABSTRACT

In my endeavour to try and understand the main mechanisms of time perception in electroacoustic music, I explored complexity and how it can affect our experience of timescales and passing of time. This experience ultimately influences our understanding of structures and balancing of sections, our appreciation of gestural and textural development, and the interconnection of concurrent, near and remote events. For the purpose of this research, important papers in time perception written mainly from cognitive psychologists have been examined, and relations to music perception were drawn. A list of situations where complexity may occur in electroacoustic music, with an emphasis on acousmatic music, has been compiled.

The relationship between complexity and psychological time, based on theories of Hogan, Priestly and Ornstein, is followed by an examination of complexity related to various parameters of sound.

1. INTRODUCTION

This paper is drawn from my PhD research on timescale perception. Originally, my research on complexity and time judgments started from the combination of micro events, and aggregates that lead to certain situations that arise from granulation when the gap between grains widens and their connecting bond weakens, so that they no longer give the illusion of one continuous sound event. However, it soon became apparent that whereas complexity at the micro level is limited to event density and rhythmic behaviour, an investigation that was not restricted to one timescale could reveal a broader range of intricate systems.

2. COMPLEXITY MODELS

In 1978, psychologist Wayne Hogan proposed that time perception is a curvilinear U-shaped function of stimulus complexity. At that time, there were two prevalent opposing views regarding complexity and time perception. One view, proposed by Priestly in 1968, showed that empty intervals are judged as longer than filled intervals; and the second view, proposed by Ornstein in 1970, claimed the opposite [4]. Hogan, in his paper, concludes that both views are correct, but they do not reveal the whole story; on the one hand, empty intervals are boring and are felt to be long, and on the other hand, sensory overload also leads to boredom. Hogan concludes that moderately complex stimuli are "experienced comparatively 'fuller' and shorter than either minimally or maximally stimulating time intervals" [4]. Subsequent studies point towards the same direction, and support Hogan's view ([2] and [3]). Experiments have been conducted with visual as well as verbal stimuli.

A modified version of Hogan's diagram can be seen in Fig. 1. Psychological time is shown on the vertical axis and stimulus complexity on the horizontal. Although there are many parameters affecting perceived durations (such as temporal structures, extra-musical associations and the psychological state of the listener)[1], this diagram shows only complexity. Both very low and very high complexities cause lack of interest; consequently, intervals that belong to either end of the horizontal axis on the diagram are judged as longer than intervals filled with moderately complex stimuli. I chose 'haste' and 'languor' to represent the opposite states of psychological time, where time passing is judged as either fast or slow. The word 'languor' does not necessarily point to a negative feeling, as it indicates a feeling of lack of interest or energy (which may lead to boredom); it is also a relaxed and comfortable feeling, as well as showing inactivity and an unusual lack of energy.

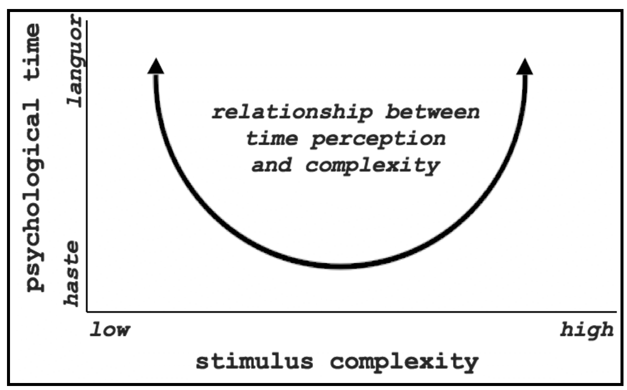

Figure 1. Stimulus complexity and time perception.

Grondin points out that Ornstein's model, whereby empty time intervals are judged as shorter than filled intervals, is now generally recognised to apply to retrospective timing ([3] and [8]). According to this model, the more changes occurring during a time interval, the more the memory is loaded with information. This affects remembered duration, which is proportional to the storage size occupied by events in

[1] My paper examining temporal associations is published in *Organised Sound* Vol. 16 (1), and it is titled 'Temporal Associations, Semantic Content, and Source Bonding' (pp. 63-8).

memory. There are obvious implications in compositional structures, where busy sections are remembered as longer than they actually are, and idle sections as shorter. However, while experiencing those sections in real time, the listener may have a different impression, because time perception depends on the model proposed by Hogan (see Fig. 1). Ornstein's model applies to duration *estimation*, whereas Hogan's pertains to *perception* of duration.[2] Remembered durations can change the perceived proportions of a piece; consequently, careful balancing between sections is required, depending on level of complexity rather than physical duration.

A sound has many parameters, and complexity may occur in any one of them. Complexity must not cause a fusion of fluctuations, or of layers, into one unvarying event; for example through saturation, or by placing layers close together in a way that they cannot segregate. We must be able to perceive a multiplicity of events or contexts, or multiple changes. Complexity can be regarded as a structural construct of composite nature, which describes a condition difficult (in various degrees) to disentangle or analyse. Therefore, complexity can refer to variance and amount of information within a parameter, and the degree of perceived complexity depends on the analytical skills of a person. Below is a non-exhaustive list of parameters encountered in electroacoustic music, in which complexity may occur.

3. PARAMETERS INVOLVING COMPLEXITY

(1) *Rhythmic and melodic complexity.* Judgements of melodic complexity are connected with the musical expectations of the listener. Melodies that create and fulfil expectancies are easier to recognise and reproduce, and so they are judged as less complex by listeners [1]. Eerola and North [1], based on existing research on perception of music cognition and melodic expectancies, summarise the factors that contribute to complexity according to the expectancy-based model. They state that factors are divided into tonal, intervallic and rhythmic. Tonal factors include 'tonal stability', which is modified by 'metrical position' and 'duration'; these modifiers emphasise the position of notes, and lead to increased or decreased perceived importance of notes. Intervallic factors are based on Gestalt laws and include 'proximity', 'registral return', 'registral direction', 'closure', and 'intervallic difference'.[3] Rhythmic factors, which account for both rhythmic and melodic complexity, include 'rhythmic variability' that depends on individual durations of events (or durations defined by changes within a continuous flowing movement of a sound), 'syncopation' i.e. deviation from a regular pattern, and 'rhythmic activity' i.e. number of events (or durations of different states of an event) in a time interval. The expectancy-based model of melodic complexity considers only single melodic lines; the 'number of simultaneous melodic lines' and the complexity that arises from their interaction and contrapuntal relationships should be added to the above factors. The 'sharpness of onset' can be another added factor, because the less defined the onset is, the less clear the changes from note to note; sometimes melodic lines made of such sounds can be perceived as less complex – we tend to follow a generalised contour instead of attending to the minute detail of each step and leap between notes.

(2) *Spectromorphological complexity.* This refers to the number of spectromorphological changes of sound events occurring within a time interval. Spectromorphological complexity multiplies by the number of changing sound-shapes and/or internal textural changes developing at the same time as different auditory streams.

(3) *Spatiomorphological complexity.* This concerns multiple changes from one space to another, trajectories, or multiple zoned or nested spaces; that is, spaces that occupy different regions, and spaces within a space [10].

(4) *Referential density.* A short section referring to many source-causes has a high referential density, and can therefore be perceived as complex. Conversely, a section referring to few source-causes has a low referential density.

(5) *Referential discourse density.* Referents also interact with each other in a discourse, thus bringing a secondary level of complexity, which is the referential discourse density. For example, bells, choir and incidental noises from people in a large reverberant space refer to three different families of source-cause; consequently, the referential density is high. However, all these sounds seem to originate in the same setting; the *intended target message* is associated with one situation, which is a ritual ceremony in a church. The referential discourse density, in this case, is low. The opposite would apply if a structure comprised layers of sounds semantically unrelated.

(6) *Harmonic complexity.* Concurrent notes in harmonic relationships may or may not segregate perceptually, depending on various parameters examined by auditory scene analysis. No studies have been located on harmonic complexity influencing time perception, so a conclusion cannot be drawn on whether a complex harmony of concurrent notes that form a perceptual unit can cause the feelings of haste or languor. However, harmonic density carries a supplementary factor, namely spectral space density. There are different ways in which spectral space is

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[2] Cognitive psychologists differentiate between estimation of duration, where memory is used, and perception of duration, which involves the experience of the specious or subjective present. The specious present is regarded as the time interval in which information is experienced as a single unit; it is generally accepted to be around 5 sec long, and it is organized as an oscillatory process that follows excitation and relaxation modes ([6] and [7]).

[3] Eerola and North also include the intervallic factor of 'consonance'. However, since musical consonance refers to Western tonal harmony (as opposed to sensory consonance that refers to absence of roughness on simultaneous tones), and depends strongly on musical experience and culture, I omit this factor. In acousmatic music, consonant (i.e. agreeable) resolutions depend on context.

occupied and filled out as discussed by Denis Smalley [9]; various motion and growth processes of gestural and textural nature may occupy and fill up spectral space, referring us back to spectromorphological complexity. In addition, harmonic density can affect time perception indirectly, as it influences perception of loudness; the more frequencies a sound occupies, the louder it is perceived [5]. Because quiet sounds are judged as shorter than loud sounds (Goldstone et al 1978, cited in [2]), a harmonically dense structure should be perceived as longer than a thin structure of the same physical duration.

4. CONCLUSION

Starting from research on the relationship between complexity and psychological time, a list of situations where complexity may occur in electroacoustic music has been assembled. These situations include rhythmic, melodic, spectromorphological, spatiomorphological and harmonic complexities, referential density and referential discourse density.

It has been noted that Hogan's model is applied while listening to a piece of music and links to our appreciation of gestural and textural development, whereas Ornstein's model operates with remembered durations which affect the perceived balancing of sections. Both systems are important in the perception of time passing and estimation of durations in electroacoustic music, and parameters involving complexity affect both systems.

5. REFERENCES

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