

Exploring The Multidimensionality Of Sound Design.

Extract: Outlining Synchronicity and Morphology.

Footnote numbering is automated and those contained in this extract will differ from those in the full Thesis.

MICHAEL C. CULLEN

MASTER OF SCIENCE (SOUND DESIGN)
SCHOOL OF ARTS, CULTURE AND ENVIRONMENT
THE UNIVERSITY OF EDINBURGH
2005

“This copy of the thesis has been supplied on condition that anyone who consults it is understood to recognise that the copyright rests with the author and that no quotation from this thesis or information derived from it may be published without prior consent of the author or the university (as may be appropriate)”.

Abstract

This thesis explores the multidimensionality of sound design within a framework of aesthetics, functionality, synchronicity, morphology, interaction and intuitive application; examining how awareness of a physical and emotional contract can enhance sound design practice in terms of declared parametric interplay.

A wealth of physical and emotional responses is revealed that one can reference while designing sonic structures in terms of interface, manipulation and interpretation.

Several references are made to sounds designed for an accompanying animated movie short, entitled 'Thrice', produced in parallel to this thesis.

2. Synchronicity

2.1 Physical And Emotional Synchronicity

Synchronicity adheres to emotional dynamics in terms of cerebral feedback from the result of any ongoing physical input via parametric modulation or gestural control. Once sensitivity from any physical operation is perceived as desirable, physical and emotional synchronicity is established (Figure 2.1).

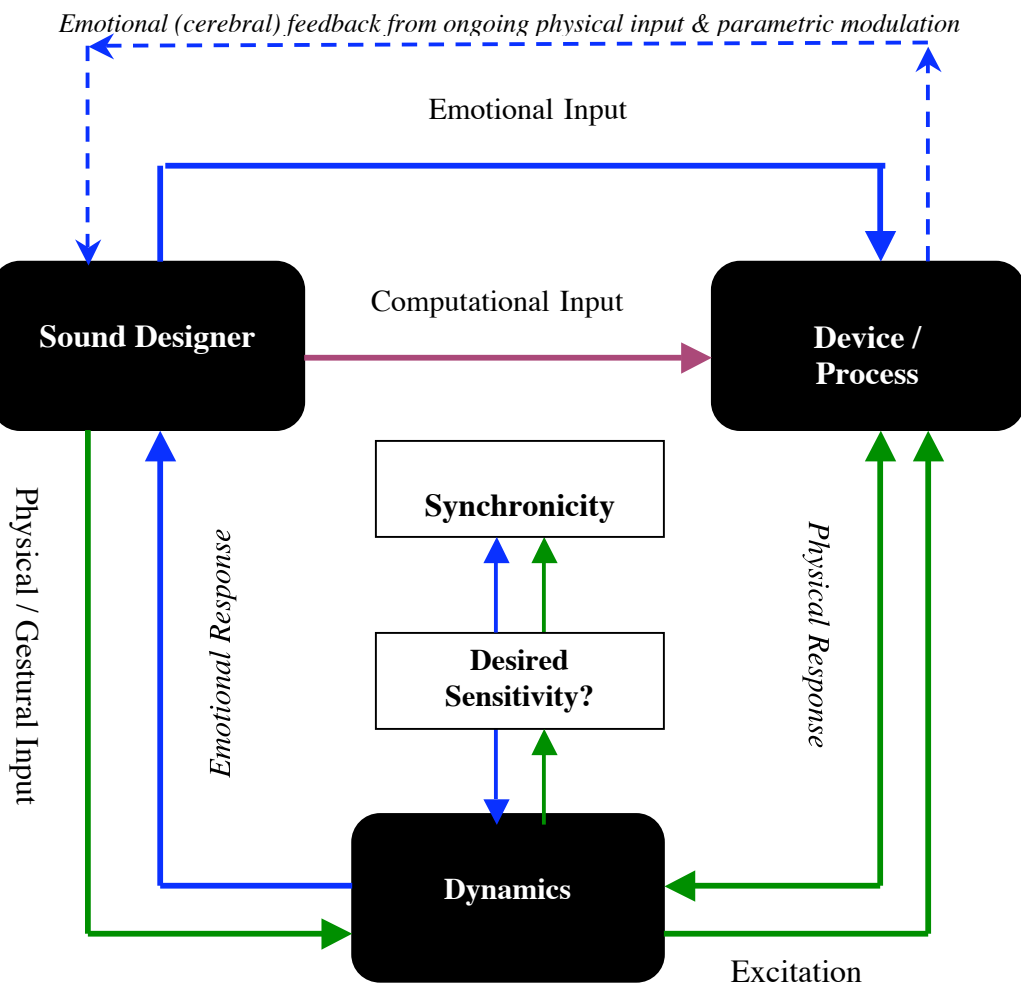


Figure 2.1 Synchronicity At The Centre Of A Physical And Emotional Contract.

Synchronicity also harnesses emotive energy at the postoperative¹ sound design stage regarding vertical positioning of sonic elements and their consequent forging in to a single entity that the designer then defines as the refined sound. This is a mode of combined composition and performance where the combined emotive elements from both disciplines collide in the structuring of a sophisticated sound design.

One can clearly associate this observation with Gestaltism, as after the design stage, the synchronicity between vertical elements becomes less important than the combined whole. Yet the emotional interplay of decision making, with respect to physical positioning of often numerous waveforms, is paramount to achieving the desired sound design. This is particularly significant in non-note or sonic structure orientated sound design where the sound designer operates outside the boundaries of tempered scale and conventional rhythmical instrumentation.

2.2 Synchronicity Within A Multidimensional Space

Synchronicity is normally based on a structure of harmony in a musical or temporal sense. But, because any natural or synthetic sound in terms of declared parametric adjustment can satisfy the aim of synchronicity, regardless of scale and time signature, the sound designer is free to move away from such references of familiarity and “explore the multidimensional space of sound itself.”²

The sculpturing techniques employed in frequency domain (spectral) synthesis and subsequent inverse Fourier transformation back into waveforms for the application of break point editing are ideal for such exploration of sound-space synchronization.

When temporal synchronicity is desirable, the application of selective vertical component audio file positioning provides a useful technique for masking repetition within a

¹ The stage at which the boundary of real-time performer blurs into that of designer and composer outside the confines of notation.

² Wishart, T. Audible Design: A Plain And Easy Introduction To Practical Sound Composition. (Orpheus the Pantomime Ltd. 1994.) p.2.

sequence of independent events. An example could be the arrangement of spectral transformations of differing lengths to create unique variations of a source file. Whether intended or not, this technique creates nonlinear characteristics that are more representative of real world acoustic behaviour, yet can be formularized to distort reality a lot deeper than the application of block repetition.

The multidimensional space of sound can be further explored through the subtle parametric interplay of vertically arranged audio regions. This is akin to a form of sonic microsurgery. One can explore and manipulate the space revealed from any parametric attenuation and either leave this revealed spaciousness intact or modify it with adjustment of another declared parameter. Upon achieving the desired sensitivity, one can observe these two parameters as having a synchronous relationship.

An example of this technique is applied in the context of the Thrice movie for the final sound of the airborne police vehicle. The concept was to develop the overall engine sound in line with the pitch cycle of a siren sound. The engine was sourced from generator and ventilator sounds and subjected to various spectral and time based transformations. Each transformation was then layered vertically and subjected to parametric break point editing to produce the overall engine sound. These techniques are discussed further in the section entitled 'Morphology' where the role of synchronicity is interpreted differently.

The vertical audio waveform structuring for the vehicle sound can be accessed in the Pro Tools session file (see Appendix B) at 3.09.173 for the vehicle descent (Figure 2.2), 6.47.381 while traversing the city streets (Figure 2.3) and at 6.56.466 for a Doppler pass-by.

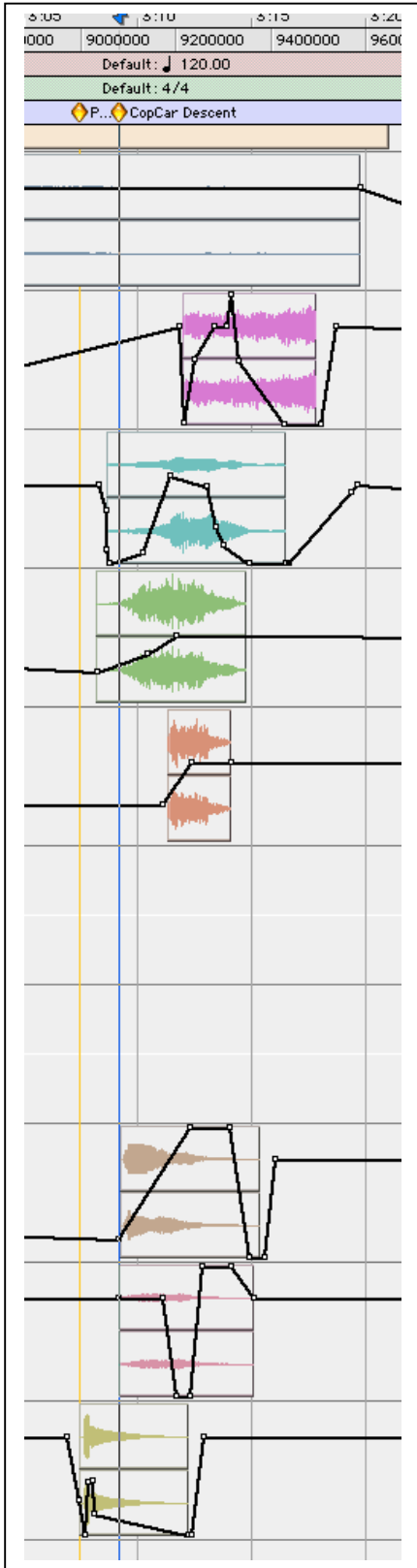


Figure 2.2. Structure For Vehicle Descent With Amplitude Envelopes

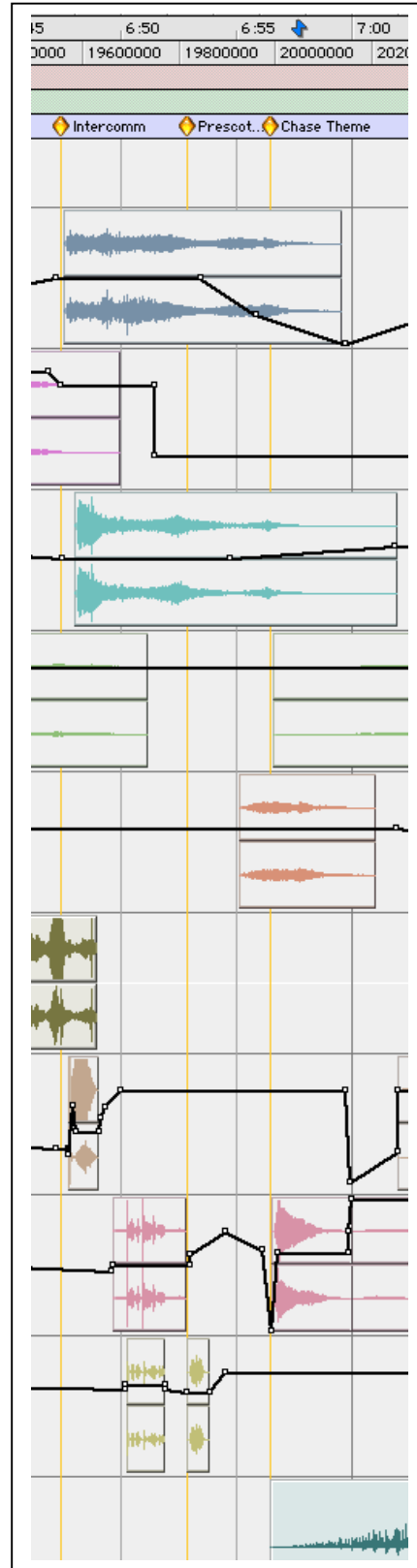


Figure 2.3. Structure For Vehicle Traverse With Amplitude Envelopes

2.3 Block Repetition

Block repetition is a process that is devoid of dynamic variation. But from a viewpoint of stimulating sound design, block repetition should not be dismissed just because of its exploitation in areas of popular culture, in particular dance music. Block repetition is a seemingly unnatural acoustic phenomenon and therefore, when applied in the context of more obscure sound design elements, rather than for example rhythm programming, it can be considered as being as equally experimental as the most unnatural and dynamically varying textural transformation. The break-point envelope editor in 'Absynth' is ideal for exploring block repetition on selective parameters of a sound design.

3. Morphology

3.1 Definitions Of Morphology

The dictionary definition for morphology is “the study of the forms of things”.³

In his book ‘Morphologie and typologie des objets sonores’, Pierre Schaeffer (1910 – 1995), introduces the concept of sound morphology. He was chiefly concerned with the analysis of isolated sound, separated from its context and examined for its characteristics outside its normal time continuum.⁴

Curtis Roads advocates Schaeffer’s concept in his book ‘Microsound’ with a section entitled “Sound Object Morphology’ in which he points out Schaeffer’s “desire to understand the enormous range of possible sound objects...” and his “...attempt to classify them, beginning in the early 1950s...”⁵

Schaeffer’s reference to *objets sonores* suggests he was thinking very much about sounds in terms of physical objects. But the term ‘object’ is initially somewhat misleading and contradictory in terms of sound and morphology as it implies an inanimate tactile form. However, keeping in mind this somewhat paradoxical observation, ‘object’ will suffice for purposes of further analysis.

Morphology,⁶ according to Trevor Wishart, is the way in which the properties of a sound vary with time. In reference to the acousmatic classification of sound-objects given by the Groupe de Recherches Musicales,⁷ Wishart describes variations within the category of continuation. He observes that in the physical world, morphing applies to continuation

³ Swannell, J, Executive Editor. The Oxford Modern English Dictionary. (Oxford: Oxford University Press, 1994.) p.693.

⁴ Snyder, J. <<http://csunix1.lvc.edu/~snyder/em/schaef.html>> (accessed 15 July, 2005, 04:43 UTC.)

⁵ Roads, C. Microsound. (Massachusetts, The MIT Press. 2001.) p. 20.

⁶ Wishart, T. Audible Design: A Plain And Easy Introduction To Practical Sound Composition. (Orpheus the Pantomime Ltd. 1994.) p.125.

⁷ *Ibid.*

over time where the continuation is discrete (without resonance), iterative (sustained trill but discrete during rapid triggering) or continuous (continuous continuation).⁸

R. Murray Schafer describes morphology in terms of “changes in groups of sounds with similar forms or functions when arbitrarily arranged in temporal or spatial formations.”⁹ This interpretation adds foundation to the importance of one’s awareness to dynamic structuring and behaviour in the vertical plane of digital audio workstation (DAW) sound design.

3.2 Categories Of Continuation And Classification Subsets

For the category of continuous continuation there exists systems of imposed¹⁰ and intrinsic¹¹ morphology. As Wishart explains, “we will split apart the category of continuous continuation to give on the one hand, sounds where there is a continuous input of energy, the continuation is due to the imposed morphology...and, on the other hand, sounds where the continuation is due to the physical properties of the sounding medium [intrinsic morphology]....”¹²

These distinctions in the morphological behaviour of sounds adhering to the category of continuation are made with reference to the physical world rather than sounds produced in computer studio synthesis, but they are important distinctions for a studio based sound designer to consider, as they help define dynamics in terms of an energy impulse that initiates a sound and governs its subsequent behaviour.

In computer studio synthesis, the synchresis of audio morphing adopts a mode of transitional temporal synchronicity via a process of spectral interpolation between two

⁸ Wishart, T. On Sonic Art. (OPA Amsterdam B.V., Harwood Academic Publishers GmbH. 1996.) p.177. From the acousmatic description given by the *Groupe de Recherches Musicales*.

⁹ Schafer, Murray. R. The Soundscape: Our Sonic Environment and the Tuning of the World. (Vermont, Destiny Books. 1994.) p.272.

¹⁰ *Ibid.*

¹¹ *Ibid.*

¹² *Ibid.* p.178.

audio files. The key properties open to varying degrees of calculated control are amplitude, frequency and phase and window¹³ length as exemplified in the morphing algorithms unique to the Composers Desktop Project (CDP) system.¹⁴

Figure 3.1 illustrates the relationship of real impulse initiated sounds with respect to imposed or intrinsic morphology separate from the more ambiguous morphology generated via computer studio techniques.

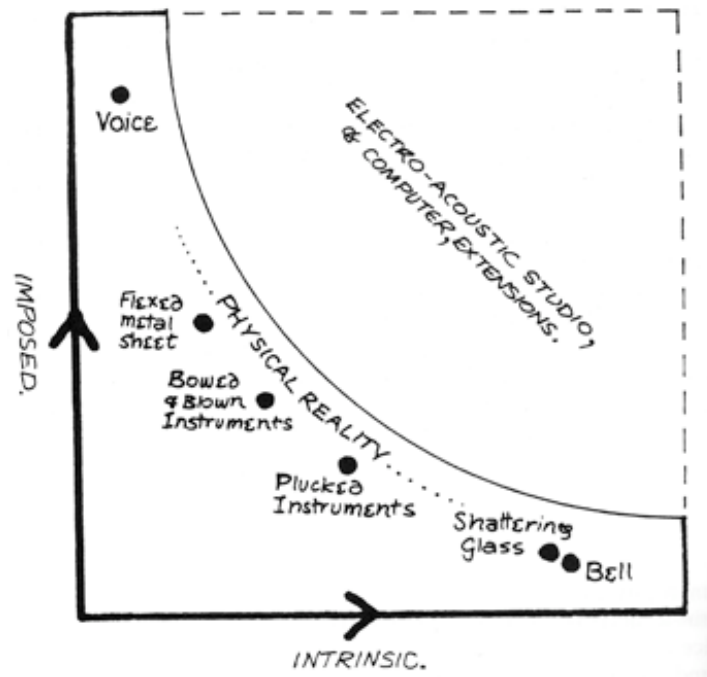


Fig. 3.1 Real Sounds In Relation To Imposed Or Intrinsic Morphology.

Source: Wishart, T. On Sonic Art. (Amsterdam, Harwood Academic Publishers GmbH. 1996.) p.188.

One can observe how morphological behaviour is determined through the excitation of gestural dynamics with respect to force, impact, friction and continued application of distributed energy.

¹³ Roads, C. Microsound. (Massachusetts, The MIT Press. 2001.) p. 246.

¹⁴ MORPH BRIDGE; MORPH GLIDE; MORPH MORPH;

<<http://www.bath.ac.uk/~masjpf/cdp/index.html>> (accessed 30 June, 2005, 05:17 UTC.)

However, whether a sound is natural or synthetic, the perceived fundamental, collective, morphological and definitive property is one of movement.

Intrinsic and imposed morphologies pertaining to the category of continuation are evident in the sound design of the *Thrice* movie. An example of imposed morphology with properties of discrete continuation is the spot effect used at 1.33.283, signifying the sound of the police character placing his gun down on the bar. It is a single non-resonating sound that one could classify as having complex characteristics of ‘Impact’¹⁵.

An example of intrinsic morphology with properties of iterative continuation is the firework explosion at 2.34.558. It is a sound that audibly sustains when heard individually, but as part of an ongoing firework display would be perceived as being discrete due to the explosive amplitude of the repeating attack elements masking any sustain characteristics from preceding detonations.

The synthesized gunshot spot effect at 7.45.620 is an example of imposed morphology with properties of iterative continuation. This sound has similar characteristics to the firework example, except that its morphology is imposed through synthesis rather than intrinsic by nature. Both examples can be classified as having complex characteristics of ‘Explosives’¹⁶.

An example of imposed continuous continuation is the sound of the helicopter at 1.11.000. This sound can be classified as having complex characteristics of ‘Modulation’¹⁷.

Other examples of imposed continuous continuation are the synthesized atmosphere sound effects used for sonic continuity during scene dissolves, for example the sounds commencing at 4.41.886. These sounds could be classified as having complex

¹⁵ See Appendix A.

¹⁶ *Ibid.*

¹⁷ *Ibid.*

characteristics of ‘Sirens’¹⁸ as the pitch or mass rises and falls in parallel with [or similar to] dynamic levels.¹⁹

Intrinsic continuous continuation is evident in the sound of the gas emanating from the cigarette lighter at 7.59.158. This can be classified as having complex characteristics of ‘Gas’.

3.3 Excitation

Excitation imposed on a sound by a performer sounds naturally more dynamic in terms of physical morphological behaviour than audio produced via electronic or computer synthesis. However, awareness of natural dynamic behaviour, whether transient, musical or non-notational, focuses one’s mind on the importance of such characteristics prior to and during the post-production of computer synthesis.

A technique for more efficient computer synthesis of natural excitation, including its exaggeration, is the application of multiple and often extremely detailed break-point edit nodes for amplitude, frequency and panorama. Computer synthesis can rarely model exactly, the gestural dynamics of a live performer, just as the live performer is rarely capable of expressing the precisely premeditated dynamics produced via hand drawn break point envelope editing. As Wishart points out, “The directness of physiological-intellectual gestural behaviour carries with it ‘unspoken’ knowledge of morphological subtlety which a more distanced intellectual approach may not be aware of.”²⁰

Sound resulting from algorithmic computer synthesis is a product of computation and therefore it is difficult to define gestural behaviour in terms of user energy input. A sound generated via computer synthesis is a gestalt entity in its own right.

¹⁸ *Ibid.*

¹⁹ Wishart, T. On Sonic Art. (OPA Amsterdam B.V., Harwood Academic Publishers GmbH. 1996.) p.183.

²⁰ *Ibid.* p.179.

Knowledge of gestalt dynamics present in intrinsic or imposed morphology, facilitate the modelling of new and interesting sounds and thus formularise new unimagined categories of sound²¹.

3.4 Emotional Morphology

It is important at this point to mention the concept of emotional morphology in terms of emotion being a natural feedback mechanism for continued physical application that concurs with the principle of synchronicity at the core of a physical and emotional contract.

This is a difficult concept to grasp with respect to continuous continuation having independence from human intervention for as long as the continuation lasts, particularly with reference to offline computer synthesis²². In this type of synthesis, the morphological impulse arises from predetermined computational values imposed prior to processing. Any perceived continuation is thus encoded²³ as a result.

Prior to computation, a degree of thought is required to determine the integer or decimal values to be imposed on the algorithmic parameters constituting an energy impulse for computation and transformation to actually occur. How much of this thought process is truly emotive is open to debate and requires specific research. But in practice, when one determines the desirability of a processed sound, emotional feedback can be considered part of the overall process, as it determines whether a sound is used or subjected to further offline processing.

²¹ Appendix A lists the sound categories chosen for the Thrice Movie.

²² Algorithmic data entry based synthesis where no real-time control is available normally due to the computational limitations of a computer's CPU. With the advent of more powerful processors offline rendering is being replaced with real-time GUI's.

²³ Upon deeper analysis of sounds generated via offline computer synthesis, the presence of both imposed and intrinsic continuation is open to debate. Therefore, encoded continuation is a preferred description.

The semantics of such processing suggest the possibility of a physical and emotional contract in terms of man and machine code. Is the machine code capable of emotion? To answer such a question effectively requires specific research in its own right. But I will briefly address this issue as one could certainly argue that code is a vehicle for emotion. A sound generated out of numeric computation is certainly capable of triggering an emotive response in the psyche of the listener.

3.5 Physical Morphology

In terms of physical morphology, it is at first difficult to accept that a keystroke or mouse click constitutes the physical impulse for a sound. Yet, these actions constitute the physical interface activity between man and machine code generation of a sound.

In both man and machine code environments, no electricity equates to no energy impulse. The keystroke or mouse click is an electrical impulse interpreted via an instruction set (code) inside a microprocessor and performs a given function. The act of pressing the key itself is the result of electrical impulses directed from the brain to the muscles in the hand and thus physical action.

The fact that the electrical process of initiating a keystroke begins as a conscious decision suggests emotional involvement in the context of this physical action. By making a conscious decision to implement parametric values for algorithmic sound design the emotional dynamic is triggered and transferred into the digital domain.

3.6 Audio Morphing In Computer Synthesis

Through the development and evolution of spectral synthesis tools, morphology in terms of 'Audio Morphing' is undergoing reinvention as a synthesis model in its own right. It is a complex model of synthesis where aesthetics in the time domain only serve to confuse

the complexities of computational spectral interplay between the gestalt properties of audio files selected for morphing.

Malcolm Slaney formerly of Apple Computers Advanced Technology Group - The Interval Research Project, describes techniques for audio morphing in terms of a multi-dimensional space. “Audio morphing is accomplished by representing the sound in a multi-dimensional space that is warped or modified to produce a desired result. The multi-dimensional space encodes the spectral shape and pitch on orthogonal axes. After matching components of the sound, a morph smoothly interpolates the amplitudes to describe a new sound in the same perceptual space. Finally, the representation is inverted to produce a sound.”²⁴

The concept of a multi-dimensional space was introduced earlier in this thesis in reference to synchronicity (see footnote 22), and it is intriguing as it suggests the possibility of unknown dimensional parameters for innovative sound design.

This is evident when one tries to describe unnatural sounds within the context of familiarity. Familiarity is limited to naturally occurring dimensional parameters such as pitch, time, space and language and therefore it is very difficult to be descriptively precise of forms forged out of extra dimensional parameters. In his definition of multi-dimensional space, Wishart points out that “Spaces may be any number of dimensions (i.e. not necessarily ones that we can visualise in our own spatial experience) from the four dimensions of Einstein’s space-time, to the infinite number of dimensions in Hilbert space²⁵.”²⁶

²⁴ Slaney, M. Automatic Audio Morphing. *International Conference on Acoustics, Speech, and Signal Processing* (Atlanta, GA. IEEE. 1996.) <<http://rvl4.ecn.purdue.edu/~malcolm/interval/1995-061/>> (accessed: 02 August, 2005, 00:45 UTC.)

²⁵ ‘Hilbert Space’, Vectors or complex sequences of numbers. “Hilbert spaces serve to clarify and generalize the concept of Fourier Expansion”. *Wikipedia: The Free Encyclopedia*, 25 July 2005, 20:24 UTC, <http://en.wikipedia.org/wiki/Hilbert_space> (accessed: 02 August, 2005, 03:03.)

²⁶ Wishart, T. Audible Design: A Plain And Easy Introduction To Practical Sound Composition. (Orpheus the Pantomime Ltd. 1994.) p.125.

Current Virtual Studio Technology (VST)²⁷ and other plug-in formats, marketed as tools for real-time audio morphing, do little more than provide an interface for cross-fades between audio files, akin to software DJ mixing with two recordings. The critical point of proposed morph is often coloured with aliasing and phasing problems and once again, the aesthetic is often more gratifying than the results of any real-time audio processing. The example of a commercially available VST plug-in illustrated in figure 3.2 reveals an interface that resembles motion-path navigation via a dual (not orthogonal) axis, cross fader.

Even in the absence of any experience with intense computational offline audio morphing technology²⁸, it would still be difficult to regard the cross fading between two audio files as acceptable audio morphing regardless of the aesthetic approach. However, upon further investigation a satisfactory explanation follows.

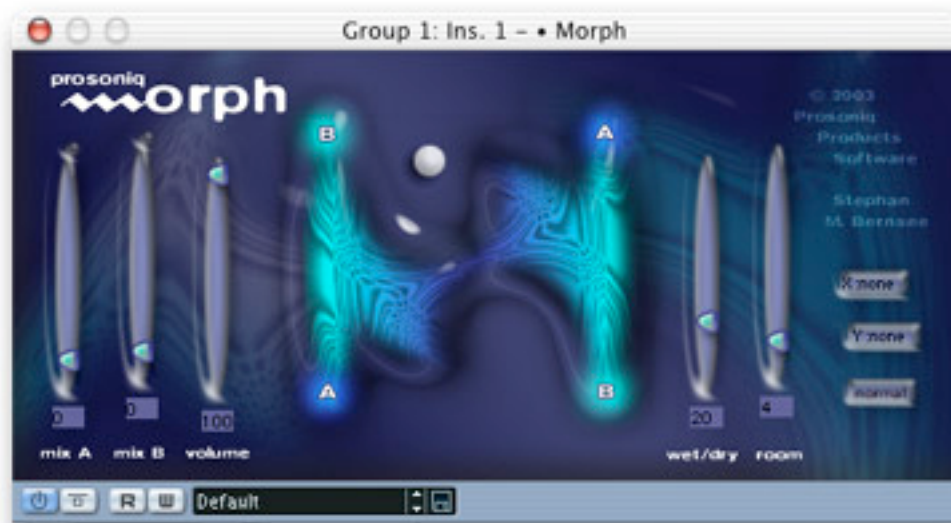


Figure 3.2 Prosoniq ‘Audio Morph’ Interface.

Source: <http://www.prosoniq.com/html/img/morph.jpg>

²⁷ A programming interface for computer music sequencing software effects and instruments as developed by Steinberg Soft-und Hardware, GmbH.

²⁸ ‘Composers Desktop Project’ <<http://www.bath.ac.uk/~masjpf/CDP/docsrefs.htm#MORPH>> (accessed 02 August, 2005, 04:33 UTC.)

In this simplest form of alleged morphing, Slaney refers to the two sounds as "...points in a high-dimensional space. The dimensions of this space include spectral shape, pitch, rhythm and any other perceptually relevant (and quantifiable) auditory dimensions. We morph between the two sounds by tracing a path between the two points in an appropriately warped space."²⁹

This is analogous to the morphing of still pictures. More complex morphing involves movement so that the morph commences with the characteristics of the first sound and finishes with the characteristics of the second sound.

Slaney mentions a third, more unique type of morph that he terms 'cyclostationary'³⁰. "It is cyclic because we play the sound repetitively to affect the morph. It is stationary since each sound instance is a completely stationary (no change) example of the range of in-between sounds."³¹

3.7 Analysis / Resynthesis

Problems arise in real-time audio morphing tools because of the intensely complex calculations involved in the conversion of amplitude and frequency phase (spectral domain) data back into time domain audio sample units represented by a waveform.

This conversion is one of analysis-resynthesis.³² The spectrum analysis method commonly employed is one of Short-Time Fast Fourier Transform (STFT)³³. One of the first commercially available real-time spectral analysis and resynthesis software tools was Spektral Delay³⁴ (See figure 1.8).

²⁹ *Ibid.*

³⁰ *Ibid.*

³¹ *Ibid.*

³² Risset, J. C. Additive synthesis of inharmonic tones. Eds. Matthews, M., Pierce, J. Current Directions in Computer Music Research. (Cambridge, Massachusetts. The MIT Press. 1989.) p.159.

³³ "A Fourier-related transform used to determine the sinusoidal frequency and phase content of a signal as it changes over time." Wikipedia <http://en.wikipedia.org/wiki/Short-time_Fourier_transform> (accessed 22 August, 2005, 02:06 UTC.)

³⁴ Native Instruments Software Synthesis, GmbH, Germany. Released as a tool for real-time spectral manipulation of sound.

The Resynthesis method used in the Spektral Delay program is a process of inverse Short Time Fourier Transformation³⁵. Other Resynthesis models include Overlap-Add Resynthesis³⁶, Oscillator Bank Resynthesis³⁷, and Analysis-by-Synthesis/Overlap-Add Resynthesis³⁸.

Real-time application of Spektral Delay's proprietary algorithms is akin to morphology between time and frequency domain data.

3.8 The Six Elements

So far, the need to recognize the physical acoustic and the emotional psychoacoustic properties of sound as well as semantics and aesthetics have been highlighted. These four separate elements define the overall nature of a sound. Author, R. Murray Schafer, describes them as being 'Sound Contexts'³⁹ that are compartmentalised and usually studied as separate disciplines. For a Sound Designer to be innovative, he or she requires knowledge of each context with particular awareness of the morphology that blurs one discipline into another.

Schafer's contexts determine Acoustics as the subject of the Physicist and Engineer; Psychoacoustics as the subject of the Physiologist and Psychologist; Semantics as the subject of the Linguist and Communicator; and Aesthetics as the subject of the Poet and Composer. To these one could add Programmer and Tester in the contexts of Designer and End User respectively.⁴⁰ The combined sum of all these contexts is a requisite for creative sound design.

³⁵ Haas, J., Clelland, K., Mandell, J. NI-Spektral Delay Operation Manual. (Berlin, Native Instruments Software Synthesis GmbH. 2001.) p.53.

³⁶ Roads.C. Microsound. (Massachusetts, The MIT Press. 2001.) p. 257.

³⁷ *Ibid.* p.258.

³⁸ *Ibid.* p.258.

³⁹ Schafer, Murray. R. The Soundscape: Our Sonic Environment and the Tuning of the World. (Vermont, Destiny Books. 1994.) p.148.

⁴⁰ *Ibid.* Figure 1.9.