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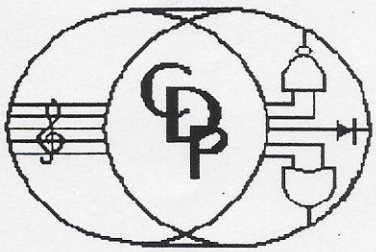

Sound Transformations in Electroacoustic Music

by

Leigh Landy

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The following text consists of an introduction to sound transformations in general, followed by a discussion of the aesthetics of sound transformations in electroacoustic music (Part II). Part III shows why a categorization system of sound transformations does not have to be based on a similar system categorizing all sound sources and/or timbres (color, tone quality). In Part IV a number of categories for sound transformations is proposed and is accompanied by a couple of hints for future users.

During several months in 1991 I spent my sabbatical working on a long-postponed research project. Essentially I was interested in learning more about the highly undocumented world of sound transformations within electroacoustic music. (Most information in this area is of a specialized nature such as software manuals.) These transformations often turn out to be a powerful compositional device and are, according to many composers, a great challenge as well.

My specific interest was to investigate what has been called the 'aesthetics of sound transformations'. I also wanted to create a classification system for sound transformations in the electroacoustic context as again no one had treated this subject either. It is hoped that through this article a start may be made towards the better comprehension of the potential of sound transformations as a compositional device.

Now completed, a second collaborative phase of this project will commence which calls for more technical, practical aspects of sound transformations to be tackled including the creation of user friendly graphic software for phase vocoding and a new user's manual (for more information, see footnote 9).

I - Background

A) What are sound transformations?

One of the many fascinating compositional possibilities among the musical extensions available in today's electroacoustic music is the ability to create timbral development from one basic sound-texture to another. This can be achieved within the course of one 'tone' or within a musical gesture. An early relatively well-known example of this can be heard in Jonathan Harvey's work 'Mortuos Plango, Vivos Voco' (1980) in which the sound of a struck bell occasionally seems to melt into the singing voice of his son as if this were a normal timbral transition (CD - Wergo WER 2025-2). As will be shown below, this concept of timbral migration is by no means new. It is the extent of potential metamorphosis and the enormous increase of potential timbres that are of greatest interest here.

Sound transformations may be defined as a timbral metamorphosis (i.e. from point 'A' seemingly naturally to point 'B') within one single sound event or sonorous gesture. In the latter case this can either take place within a sound continuum or by way of a discrete sound's repetition being transformed into that of a second[, third, etc.] sound, again as 'naturally' as possible.

It should be mentioned immediately that there are several opinions concerning the borderline between a single sound's morphology (think, for example, of the evolution of a sustained cello tone, growing from a somewhat dry timbre to a vibrato and so on) and a sound transformation. The difference can be found in the fact that from the listener's point of view, there should not be a perception of just one original sound source, the 'A', within any transformation. This implies that the subtle composer could in fact manipulate one sound source (therefore generating a morphology of that single source) and create what is presently defined as a sound transformation. Even if this line of separation is mildly vague, most consciously created sound transformations can in fact be heard as such.[1]

B) Is this a new concept?

As mentioned above, it is the hypothesis of this text that sound transformation potential has grown enormously with the coming of electroacoustic music. Of course 'grown' is the key word here. Timbral metamorphosis is almost as old as music and knows a variety of forms within vocal and instrumental music historically as well as within contemporary styles. As a matter of fact, since music has rarely been composed in what might be called block-structures, one might conjecture that timbral transformation has always been one of many basic elements of orchestration. A small selection of timbral metamorphosis within non-electroacoustic music now follows.[2]

The first example is not necessarily the earliest. In John Taverner's Mass 'The Western Wind', non-notated gradual overlapping is said to take place between choral tuttis and solo voice passages so that a more dense choral texture seems to flow into or become a thinner solo texture and vice-versa. This sense of taking over parts can also be found in various instrumental works of Schutz and Gabrieli; Haydn was known to have an interest in instrumental exchanges as well. One of his favorite transformations is to have a pitch played by one instrument before a cadence and then have it seemingly magically taken over by another one immediately afterwards thus changing the timbral texture entirely.

These metamorphoses become more sophisticated with time, especially during the last two centuries. Towards the end of Mahler's 'Abschied' from 'Das Lied von der Erde' there is some wonderful timbral interplay including brass sonorities being born of string textures. This might have inspired Berio, for example when he composed 'O King' (also part of his 'Sinfonia') which is a whole work centered on timbral metamorphosis. Not only does sophistication increase with time; the quantity of metamorphosis-users also expands. A historic climax can be found in the work of Ligeti, the uncrowned master of timbral metamorphosis. He has spent most of his career developing techniques within this area. His Cello Concerto and Requiem are but two excellent examples of his timbre transformational works. To conclude, the step from timbral metamorphosis in instrumental and vocal music to sound transformations in the electroacoustic genre was inevitable.

C) What is its particular relevance within electroacoustic music?

The tale has been told many times, but it deserves a quick mention here as well. The birth of electroacoustic music meant leaving the realm of 'just' notes and stepping into the realm of all sounds. This of course might be categorized as a case of historical necessity, just like the sound transformation story above, as music's timbral expansion has largely characterized music of this century (especially music written after 1945).[3]

Not only has the the number of sound sources for music grown enormously, but the possible sound

[1] It is useful to mention that Trevor Wishart subdivides defining morphologies of sound into a dimension ranging from what he calls intrinsic morphologies (things which sound the way they are, e.g. the sound of striking or breaking glass) to imposed ones (e.g. the manipulation of the vocal chords when speaking or singing). Many blown instruments which are influenced in terms of their timbres whilst including a heavy dosis of their own spectrum exemplify the halfway point between the two extremes. (Wishart: 1985, 97) We will not return to this below.

[2] By the way: timbral metamorphosis' equally interesting well-known cousins, tonal and harmonic metamorphosis are common as well. They call for 'natural' transitions between tonalities or harmonic fields but are not directly relevant to timbre.

[3] Of course this new genre has also been proven interesting in terms of our spatial awareness, especially where performance focuses upon this subject as well. The treatment of space will be briefly mentioned below (part IIIb - Smalley, part IVb - 'Some extras').

treatments have grown in equal proportion as our technology has evolved. If one were to study the growth of timbral possibilities for the cello for example - e.g. col legno and other indications found in Schönberg scores - and a farther jump beginning at the time of the early Darmstadt years - e.g., all the timbral research Berio did in preparing his 'Sequenze' - we can see how timbral evolution has grown almost exponentially. Many 'new' sounds been created on the front, back, top and bottom of the cello; furthermore innovative complex timbral combinations and sound morphologies have been created on the cello as well as on all our traditional instruments. It is this point of sound morphology which is now relevant.

Along with the known building blocks of electroacoustic music - composing with sounds, the search for new structures, new ways of listening (see II-B and II-C below) - researching a sound's potential development in time (theme and variation?) can become equally as important to a composer as the prior choice of sound source materials. As mentioned above, this sort of sonorous development can take on the form of a sound morphology, similar to the evolution of a cello tone. It can also take on the form of a sound transformation.

What, then, given this introduction, is the relevance of sound transformations within electroacoustic music? These sounds can play a major role within a composition without falling into the category of special effects. Many commerically available works such as 'Red Bird' (1973-77: an analog composition on the record YES-7) and 'Vox-5' (1986: a digital composition on the CDs - Wergo WER 2024-50 as well as Virgin Classics VC 7 91108-2 / 260 270-231) of Trevor Wishart and 'Phoné' (1980-81: a digital work on the CD - Wergo WER 2012-50) of John Chowning, just to name a few, illustrate this. The relevance of sound transformations can be found at the heart of what might be called their aesthetics which can be a very individual question. The aesthetics of sound transformations is the subject of Part II.

II - Some words concerning the aesthetics of sound transformations

A) What is meant by the aesthetics of sound transformations?

This article is more concerned with why sound transformations are used in electroacoustic music than what they are made from and how they are made. Therefore this discussion is not one of the traditional aspect of aesthetics, 'musical beauty', but instead of what might be called 'musical dramaturgy' (see Landy: 33 and chapter 7). In this way this section focuses upon musical raisons d'être for the use of sound transformations.

It should be stated here that as this text is not so much 'what' and 'how' oriented, a clear choice has been made to discuss this issue from the listener's point of view. We unfortunately have few documents (scores, print-outs) to deal with which could be used to discover how these sound transformations work and even less information concerning their perception within the musical context of a composition. The following paragraphs are based on personal experience, interviews with composers interested in sound transformations and more general texts on electroacoustic music that were found relevant to this subject.

To begin, in a recent article (in Paynter Vol 2: 514-554) by the composer/scholar Denis Smalley, the term, 'transcontextuality' (borrowed from L. Hutcheon) in electroacoustic music was introduced. Smalley writes, 'Where the sounds taken from cultural activity or nature are used as recorded, or where transformation does not destroy the identity of the original context, the listener may become involved in a process of transcontextual interpretation. We should include any recorded sound event where we are simultaneously aware of two (or more) contexts. ... In transcontexts the composer intends that the listener should be aware of the dual meanings of a source. The first meaning derives from the original, natural or cultural context of the event; the second meaning derives from the new, musical context created by the composer.'

Smalley believes in using concrete sounds as the basis for transcontextuality as he views their interpretation as being based on 'a particular attitude towards the material' as well as on a dependence on 'shared norms and meanings'. Those sounds without 'real-life context' are by definition ambiguous and therefore would not fit

into the above description.[4] Do note that an electronic motor-like sound simulating crickets and a recording of real crickets may be similar from the listener's point of view and are therefore both relevant here (Wishart: 1985, 82).

He continues along these lines, 'The concept of transcontextuality is a useful way of understanding an indicitive process since it is obvious that something outside the musical context is indicated'. But Smalley also warns, 'The more the composer intervenes in the spectro-morphology [see Part IIIB for a description] of an identifiable source the more vestigial that source will become. ... When transcontextual identity becomes less clearly defined the ear relies more on alternative indicitive interpretations, and the composer remains the sole guardian of a dual knowledge.'

This lengthy borrowing from Denis Smalley has been chosen for many important reasons leading to an interest in the music of sound in general, and specifically the smaller world of sound [transformations, are contained in his concept of transcontextuality (although this is not the only road leading to Rome). Obviously as any transformation of representational 'A's' and 'B's' will contain a drop of surrealism (see part IIb below for an elaboration of the term), change of context is implicit. This is why this concept of Smalley's has been chosen here as a starting point. His desire to offer tangible, that is representational sources, is important here. Surely one can construct a sound transformation using only electronic non-representational sounds, but its perception will be highly different from the examples mentioned in Part I and tends to be less frequently applied than representational ones. One might therefore ask whether transformation is possible without changing or dualizing context.

B) One goal: new sounds and sound structures

One of the greatest attractions of electroacoustic music is the ability to search for new sounds (in a musical context) and sound structures.[5] This is as old as the genre, but has not lost its impact after some forty years of electroacoustic composition.

As mentioned in Part I, timbral transformation as such is not new. Simply stated, the discovery of new sound structures within a musical context using sound transformations is inviting to those electroacoustic composers sharing this goal.

C) Another goal: new ways of listening

This subject also dates from the beginnings of the history of the genre. Think for example of the 'Quatre écoutes' (Schaeffer: 112-128), Pierre Schaeffer's approach to what he calls 'reduced listening'.[6]

The thesis here is a simple one. By expanding the music of notes to the music of sounds, the experience of listening to music has been widely broadened. The Schaeffer notions lay a theoretical foundation for discussing the phenomenon of listening to electroacoustic music. What is of interest to us is that through the application of sound transformations, creating as it were 'impossible sound complexes' in the sense that such

4] One of Smalley's hypotheses dating from an earlier text (in Emmerson: 61) is that 'listeners can only apprehend music if they discover a perceptual affinity with its materials and structure.' Although the subject of structure will prove to be less important to the current discussion, suffice it to say that the author feels that this statement is not to be underestimated. How the listener gets used to and learns to appreciate new materials and structures is one of the greatest challenges facing today's composer.

[5] One could add the words 'musical structures', but this is generally true to all contemporary music and is less relevant to many electroacoustic works than to their instrumental/vocal counterparts (as is generally accepted). There are virtually no common denominators in the electroacoustic genre. Compositional structure is rarely linked to the application of sound transformations anyway (according to most composers using them). Therefore we can limit ourselves to the more micro-level details of a work.

[6] An aside for those interested in this subject: Denis Smalley has refined the Schaeffer approach in his recent article, 'The Listening Imagination' (in Paynter). He speaks of three 'relationships' of listening: the indicative, reflexive and interactive. (Anecdotically a fourth relationship, technical listening, i.e. listening to how sounds have been made, may be added to this list, a strange way of listening to music at best.) These relationships form the basis of his discussion leading to what he calls nine 'indicative fields' that prove most useful as far as creating a working terminology for the perception of electroacoustic music is concerned (see also part III below). The author refers the reader to Smalley's text for further detail.

things do not exist in nature, the listener is confronted with transcontextuality.

The combination of creating new timbral material and new musical circumstances for the listener must be underlined by a composer's musical dramaturgy as such sound complexes can be 'attention-grabbers' and therefore should only be used with care, in a sense one might consider the composer's paying special attention to the (passive) listening experience as the (active) search for new sounds and sound structures as seen through the looking glass.

D) Or a combination of these two goals, or even something else

Now that we have seen that the aesthetics of this subject can be approached from two points of view both involved with the discovery of sound, the story is not yet finished as these two goals are but the obvious ones to attract a composer towards applying sound transformations within electroacoustic music. Individuals have their own personal reasons which sometimes complement the above. Before giving the word in part IIe to the composer most associated with sound transformations, Trevor Wishart, the word will now be given to him anyway to exemplify one personal view. (Wishart: 1991)

He speaks of applying metamorphosis to sounds to create 'musical metaphors'. He is interested in narrative (which may be difficult to grasp or ambiguous in some works) as opposed to 'art pour art' abstraction. There have been many treatises written on metaphor within traditional European instrumental music, but those metaphors are rooted in music which is essentially abstract. It is through the concrete nature of most electroacoustic sound transformations (by their consisting of two or more representational sounds) that the ancient concept of metaphor within a musical framework can be modernized.

Wishart claims to be highly interested in the combination of mythology and music. Although this particular subject could take us on a large detour, one element associated with myths, 'the symbol' is essential here. Wishart speaks of the thought that a sound transformation can become 'a truth that reveals itself'. (Wishart: 1991) Semiologists have been searching for signifiers and signifieds in music for a couple of decades. Wishart is of the firm belief that modern symbols can be created within the electroacoustic context and are therefore one of the main cornerstones of his approach to the choice and application of sound transformation in his oeuvre. Obviously one continually needs to search for new sounds to achieve this and equally obviously the listening experience is at the heart of the matter. As Wishart has formulated his dramaturgy to this extent, it offers some food for thought for others who might be interested in a similar sonorous universe. These ideas are easily combined with the previously mentioned subject of musical surrealism.

This musical surrealism should be finally made more precise now. If we think of the traditional surrealist work, be it written, painted, sculpted or otherwise, elements of reality were combined in seemingly impossible ways (e.g. Salvador Dali's melting watch). Might it be true that sound transformations using identifiable 'A's' and 'B's' are an excellent, be it historically late way of attaining a musical form of surrealism? Of course simply mixing sounds that do not belong together (e.g. breaking ice and tropical birds) forms another version of musical surrealism. In any event it is through the genre of musique concrète that musical surrealism has become feasible.

An aesthetic for a surrealist approach to music, including sound transformations, is an interesting subject with respect to musical dramaturgy and should be looked into in more detail in the future. Returning to the concept of transcontextuality, although surrealism is just one way of articulating this, the composer should be aware of both contexts as articulated by Smalley: the sound's own context as well and the musical/compositional one.

E) A case in point: Trevor Wishart

'Making a good transformation is
like writing a tune. ... There are no rules.'[7]

Trevor Wishart has done more for sound transformations than any other composer or researcher. He has used them in his compositions for some 15 years, beginning with his work 'Red Bird' (see Wishart: 1978). His frequent choice of the voice within sound transformations turns out to be an obvious one for him as those who know his music realize that he is also one of the most inventive composers using extended vocal techniques. Convenience is not the only reason for this combination as we will now see.

Wishart claims to have become interested in the concept of transformation, not due to the evolutionary step from musique concrète techniques as one might assume, but through enthusiasm for the instrumental transformations he discovered in the early works of Iannis Xenakis. Again, as we found in part IB, the link to the tradition of transformation in instrumental music can even be found in the work of this highly experimental composer. Wishart's goal is to make transformations with what he calls 'real world sounds'.

As mentioned, Wishart has a preference for the narrative and the 'objective'. He hopes that his music contains 'more action than resonance'; therefore the identification of sources by the listener is fundamentally important in his works. He sometimes speaks of a sound transformation's 'story'.

Perhaps his use of the term objectivity can best be understood through the fact that he chooses his sounds so that the listener can construct a relation to that sound's role in human experience. (Here the concept of transcontextuality again comes to the fore.) This by no means reduces the value of Wishart's comment concerning metaphor and metamorphosis, for it is through these 'real world sounds' that he achieves his contemporary musical mythology, something he expects to work out further in his largest-scale work to date, his forthcoming opera 'Orpheus - The Pantomime'.

One 'real world sound' is used most often, namely the human voice. Wishart writes: 'Certain sounds retain their intrinsic recognizability under the most extreme forms of distortion. The most important sound of this type is the human voice, and particularly human language, although the particular formant structure of the human voice itself has a highly intrinsic recognizability for human beings. This is partly due to the obvious immediate significance of the human voice to the human listener, but also the unique complexity of the articulation of the source' (Wishart: 1985, 82 - this brings us back to Part IIC - ways of listening). Here one notes as we so often hear that the voice is the world's most versatile and communicative instrument. It turns out as well that through the voice's flexibility it can be used effectively at the beginning or at the end of a sound transformation due to its ability to match a corresponding sound. As transformations with similar 'A's' and 'B's' tend to be more successful than larger-scale interpolations, Wishart's extended vocal techniques accordingly have led to successful transformations (see the [dis]similarlity section in part IVB; Wishart says, 'The voice can be made to match almost any other sound, apart from bell-like stable inharmonic spectra'. [Wishart: 1988, 24]). So in this composer's case, 'Transformations come out of the voice'. Wishart's goal is that 'the voice speaks the world'; this is possible given all the potential 'B's' to follow the voice's 'A'.

Before letting this composer 'talk shop' for awhile, let's briefly look into what he said about his composition, 'Vox-5'.

In the introduction to his 'Computer Music Journal' article concerning the piece, Wishart begins by stating that this fifth of the six part 'Vox' series contains a primary aural focus, namely 'a (super)human voice that metamorphoses into many recognizable sonic images, such as the sounds of crowds, bees, a horse, or bells.' (Wishart: 1988, 21) Extended vocal techniques are of course at the heart of these sounds. He continues: 'In

[7] Where no further information is provided, the Wishart citations are from a conversation at his home in York on 10 July, 1991.

all the spectral transformations one aesthetic aim has been to retain the "source credibility" of the resulting sounds; that is, they must always be believably vocal or naturalistic' (although he often refers to a transformation's dream-like quality [Wishart: 1988, 21]). Discussing the matching of sources (idem: 24) Wishart states that in sound transformations, 'The two source sounds should have as many similarities as possible ... [W]ith more complex sounds [like the voice-L.L.], a high level of acoustic/musical judgment is required to match the sources sufficiently before embarking on what can be a long interpolation computation.'

Wishart finds the subject of perceptual boundaries within sound transformations to be of particular importance. When does it sound more 'A-like', when more 'B-like'? How dangerous or successful is the switch at the point of maximum ambiguity? (Wishart: 1988, 24-25)

Another subject of interest, as is often the case with composers of tape compositions, is Trevor Wishart's involvement with 'landscapes', primarily in terms of the transcontextuality issues raised above, but also in terms of spatializing the performance of an electroacoustic work. (This latter subject refers to highly interesting diffusion questions, but cannot be further treated here.) In presenting his ideas about landscape, Wishart discusses three sorts of 'imaginary landscapes' which are important to transcontextuality in general, as well as sound transformations specifically (in Emmerson: 48 as well as Wishart: 1985, 79-80). The combination of 'unreal objects / real space' is exemplified by the composer with the sonic image of substituting birds and animal sounds by arbitrary sound objects within a specific landscape. The converse, 'real objects / unreal space' is exemplified by leaving the nature sounds and removing/changing the context into an unreal (or ambiguous or fictitious (in Emmerson: 90) one. Finally the Wishart surrealistic pair consists of 'real objects / real space' where the sounds do not belong to the space. These imaginary landscapes along with a real one where sounds and context belong together are a handy way of approaching sound transformations within acousmatic conditions.

In part IV-B we will return to this concept of landscape or context (see the '+1' paragraph). One of the approaches to be dealt with there is Wishart's keeping the sounds constant and instead transforming the landscape within a transformation.

Trevor Wishart has a definite preference for the use of what he calls dynamic or unstable ('second-order') morphologies for his 'A's' and 'B's' above clear, periodic ones. (In his vocal works he has even defined special notations for such timbres.) He emphasizes these morphologies while presenting the concept of 'gestural structures of sound' in his texts, a notion worthy of special attention at this point.

Denis Smalley has discussed the importance of the pair, gesture and texture at length in his article, 'Spectro-morphology and Structuring Processes' (in Emmerson: 81-84 - also part III-B). He defines 'gesture' as being 'concerned with direction away from a previous goal or towards a new goal' and with musical causality. 'Texture, on the other hand, is concerned with internal behavior patterns ... ' (in Emmerson: 82). So it is primarily gesture that one is involved with when discussing sound transformation. They might best be called 'gesture carried' structures.[8] Wishart's version of gesture includes four distinguishable gesture types (Wishart: 1985, 67): stable, unstable, leading-to and leading-from. He claims to focus on such gestural types while making his transformations.

But returning to a more tangible level, this case-in-point composer - who has been known to contradict himself at times in a charming manner - has often stated that he finds the '->', the interpolation aspect of a given sound transformation more important than its 'A' and 'B'. Essentially his thought is that it is not just the transformational concept that is important, but the long, sometimes tedious and hopefully rewarding road to a successful transformation that is equally of relevance. In other words a transformation's dramaturgy can also be found in its '->'.

[8] Smalley describes various 'surrogacies' in his gesture discussion. A first order surrogacy concerns 'the traditional business of instrumental music'. A second order surrogacy is 'where gesture is surmised from the energetic profile but an actual instrumental cause cannot be known or does not exist'. A remote surrogacy is defined as occurring when 'links with surmised causality are progressively loosened so that physical cause cannot be deduced and we thus enter the realms of psychological interpretation alone'.

So what finally drives Trevor Wishart towards composing with sound transformations? When talking about 'Vox-5' he added a 'Coda': 'The creation of 'Vox-5' helped me to test out many ideas about the control of musical articulation in a continuum, about spectral interpolation [i.e. sound transformation - L.L.], and about the organization of sound in space. ... The computer opens up areas of compositional exploration that were previously inaccessible. The precision with which sound materials can be specified implies ... [a]reas of sonic organization previously inaccessible to composers through the existing media of notation can be explored, opening a new world of dreamed of, but unsung possibilities.' (Wishart: 1988, 26-27)

F) A Nota Bene: music above technique

Before leaving this section a few closing words are apropos. All the above has been written from the MUSICAL point of view. Most such articles tend to put a great deal of weight on the technological side of the affair. Certainly more information must be made public concerning the 'how's' of sound transformations,[9] but one point should be made at present which is at least as important as any other made here. The choice to use sound transformations should be born of a composer's musical intention founded upon a solid musical purpose or dramaturgy (that 'why' spoken of above).

As we all know very well, in today's 'image culture' many a video effect can be used to attract a viewer's attention to something.[10] Overuse of visual effects, on the other hand, is simply not substantial aesthetically and often leads of inferior quality as far as content is concerned. In other words, by having a shaky aesthetic basis, or, conversely, choosing a technological approach to music where the music itself is subserviant to a technological vision, one often arrives at a less satisfying musical result. It is the opinion of the author that music must preside above technique at all times (except perhaps when something is technologically impossible at present and needs to be invented). This must be kept in mind whenever one decides to apply the exciting sophisticated potential of sound transformations. Therefore only a few helping hints for users will be offered in Part IV of the current texts, everything else here concerns the music or musical goals.

III - Before categorizing: why sound sources/timbres aren't the central point here

A) Background

Do sound transformations have to be categorized in terms of sound sources and/or of timbre? Initially when embarking upon this project, the author was uncertain about its feasibilty. The worry was that literally hundreds of transformations would have to be made before the results would be worthy of being called a categorization system. Then there was the question of whether timbre or specific sound sources should be at the focus. But fortunately this sticky problem was circumvented as in fact the idea of the detailed categorization system quickly turned out to be an unnecesary one as now will be demonstrated.

In recent years there have been several attempts towards sound categorization (though not one turns out to be as rigorous as originally expected) - each seemingly from a different point of view. Others interested in this area have been satisfied with their own (general) descriptions of sound color. Many of these systems are credible in their own right, but not necessarily universally applicable.

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[9] As mentioned in the introduction, in a later phase of the current research project, a user friendly environment for the creation of sound transformations using the Phase Vocoder most likely employing DSP (digital signal processing) for added speed is to be made in collaboration with a number of British colleagues. Along with this, a user's manual for Phase Vocoder sound transformations will be written which will complement the current text. The software is being written for the Composers' Desktop Project (CDP) system and all documentation will be available from them. For further information please contact CDP at 11 Kilburn Rd. / York YO1 4DF ENGLAND. Furthermore, a 1993 issue of the periodical 'Interface' will be published on this theme. Many of the main figures in this text will be among the contributors.

10] Too many of us involved in music concentrate too heavily on sonic art and tend to forget or ignore parallel developments in the visual arts. In the visual arts transformations are being developed in the time-based arts (such as video) as well as in image processing. We all are acquainted with the former which has been highly developed in recent years through sophisticated computer animation. For those interested in the scientific basis of computer graphic 'image mosaics' (e.g. an apple merging into an orange within one single image), see the article by Burt and Adelson.

B) Examples: Seven approaches to the categorization of sounds

1) Most obviously one should first think of the pioneering work done by Pierre Schaeffer and associates leading to his 'Solfège de l'objet sonore' (see Schaeffer, Reibel and Ferreyra). Although there never was a system made to classify all sound sources or timbres, this was the first important attempt within electroacoustic music providing a reference. His 'Scheme for the classification of sound objects' is the heart of the system (Schaeffer: 442). Even for those unable to read French one notices immediately that no specific sounds or sound types (the likes of aerophones, chordophones, etc.) are presented here. Instead relative terms including 'balanced objects' (= notes!), 'somewhat variable mass', 'too original objects', and 'continuous sound of unknown construction' are used. Suffice it to say that the system works as a universe of itself and that composers and musicologists may find it useful for their own individual purposes, but Schaeffer has not offered the musical world THE all-purpose sound source system.

2) Karlheinz Stockhausen's score for 'Mikrophonie I' for 6 players (1964) includes an introduction with an entry which is essentially its own sound reference list. This list consists of descriptive words to help the performers to approach timbre during playing. Although these terms are by no means exact, they are useful for the interpreters. Examples include: wailing, pitched sounds, crackling, grating, crunching and tromboning. This approach differs highly from the above as it has a entirely different, though locally useful goal.

3) One who might have taken the trouble to create such a system is R. Murray Schafer who for many years headed the World Soundscape Project in which 'acoustic communities' were described. Schafer, a prime candidate for the ultimate sound source categorization system only describes the presence of sounds locally in this project's major texts. (see the Schafer references)

4) Robert Erickson devoted an entire book to 'Sound Structures in Music', yet the only true step towards categorization can be found in his 'transformation triangle' which consists of 'pitch (with timbre)', 'a sound' and 'a chord'. The book is of a more illustrative nature.

5) Wayne Slawson's major work in this area, entitled 'Sound Color' is based on vowel formant analysis. His employs a terminology which can be of relevance to people who want to approach timbre in this manner, but is, as is often the case here, useful as A way of discussing sound color, not THE way.

6) Denis Smalley has written two major texts on spectro-morphological thinking (see Emmerson, Paynter) in electroacoustic music. Based on Schaeffer's work concerning typo-morphology in his 'Traité des objets sonores', Denis Smalley writes, 'Spectro-morphology is an approach to sound materials and musical structures which concentrates on the spectrum of available pitches and their shaping in time.' (in Emmerson: 61) This has been created from the listener's point of view as opposed to the construction point of view of the composer and is in the opinion of the author the first major attempt to offer all involved in the music of sound a model for a potential terminology. Until now it has been primarily musicologists and a few composers who have been influenced by Smalley's proposed way of thinking. It is expected in the future that his text will serve as a basis for greater, much needed developments in this area. Still it has not been created specifically for the categorization of sounds as such.

7) Let's call on Trevor Wishart once again. In his book, 'On Sonic Art' (Wishart: 1985), he begins his treatment of the coherence of sound objects (idem: 37-38) by citing Steve McAdams' four groups of sounds for 'audio imaging': similar envelopes, parallel frequency modulation, same formant characteristics and same apparent spatial location. We remain far from our desired detailed categorzation system.[11]

[11] Later (pg. 76) Wishart reminds his readers that dealing with sound objects may be divided into the nature of perceived acoustic objects, the dispersion of the sound objects within the space and the recognition of individual sound objects. Here our one subject has been divided into three. This gets worked out further in terms of the sounds' morphologies (internal morphologies consisting of continuous, iterative or unstable bases; when a morphology is unstable, a sound's morphology may move from one to another [Wishart: 1985, 97]).

Again these examples are all potentially useful as far as sound transformations are concerned. However, none will be chosen for further consideration; for to make an accurate categorization, one would therefore need to choose at least one of these systems, including one with a largely detailed approach to sound sources and/or timbre, and virtually try out every sort of transformation on every sort of sound to create a sound transformation categorization system. However by re-reading the previous sentence we are led to the crux of the reason which made this sort of work finally unnecessary. 'Every sort of transformation on every sort of sound' implies that a sound transformation categorzation system has already been made and then tested with every type of timbre and/or sound source. We will only be interested in the former subject in Part IV.

Having said that, we must let technology preside above musical application for a few lines for once in this text. As was proven in the experiments in creating sound transformation examples during the preparation of this article, certain types of transformations work differently/better using various types of techniques and are therefore worthy of specific attention. These will be specified in Part IVC below.

IV - A simple framework for categorizing sound transformations:

A 'parametric' approach

A) Introduction: The three 'how's'

This final section is a non-high tech attempt to delineate the world of sound transformations. This is not intended to be a user's guide with how-to examples, but simply a basic introduction to what sorts of methods and types of transformations are possible offering the first model of its kind - be it a simple one - which hopefully will invite others to participate in its future expansion.[12]
The three 'how's' to make a sound transformation are:

(1) electroacoustically (through analog and/or digital treatment of recordings or previously generated sounds). This is most likely the most tedious way to go about this sort of work.

(2) Through synthesis (digital sound generation using e.g. CSound or CMusic leading to transformation), which sometimes may become a cumbersome process as well.

(3) Through resynthesis (e.g. through the use of the Phase Vocoder which first analyses input sound data and then allows sound manipulation to take place including interpolation, shifting of spectra, stretching, etc. all of which can be used towards the creation of sound transformations). This is the method used most often currently. See Wishart (1988) for a general introduction to the relevant techniques and routines.

B) Four (plus one) categories of sound transformations

During the course of the project four categories, each in the form of a parameter, were found which seem to span the space of sound transformation types. These parameters are absolutely not mutually exclusive.

(1) Comparability: A and B are very comparable to the ear ... incomparable (do note that our technology is currently unable to transform sounds 'naturally' that are quite dissimilar, at least as far as our perception is concerned).

12] It should be mentioned that the subject of MIDI has been avoided. To make a sound transformation, MIDI technology lacks sufficient sophistication and can only be used to play-back sound transformations through a sampler.

In fact the most similar ones most resemble sound morphological movement. Between the time this paper is written and the time it is printed the amount of potential dissimilarity in perceptually successful transformations will probably increase; therefore, it is useless to attempt to define where the borderline is or will be at any given point. This parameter therefore concerns the extent of transformation. (It should be stated that questions the likes of: are A and B based on stable or unstable morphologies, are they more pitch or noise based, may be added here but are not central to this categorization system.)

Again Denis Smalley's terminology is of use to us. In his recent article (in Paynter) he discusses the concepts of 'graduated' and 'interpolatory shifts'. Although Smalley is not directly addressing a categorization of sound transformations - he is addressing what he calls 'shifts in sounding models' - these terms are useful as 'graduated' refers to sounds 'based on shared morphological attributes', and interpolatory 'ignores common attributes and emphasizes dramatic differences'.

(2) Are the sounds both sequential (discrete) ... continuous?
This leads to various approaches to transformation. Short sounds transform better through sequential repetition and development. Continuous sounds transform better within their own continuity. Anything in between is to be treated based on specific features.

(3) Is the transformation to be short (from grain level) ... long (eventually up to the structural level of a work)?
Trevor Wishart has said that a sound transformation using recognizable end points must last at least four seconds to be clearly perceived as being a sound transformation as such. Of course those composers who are not in need of this recognition or are working with abstract materials or structural approaches could essentially choose for transformation to take place at a granular or even on a large-scale structural level. Individual goals are perhaps more relevant here than elsewhere.[13]

(4) A and B are representational (clearly identifiable, mimesis intended) **... ambiguous ... abstract** (unclear, non-representational)

This final category does not need any further elaboration.

Some extras:
Here it should be reiterated that we have talked about the sorts of transformations, not how we go about them. Let's return to Wishart's mocking remark that the '->' between the A and B, i.e. the interpolation process itself is at least as important as its main characters. A sound transformation may be linear, it may follow a concave or convex curve of interpolation. Other even more complicated routes may be taken. There may be intermediate stages the transformation passes through. There may even be a 'C' and 'D'...

Furthermore, a composer may have personal preferences as to how such transformations should/must be made. Therefore a given A -> B may sound very different than another transformation with the same end points. One might choose to use characteristic analysis to feature certain parts of A's and/or B's spectrum during the interpolation or other transformation process.

(+1) An issue mentioned a number of times above is now added to our four categories here as an 'extra'. This concerns keeping the sound objects, but changing the context, a sort of sound transformation which is the fifth of the four categories and is therefore named separately (as it concerns a spatial or contextual transformation, not directly a sound transformation). Smalley refers to this area as the outer limit of what he calls 'spatio-morphology' (morphology being in a sense singular, transformation plural). (in Emmerson: 91) An excellent example of dealing with this element is Bernard Parmegiani's 'Dedans dehors' (1976 on record - INA-GRM 9102Pa). (What's in a name?).

[13] It has often been mentioned that some works known to contain transformations include many that are too quick or difficult to perceive or contain hardly or unrecognizable 'A's' and/or 'B's'. If the composer does not mind this it is fine, but it has occured that composers have given talks about transformations that are finally inaudible. If recognizability is important, then Wishart's remark should be taken into account.

C) Some final tips

This final paragraph is offered to those working with sound transformations or are about to try creating some. Rajmil Fischman has provided the following seven suggestions which, depending on the circumstances and the context of a composition, may help in producing convincing results.

1) Differentiability: The 'A' and 'B' of a sound transformation must be perceived as such. For example, a transformation from a soft trumpet timbre into a flute may not be perceived because the steady state of both of these sounds is similar. The main perceptual difference resides in their attacks.

2) Similarity: As previously mentioned, some common characteristics between the 'A' and 'B' help in achieving continuity in transformations. For example, sounds that have the same pitch are recommended. (Sounds with different pitches can be problematic to convert into one another.) Transformation between a highly pitched and a non-pitched sound may require some pre-processing to achieve similarity: gradually making the pitched sound more noisy by means of thickening, frequency modulation, etc. and/or gradually making the non-pitched sound less noisy during the transformation by means of time variable filters, etc.

3) Duration: The duration of a transformation is dependent on the type of sounds. This is probably the most difficult characteristic to generalize. Perhaps the closest one can get to this is saying that sounds with slowly changing morphologies will probably require longer transformations than quickly changing ('gestural') ones. Furthermore, transformation between slowly changing long sounds and short ones may not work.

4) Linearity: Whether to choose a linear or exponential transformation depends again on how fast and how violently it is to be perceived. If we take two transformations of the same duration, one linear and the other exponential (= exp(a) where a > 1), they may be perceived as having different durations because of the slowness of the change of the latter at the beginning of the transformation and its speedy variation toward the end.

5) Spatial movement: One of the criteria used by our perception when separating sound sources is their position and movement in space. Therefore, if two sounds have the same spatial movement, we are cancelling one of the characteristics that make them appear as coming from different sources. However, convincing spatial movement of a transformation (including Doppler shifts) - e.g. the 'A' at one point, the interpolation moving along a continuous stream towards the 'B' at the final destination - can assist the listener's perception of a sound transformation.

6) Diversions: Even if the first five points have been taken into account, there may be a problem that our perception does not accept the transformation, the '->' as containing either the 'A' or the 'B'. Instead one may hear an unrelated unrecognizable sound, a sort of 'grey area'. In this case, the ear needs to be 'fooled' by attracting the attention of the listener to something else, including a third sound, happening at the same time.

One such technique is called 'blurring' (also known as 'wedging'/'reverse wedging', 'flocking' - see Wishart [1978]). Here during the transformation several layers of the same or slightly modified sound are used to aid in the natural flow from A -> B. This how-to recipe is taken from the sound transformation kitchen as it is used surprisingly often. (This technique was used originally by Wishart in 'Red Bird' to hide analog technical limitations.) The classical example is probably Wishart's vocal buzz to bee swarm transformation in 'Vox-5'. In order to capture the attention of the listener, the spectrum of the vocal buzz is made to change independently of the transformation while the latter is taking place.

7) Context: The context of the actual piece may help overcome some other difficulties. When there is a common element, e.g. Wishart's voice, in several of a work's transformations, this can stimulate the perception of a 'voice to ...' (or whatever) quality through a sort of pattern recognition. Perhaps a transformation might not sound convincing when heard outside of the context of a piece, but can work in context for this very reason.

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