Music and 3-space
Some preliminary remarks concerning an ecological approach

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There is a growing interest in spatial music. Karlheinz Stockhausen recently said:

> I think that all music will become space music and that space becomes as important as pitch in the traditional music, as durations and rhythm and metre and there is a very new development of harmony of space and I mean space chords, space melodies and that doesn't mean pitches, it means movement on several levels around the listener: above, below, in all directions. (Stockhausen 1977)

Music and 3-space[1]

Perhaps it's best that I begin by sharing a few thoughts about music because, like John Cage, I too have been interested to discover what music is. Unlike Cage, I have been less distracted by definitions of mushrooms[2], which I'm not saying is better - simply different! Today I think of most musics as "sound with attitude" or "sonic rhetoric" i.e. that activity by humans and perhaps other life-forms which organises or uses sound to carry an overtly composed message. In this way it is open to projecting social and political ideas and (less frequently these days) ideals. It seems not uncharacteristic then, that in a time when our sense of 3-space is being radically challenged and modified through our use of new global communication technologies, musicians should take an interest in it. In doing so, they are simply expressing their contemporaniousness.

Unlike some, I am less interested in the aesthetics of what can be thought of as concave virtual spaces, i.e. immersive environments, interactive or not, entered by donning headphones and other interfaces to access the human sensory receptors via computer-mediated stimulation, than I am in convex spaces which are psychologically coherent but are also inclusive of unencumbered

social interaction. As I discuss later, there is a major perceptual difference when sounds are presented to the auditory system over headphones and when sounds are presented to in 3-space: In the former case, the experience is of the sound being inside one's head, yet this concavity is not experienced in listening situations where the head is free to move independent to the source of the sound. Creating (sonic) environments which allow this to occur socially is a major goal in the devlopment of the geodesic performance space (Worrall 1989).

Similarly, I am less interested in making a music which directly or overtly manipulates the listener towards a common projected emotional state (in the way that the 19th century Romantics did through functional harmony) than in providing listening environments which are structured to be open enough to allow the listener to listen; compositions which are sonically rich and interesting and which allow the listener to develop a direct relationship with the sound material itself.

In order to make such a music in which 3-space plays an integral part, it is necessary to develop an understanding of 3-space and our (aural) perception of it. Only then will it be possible to develop techniques and technologies to assist in creating <u>coherent</u> listening experiences. This means moving beyond mere effects such as of sounds "whizzing" around the auditorium, or as Boulez expressed it:

> There remains a fifth dimension, which is not, strictly speaking, an intrinsic function of the sound phenomenon, but rather its index of distribution: I refer to space. Unfortunately it was almost always reduced to altogether anecdotal or decorative proportions, which have largely falsified its use and distorted its true functions. (Boulez 1971: 66)

Perception and the materials of music

Any experimental practice necessitates a renewal of experience with the materials used in order to develop new perceptions leading to new inter-relationships and thus new methods of construction[3]. Because the inner ear (the cochlea) is essentially a frequency analyser, perception of pitch is acute and this accounts for the primary role which it plays in music. However, we don't have sense organs for timbre and location. The perception of them is not only of a different order,

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[1] Concrete space, or real space (hereafter called 3-space) defined by the OED as:
   1. Continuous extension viewed with or without reference to the existence of objects within it;
   2. Interval between points or objects viewed as having one, two or three dimensions.

[2] Cage's interest in mushrooms stems, he says from his interest in dictionary definitions of music; Mushrooms being the word before music in most dictionaries. See (Cage, 1961).

[3] In music this happens most frequently with melody - the carrier of "tone" - which observation explains Schoenberg's use of *Sprechstimme* and the "spoken song" of rap-music: new sonic structures outside the confines of the current theories of construction are discovered in the inflections of speech, thus encouraging a renewal of the language enabling new structure and form possibilities.

but of a different kind. They are somehow "constructed" or inferred from the processing of the sensory information Yet we seem to experience these aspects of sound very directly, with little active mental processing.

Most artistic techniques involve the use of abstract thinking and this requires the requires the development of abstract spaces[4] - however informally undertaken. The compositional parameterisation of these spaces is sometimes strongly based on psycho-perceptual biology and sometimes not. The resulting parameters are not all considered equal or of equal resolution and we know that these resolutions vary through time displacement and location displacement. - from culture to culture and for different time periods in the same culture. In Western art music for example, pitch is considered a primary parameter whilst loudness is not. Pitch results from the physical and psychophysical analysis of pressure variations in the atmosphere (amplitudes) according to the resolution of the hearing system. This analysis of time-varying amplitude is considered different from loudness, which is a time averaging of amplitudes but which is also affected by spectral distribution (timbre, for want of a better term) and timbre is again even more complex, resulting from the interaction of several different parts of the perceptual system. Pitch and loudness are relative, they do not have the same perceptual resolution and thus can not support the same degree of abstraction; loudness in music is usually referred to using dynamic and expression markings (note the psychological and cultural terms), and is not considered as primary as pitch.

So for example, we have many compositions which are a multitude of pitches at single dynamic and few which are a single pitch at multiple dynamics. In Western music, timbre was also considered secondary to pitch (the same melody played on different instruments) but this hierarchy is not sustained, certainly not to the same degree, in other cultures nor has it remained invariant in the West. The increasing importance of inharmonic percussion in Western music is related to the freeing of compositional thinking from functional harmony as the (culturally emphasised) means of organising musical thought, whilst in those cultures that have never used this organisational principle, timbre has played a much more important role -the gamalen music of Bali and the shakuhachi music of Japan to site just two examples.

Reverberation is another example of the way we concepually separate the source of a sound

(considered primary) from its location in physical space: We speak of a sound being in a 3-space, yet it is equally true to say that a 3-space is (encoded) in all sound. Whilst it is physically true to say that there is no sound without 3-space, most of us don't think about it (perceive it) that way and this, together with the philosophical underpinnings discussed below, radically affects the way we perceive 3-space itself.

Philosophical theories of perception

These historical and locational cultural differences can be accounted for, at least partially, as perceptual differences and these perceptual differences are affected by the basic underlying philosophical tenets (including perceptual theories) of the listener's culture. Western music theory, like most of Western thinking, evolved from the philosophical theories of Pythagoras (and others) which were most decisively first codified by Plato. Plato's pupil Aristotle, would eventually refute Plato's basic philosophical and perceptual tenets and the dialogue and ramifications of these two ways of thinking have reverberated throughout Western culture ever since. It behoves us then to examine these principles as they radically affect our perception and thus of our understanding of known musics and and our compositional practices.

Whilst a complete enunciation of Plato's and Aristotle's philosophies of perception and their ramifications is well beyond this paper, the fundamental differences in their thinking has been their assertions on ontology (what exists) and in particular, what is known as mind-matter dualism. For Plato,

> Mind and matter are independent, absolute, and distinct. Mind and matter may "somehow" affect or parallel each other, but existentially and qualitatively each is a world unto itself. The epistemology (theory of knowledge) of indirect perception historically follows from Plato's dualistic ontology. Mind can only be acquainted with itself--the material world is known indirectly through representation, inference, or effect. Plato's dualism extended to separating permanence (eternity) and change (time) and universals (order) and particulars (individuals). (Lombardo 1987:3-4)
> .....

Plato separated the knowing mind with its capacity to apprehend eternal and universal truths from the fluctuating, individualized world of matter. Within the Scientific Revolution (1550-1750),

> ... Mind was elevated to a detached and ethereal creator and manipulator of abstractions, generalities, and ideas. With the rise of reductionistic biology (1650-1850), neural and sensory physiology was analyzed into

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[4] abstract space: a formal system characterized by a set of entities, together with a set of axioms for operations on and relationships between these entities (eg metric spaces, topological spaces, and vector spaces).

independent, simple elements. Monistic trends inspired by the success of physicalism and elementism in science attempted to reduce and/or eliminate the mind. Instead of becoming more intelligible, perceptual experience, as well as other psychological phenomena became increasingly unintelligible and divorced from the supposed real (elementaristic) world of physics, chemistry, and biology. Reflecting these earlier intellectual trends, the standard modern explanation of perception ran as follows: Beginning from an order-imposed world of localized elements in an instantaneous present, lines of energy are transmitted through space to a physical mosaic of sensory receptors. In turn lines of energy are transmitted along neurons to a brain where organizational processes transform this "blooming, buzzing, confusion" into a spatial-temporally ordered experience. The resultant experience is qualitatively and ontologically distinct from the world at the beginning of this chain of events. (Lombardo 1987:5)

Aristotle eventually challenged this dualism and asserted the absolute interconnectedness of mind and matter. He

> .... logically distinguished the knowing mind (or "subject") from the known "object ," but stated that in reality the two were inseparable. Aristotle saw knower and known united in a functional interdependency. (Lombardo 1987:5)

He took the empirical world on its own terms as fully real. True reality, he believed, was the perceptible world of concrete objects, not the imperceptible world of eternal Ideals.

He developed the notion of categories to distinguish different ways in which things can be said "to be" in many non-equivalent ways. Two of these categories (there are ten in all: substance, quantity, quality, relation, place, time, position, state, action, and affection) are **substance** (a particular horse, say) and **quality** (its whiteness). He asserted that only substance signifies concrete reality whilst the others quality ("white"), **quantity** ("tall"), **relation** ("faster") and the rest are derivative ways of being in that they depend on individual substances to exist. If substances did not exist, nothing would exist. Thesefore, these ways of being are not ontologically equivalent, for the tallness and the whiteness of the horse depend for their existence entirely on the primary reality of a particular horse. The real world is one of individual substances which are separate from each other, yet which are characterised by qualities held in common with other individual substances. Common qualities are universally recognisable by the intellect in sensible things, but they are not substances and these commonalities do not signify

the existence of transcendent Ideals from which common qualities are derived.

Aristotle maintained that Plato, by treating a quality, for example, as a substance, was ontologically confusing categories. In contrast to the primary reality of a substance, a quality is only an abstraction - though it is not merely a mental abstraction, for it is based on the substance in which it resides. For Plato, the particular was less real, a derivative of the universal; for Aristotle, the universal was less real, a derivative of the particular. Universals were necessary for knowledge, but they did not exist as self-subsistent entities in a transcendent world.

A related major issue in Greek thought, going back to Parmenides and Heraklitus, was the distinction between "being" and "becoming". For Aristotle, a substance was not simply a unit of matter, but an intelligible structure or form (eidos) embodied in matter. Although the form in entirely immanent, and does not exist independently of its material substance, it is the form that gives to the substance its distinctive essence. Form for Aristotle was not static.; it gives to a substance not only its essential structure but also its development dynamic. He brought a more pronounced recognition of nature's processes of growth and development, with each organism striving to move from a state of potentialty to a state of actuality through its realisation of its forms: the seed is transformed into a plant, the embryo becomes the child which becomes the adult etc. So form is an intrinsic principle of operation that is implicit in the organism from the organism's inception, as the oak is implicit in the acorn. The organism is drawn forward by the form from potentiality to actuality. After the formal realisation is achieved, decay sets in and the form gradually "frees its hold." For Aristotle, "form" and "matter" are relative terms, for the substantiation of a form can in turn lead to it being the matter out of which another form can develop. Every substance is composed of that which is changed (the matter) and that into which it is changed (the form). Matter here does not simply mean the physical body but "an indeterminate openness in things to structural and dynamic formation." Matter includes the possibility of form, which form molds and impels matter from potentiality to actuality. Matter becomes realised only because of its composition with form. All of nature is itself the process of this conquest of matter by form. Every substance has a form (possesses form) but is possessed by form, for it naturally strives to realise its inherent form. Every substance seeks to actualize what it already is potentially.

(Organic biology rather than abstract mathematics)

For Plato, "being" was the object of true knowledge and "becoming" the object of sense-perceived opinion, and this reflected his elevation

of real Forms above relativly unreal concrete particulars. For Aristotle, the process of becoming has its own reality, asserting that the governing form itself is realised in that process. Change and movement are not signs of a shadowy unreality but are expressive of a teleological striving for fulfillment. Aristotle stressed the human intellect's capacity to recognise these formal patterns in the sensible world. While Plato distrusted knowledge gained by sense perception, Aristotle took such information seriously, contending that knowledge of the natural world derives from the perception of concrete particulars in which regular patterns can be recognized and general principles formulated. Human understanding of the world begins with sense perception. Before any sensory experience, the human mind is like a clean tablet on which nothing is written. It is in a state of potentiality with regard to intelligible things. Yet it is man's reason that allows sense experience to be the basis for useful knowledge.. Aristotle best articulated the structure of rational discourse so that the human mind might apprehend the world with the greatest degree of conceptual precision and effectiveness.

Aristotle regarded the mind not only as that which is activated by sensory ecperience, but also as something that is eternally active, and indeed divine and immortal. This aspect of mind, the intellect (divine nous) alone gave man the intuitive capacity to grasp final and universal truths. Empiricism renders particular data from which generalisations and theories can be derived, but these are fallible. Man can attain necessary and universal knowledge only through the presence of another cognitive faculty, the active intellect. Just as light makes potential colours into actual colours, so does the active intellect actualise the mind's potential knowledge of forms and provide man with the fundamental principles that make possible certain rational knowledge. Cognition takes place when a the mind receives the form of a substance into itself, even though in the world that form never exists apart from its particular material embodiment. The mind conceptually separated, or abstracts, what is not separated in reality.

Aruistotle realigned Plato's archetypical perspective from a transcendent focus to an immanent one, so it was fully directed to the physical world with its empirically observable patterns and processes. Unless a form is incorporated in a substance (the form of a man is embodied in Socrates) the form cannot be said to exist. Forms are not beings for they possess no independent existence.. Rather beings exist *through* forms.

Although Platonic Idealism was dominant throughout the Middle Ages and into the scientific revolution and produced some remarkable achievements, a number of philosophical and scientific movements have seriously challenged it.

Many would try to eliminate either the mind or the matter (or both) from the dualism, and yet it still remains the dominant mode of thought in western science and philosophy. However recent developments such as quantum mechanics and chaos theory have created serious dents in its validity, and in its extended usefulness. The direct perception theories of perception (Gibson, 1979) discussed elsewhere (Worrall 1997) are Aristotelian in concept and are supported in audition by a model of hearing which explains the way the auditory system "learns" and adapts to the sonic environment in which the perceiver exists.

The Jastreboff model of hearing[5]

The Jastreboff model of hearing , which is in accord with the "digestive" model of perception, as summarised by Kolers (1972: 192), moves away from the electro-mechanical model of the ear - especially of the function of the auditory nerve. The mechanical ear changes sound waves into electrical patterns which are passed along the auditory nerve to the part of the cortex in the temporal lobe of the brain. This is quite a long way from the ear and there is no perception of sound until these electrical impulses reach it.

The auditory nerve is a bundle of approximately 10,000 fibres made up of millions of cells. Between the ear and the temporal lobe there are subconscious pathways which consist of millions of nerve cells joined together by many connections in dense networks that act like filters for identifying patterns of sound. These networks group together frequencies on the basis of "knowledge" of how sounds form complex signals. The subconscious part of the brain has been taught to recognise and respond very strongly to important sounds (such as one's own name, and timbral forms) by "encoding" an amplifier for them on the auditory nerve so that we can hear them more clearly and thus respond to them more quickly. They produce a conditioned response: we always respond to them like the way we respond on hearing the sound of a motor-car horn when we're about to cross the road. They're part of our protective mechanism, necessary for our survival.

So as the signal moves along the auditory nerve, it is being subtly but significantly modified by all sorts of influences that are crowding around this signal pathway as it passes up towards the brain. There has to be a lot of processing of this information because the auditory nerve just passes along frequency information (it doesn't know what

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[5] This section was developed from a radio interview with Jonathan Hazel, The Royal Institute for Deaf People, London, *Ockham's Razor*, ABC Radio National, August 1997.

speech is, what environmental sound is, what internal body sounds (including of the hearing organ) are etc. So these sub-cortical pathways have to sort out and group those frequencies and identify what the discrete signals are. It's a very complex processing procedure but once it's done, those signals which are meaningful/required are enhanced and those signals which are not are reduced in amplitude or filtered out. Also, if there is some change in the inner ear (by infection, change in pressure etc) there is a "callibration signal" sent to the brain. These "sounds of ear" (long codified by some meditation traditions, the buddhists for example) are heard as a signal that the ear is responding to it's change in physiology.

These conditioned reflexes are initiated by emotional responses from the limbic and autonomic systems of the brain which cause a heightened awareness. This heightened awareness creates a survival reflex and autonomic response (very like the fight or flight response to fear for example) and cements this group of frequencies in the auditory pathways in way suggested. This autonomic response is an explanation for why we can recognise timbres, once "imprinted", so directly. It is also possible to "undo" these filters (learning not to jump in response to a ringing telephone, or eliminating tinnitus by retraining therapy for example).

Spatial characteristics are more complex - remember they are processed "higher-up" than timbre in the auditory pathway and they also involve more disparate and environmentally derived parameters such as our expectation that low frequency sounds are likely to be closer to the ground. However it is likely that processes similar to those described are in operation and this would account for the "direct perception" of the location of certain sounds in 3-space.

Summary and temporary conclusions

A major support of the Aristotelian/Gibson world view was provided by Charles Darwin in his *Origin of Species*.

> Darwin would challenge the absolute separation of mind and matter in his evolutionary view of life. Mind evolved as an adaptive function geared to the material environment. It was not placed "within" the body from some independent spiritual realm. Darwin's emphasis on change in biological forms came to challenge, more than any other single idea, the static Newtonian universe. Within the l9th century, geology, archaeology, paleontology, and astronomy were all coming to a similar conclusion that natural forms changed rather than remaining static. The Darwinian Revolution introduced the idea that the mind was a

> developing capacity intrinsic to nature and not a fixed form extrinsic to nature. (Lombardo 1987:12)

Throughout the evolutionary history of any species, species-typical developments in spatial competencies have become adapted to changes in the ecological contexts encountered by the species over the course of the life-span; that is, organisms develop more sophisticated spatial orientation competencies to meet increasing needs for spatial activity. Naturalistic theories of perceptual psychology, based on observation in complex environments offer insights not offered by other methods.

So 3-space can be considered to be defined as much by its contents and what they afford us as vice versa. I have outlined how this approach might be applied to obtain a better understanding of how we perceive two aspects of the perception of 3-space - those of proximity and movement.

In conclusion, Gibson's ecological approach to analysis of what the environment is, combined with stream analysis, is likely to provide significant insights into our understanding of 3-space and it's use in sonic design. Perhaps it is fitting then to end this temporary conclusion with him.

> I am also asking the reader to suppose that the concept of space has nothing to do with perception. Geometrical space is a pure abstraction. Outer space can be visualised but cannot be seen. The cues for depth refer only to paintings, nothing more. The visual third dimension is a misapplication of Decartes's notion of 3 axes for a coordinate system.
> .... Space is a myth, a ghost, a fiction for geometers... For if you agree to abandon the dogma that "percepts without concepts are blind," as Kant put it, a deep theoretical mess, a genuine quagmire, will dry up. (Gibson 1979: 3)

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