# Musical Desegregation of Acoustic Space *

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Auditory stream segregation has become central to understanding the perception of auditory fields. The construction of the auditory self in relation to acoustic space has also been explored using Lacanian psychological theory. This article will review auditory cues implicated in the perception of consonance and other musical devices, and propose that musical efficacy may in part be due to the *de*segregation of auditory streams, leading to a partial collapse of the subject's sense of acoustic space. This creates experiences in which the auditory information is strongly internalised within the self, rather than belonging to events occurring in the natural world.

**Spatio-Temporal Perception**

Sensations occur within or at the surface of our bodies. Two of our senses, sight and hearing, involve the interaction of sense organs with wave-like phenomena transmitted over distances from distinct directions.

Physical work is done in the exchange of energy that initiates a sensation. Photons are absorbed in specially evolved mechanisms in the eyes, and the ear-drum is moved by changing air pressures on its surface. Our senses react to energy and force, physical terms defined by mass (m), velocity (V) and acceleration (A). Newton defined velocity as the change of displacement (ΔX) per change of time (ΔT), where ΔX is a vector, and acceleration as the change of velocity per change of time (Equations 1 and 2). Force (F) and Kinetic energy ($E_k$) could then be defined (Equations 3 and 4) and much later Planck and Einstein defined the energy ($E_p$) of photons in terms of the light frequency (f) and Planck's constant (h).[1] Since we sense forces and energies, displacement and time must then be concepts derived in cognitive and mathematical models of the world, built up from sensations and measurements.

$$V = \Delta X \ / \ \Delta T \qquad (1)$$
$$A = \Delta V \ / \quad T \qquad (2)$$

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[1] Francis Sears, Mark Zemansky and HughYoung, *University Physics,* 5th ed. (Boston, Mass.: Addison-Wesley Publishing, 1978) 49–63, 117 and 757.

$$F = mA \quad (3)$$
$$E_k = 1/2mV^2,\ E_p = hf \quad (4)$$

Newton's derivations were only possible by the invention of a pendulum; a mass subjected to the constant acceleration of gravity, which once perturbed will undergo a slowly decreasing oscillatory motion of constant period. With reference to the pendulum's period of oscillation, one motion was then comparable to another, and relative displacement could be predicted for an object of given velocity or acceleration after a certain number of oscillations using equations 1 and 2. Similarly, relative time could be measured by the relative displacement of a clock mechanism controlled by the pendulum.

We are always in motion. However, to be constantly aware of these motions would consume wasteful amounts of mental energy. Therefore we define our relative displacement against pertinent objects that are moving with the same motion as ourselves.[2] It is easy to generalise from these frames of reference to believe that spaces (displacements in three dimensions) may physically exist as static entities independent of time. Furthermore, the speed of light is so great that we do not usually notice the time lag involved in its transmission and reflection. Therefore the visual field of perception appears instantaneous, and visually perceived and defined spaces may appear independent of time, or even timeless and eternal.[3] It follows that this creates a notion of time as independent of space, abstracted as a dimension in its own right, rather than integral to perception itself. The temporality of perception of acoustic space is commonly experienced as echoes and reverberation. However, acoustic perception has not often been used within philosophy to conceptualise space, possibly due to the variability of acoustic fields.

**The Acoustic Self**

Cognitive models of space are maintained in our memory and may be explored in our imagination. Our attention flickers disjunctively between the act of sensing itself and imagining remembered spatial locations and projected trajectories. The ability to interpret sensations to generate these spatio-temporal cognitive models takes practice. It is many months before an infant has developed an idea of what is bounded by their own body and what may be best described as other. While Lacan defined the psychological processes involved in splitting off the 'other' from the 'self' visually (the 'mirror-stage' literally describes the moment when a mirror's reflection defines the child's sense of self), more recently Kaja Silverman described the construction of identity in Lacanian terms within acoustic space/time.[4] She proposed that the acoustic equivalent of the mirror stage is the process of the discovery of one's own voice through the emulation of the mother's.

But how does the infant know which sounds belong to the mother, and which belong to the squeaking of the cot? Bregman details the psychophysics of acoustic perception by first describing Gestalt concepts of ordering sensations to produce the simplest cognitive model of

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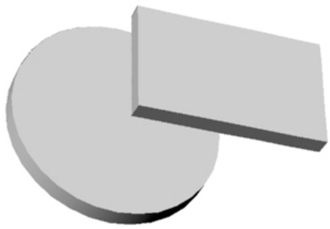
[2] John Campbell, *Past, Space and Self* (Cambridge, Mass.: MIT Press, 1995) 15–19.
[3] Martin Jay, *Downcast Eyes: The Denigration of Vision in Twentieth Century French Thought* (Berkeley: University of California Press, 1993) 83–90.
[4] Kaja Silverman, *The Acoustic Mirror* (Bloomington: Indiana University Press, 1988) 72–78.

a physical system that could produce such sensations.[5] A simple example of Gestalt ordering of visual sensations is shown in Figure 1. The visual processing in the brain produces a cognitive model that these sensations arise from two overlapping plates rather than a series of flat planes, *prior to any conscious decisions regarding symbolic representation*.

**Figure 1.** Gestalt principles of vision generate the cognitive model of two overlapping plates.



The human ear is capable of determining the spectrum of sound waves for frequencies between about 20Hz and 16,000Hz. The brain uses this information from both ears to build a cognitive model of sound sources in the physical world. Time-frequency localisation, timbre and direction are three of the most important cues used to segregate overlapping sounds into individual source models. Often all three cues are required to successfully segregate sound sources. As an infant learns to differentiate external sounds, it also learns to differentiate itself from the acoustic world around it.

**Musical Spaces—Consonance: From the Latin 'Consonare,' to Sound Together**

Music is a social activity that in some ways may even pre-date speech. One of the most common attributes of music is a common tempo played by different musical instruments. This attribute may have evolved through the coordination of work activities by sound. However, there may also be psychoacoustic factors involved. Sounds from different sources arriving at the ears simultaneously will be much harder to differentiate. Not only will this obscure time-frequency localisation cues (where a cluster of frequency amplitudes with the same temporal onset are likely to belong to the same sound), it will also confuse binaural directional cues (where the inter-onset time differences between ears are important). In effect, the distinct musical voices will become less distinct, and for complex drum like sounds, *de*segregated or despatialised.

When sound sources belonging to the external world are despatialised, what happens to the boundaries between self and other that evolve during the acoustic mirror stage of infancy? When one is directly involved in the musical activity, the self may become much larger to include all the other players. This effect would explain the strong social binding generated by group musical activities, and provides a strong motivation to maintain the synchronised activity. For the passive listener the acoustic other may blur with the self in a cognitive space abstracted from normal experiences. This cognitive space of music has dimensions not usually encountered in the naturally occurring world, and the better defined these dimensions are in the music, the more powerful the hold this abstract space will have on the listeners' attention.

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[5] Albert Bregman, *Auditory Scene Analysis: The Perceptual Organisation of Sound* (Cambridge: MIT Press, 1990) 1–45.

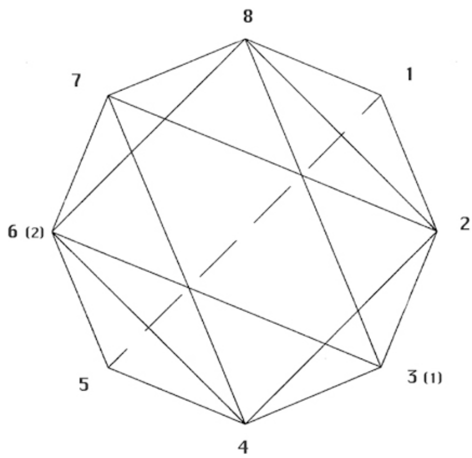
Shepherd and Wicke wrote:

> It is in this way that the sounds of music can be thought of as mediating effectively between the external and internal worlds in their appeal to the unconscious, sexuality, emotion and affect, in much the same way as language is conceived by Lacan as a phenomenon external to the subject which then constitutes the subject's internal world through the unconscious.[6]

However, in considering music to be unlike language, in that it is not entirely symbolic, they later discounted this explanation. Diverging from Lacan's focus on symbolic language, this paper describes a sub-symbolic stage of cognitive processing of sense data, dominated by Gestalt-like rules of ordering,[7] that act in the constitution of the subject and may be influenced by music.

Tempo is a primary dimension of music. However, more rhythmically complex structures are usually involved in musical performance in which not every beat is sounded equally. Gestalt ordering principles aided by musical repetition quickly group uneven beats into rhythmic structures. Figure 2 shows a cyclic representation of two of the musical parts of the Kecak chant that originated in trance rituals in Bali.[8]

**Figure 2.** Balinese Kecak music mapped in an eight-element cyclic array. One part is denoted by sounding beats at elements 3, 6 and 8. The second part is the same pattern reflected through the line between elements 1 and 5. The two parts combine to mark out the square (rotated to 45$^{o}$) through elements 2, 4, 6 and 8.



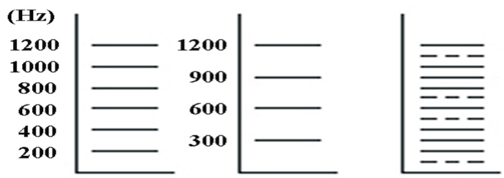

It can be read like a clock face, with a sound occurring whenever the lines intersect the perimeter of the figure. The cyclic representation formally describes the rhythmic closure that occurs at each repetition, and reveals through the emerging geometry of the parts some of the formal structure of the music. The two identical, asymmetric parts in opposite phase consisting of

[6] John Shepherd and Peter Wicke, *Music and Cultural Theory* (Cambridge, UK: Polity Press, 1997) 70.
[7] Paul Smolensky, 'On the Proper Treatment of Connectionism,' in Alvin Goldman, ed., *Readings in Philosophy and Cognitive Science* (Cambridge, Mass: MIT Press, 1993) 769–99.
[8] Neil McLachlan, 'A Spatial Theory of Rhythmic Resolution,' *Leonardo Music Journal* 10 (2000): 61–67.

two groups of three beats duration, followed by a group of two beats duration, are shown as the interlocked triangles. They combine to create a simple symmetrical square of four primary beats with two off-beats. This combining of two asymmetrical parts played by sounds arriving from two different directions, into a simpler symmetrical part, contradicts the usual Gestalt ordering of sounds according to source direction. It despatialises normal acoustic space and places the listener in an abstract space with highly ordered rhythmic dimensions.

There are many other dimensions in music. Pitch hight is derived by mentally mapping the harmonics that naturally occur in the voice, or in string and wind instruments, against the perceived sound.[9] Harmony is derived from the absence of roughness or beating when the overtones of one sound are heard in the presence of the overtones of another.[10] The most consonant musical intervals will have harmonics occurring at precisely the same frequency, or at widely spaced frequency intervals. In the absence of strong cues to distinguish these sounds, spectral fusion may then occur in which the listener perceives just one sound, despite there being two distinct source locations. This effect is more likely to occur in reverberant environments like concert halls where source direction is less well defined. Figure 3 shows the combination of harmonics that occur for two harmonic sounds tuned to a ratio of frequency of 3:2 (a perfect fifth in Western music).

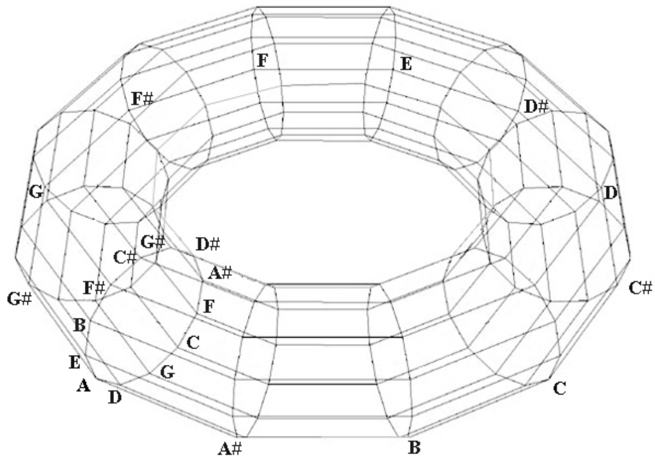
**Figure 3.** A spectral diagram of two sounds with harmonic overtones and fundamentals of 200 and 300 Hz. The third sound is the fused spectra; solid lines are actual frequencies present in the sound and broken lines represent frequencies naturally interpreted as present by the cognitive source model but assumed inaudible. The resulting cognitive model is a representation of a sound with harmonic overtones and fundamental frequency of 100 Hz.




The equally tempered scale adopted in the West in the nineteenth century compromises interval consonance to enable the construction of a scale of equally separated notes (logarithmically). The desire for such a scale derives from Pythagorean tuning in which the interval of a fifth (frequency ratio of 3:2) is repeatedly marked out across an octave (frequency ratio of 2). Twelve repetitions of the interval of a fifth produce a frequency ratio of 531,441:4,096 (129.7) that is almost the same frequency as six repetitions of the octave (a frequency ratio of 128). The equally tempered scale adjusts for this small inconsistency in Pythagorean tuning. The equally tempered scale can be plotted to reveal the spatial relationships generated by the two primary harmonic relationships of the fifth and octave (Figure 4). Other pitch space representations have been developed to represent more complex harmonic relationships.[11]

[9] Ernst Terhardt, Gerhard Stoll and Manfred Seewann, 'Pitch of Complex Signals According to Virtual-Pitch Theory: Tests, Examples and Predictions,' *Journal of the Acoustical Society of America* 71 (1982): 671–78.
[10] William Sethares, *Tuning, Timbre, Spectrum, Scale* (London: Springer-Verlag 1998).
[11] Gary Balzano, 'The Group-theoretic Description of 12-Fold and Microtonal Pitch Systems,' *Computer Music Journal* 4.4 (1980): 66–85.

**Figure 4.** Chromatic pitch space plotted to show the 'circle of fifths' in the vertical plane and octave in the horizontal plane. Melodies created in the horizontal plane are commonly modulated through the circle of fifths in the vertical plane.




This plot reveals the highly ordered space in which the melodic modulations of Western music are played out. Modulation of a melodic fragment configures it as a perceptual Gestalt or object against the background of equally spaced notes, since the internal pitch relationships of the melody are conserved whilst it undergoes a pitch translation. This is analogous to the configuring of a visual object as separate from its background if its form remains consistent during a spatial translation (for example, a cup moving across a patterned tablecloth). The modulations sequentially include more of the twelve pitch classes, and reveal the unifying mathematical order shown in Figure 4.

**Internalised Space**

Time and all types of space are cognitive constructs, and music employs our mind's natural faculty for constructing spaces from sense data to produce spaces with no direct relationship to the physical location of sound sources. In the earlier examples it has been shown how music may even confuse the mind's ability to spatially locate individual sources, and so focuses our attention on these semi-internalised musical spaces. Since the cognitive construction of spaces that describe the location of entities other than the subjective self is an essential process in the construction of identity, music may have powerful influences on emotional and other attachments to personal identity.

Music is closely associated with ritual performances. Becker,[12] used connectionist theories of mind to propose that particular neuronal maps of trance states may be produced in performers' minds by the repetition of religious rituals. Becker describes these maps as containing a rich tapestry of remembered associations and sensations, contained within themselves and exclusive of normal experience. The desegregation of acoustic perception,

[12] Judith Becker, 'Music and Trance,' *Leonardo Music Journal* 4 (1994): 41–51.

and the generation of abstract musical spaces that hold the listener's attention away from the normal world, may be a tool to aid ritual performers to enter trance states. Since these abstract musical spaces occur partially within the acoustic self, wider symbolic meanings associated with the music through verbal language, and visual or performance elements in the presentation of the music may become more strongly associated with the self.

This paper suggests that, to some extent, all listeners who have learnt to engage their attention on the abstract spaces created within a musical performance, may experience a trance-like state. In rituals regulated predominantly by market forces, contemporary popular music is a well-known agent for transmitting social identity to adolescent individuals in the midst of a very difficult social transformation.[13] Of course, orchestral music simply transmits another set of social identifications associated more strongly with the conservation of social position.

[13] Shepherd and Wicke, *Music and Cultural Theory* 48–55.