Hearing Things and Dancing Numbers: Embodying Transformation, Topology at Tate Modern[1] [to appear in Theory, Culture & Society Journal, Topology Special Issue]

Can we hear geometrical and topological shapes? Is it possible to dance numbers? How can we grasp topological shapes mathematical ideas through our senses of sound and movement? These were some of the questions explored in a recent sound sculpture and dance performance event at Tate Modern that Brian Rotman and I conceived as part of the Tate Topology speakers' series. With the so-called turn to embodiment and the issue of affect, the role of embodied sensory expression and impression is important for understanding "thinking" outside the rubrics of cognitive processing, discourse or representation. In so far as philosophy and mathematics venture away from text and symbol, traditionally vision has been privileged as the most "noble" of the senses - on the basis that the distance it gives from corporeal contamination, unlike touch for instance. But with topology the mind's eye loses its grip, it could be said, yielding to the possibility of auditory, gestural, kinetic and other sense of conceptualisation. While a Möbius strip can easily be made by twisting a length of paper, a Klein bottle cannot be perfectly produced in the three dimensions of Euclidean space. The mathematical imagination leaps to further dimensions than anyone can visualise. This is evidenced by significant number of geometers and topologists, including the great Euler, have been blind.[2] Embodying Transformation was concerned with how topological relationships and mathematical concepts exceed the bounds of the visual, but by embracing rather than eschewing the senses.

The distinctive feature of the sound sculpture was to explore "acoustic space" and the spatial dimension of sound.[3] An auditory image or gestalt can be described in m any ways – a melody or a rhythm, the timbre tone of a musical instrument or voice, or what a particular sound, a creaking door for instance, denotes. But with Knots and Donuts discrete sound sources were programmed to travel all around and through the listeners who were immersed in a three-dimensional auditory field filling the entire East Room of the Tate Modern (Figure 1). Before the start, the audience were briefed to expect what the travelling sounds would describe (as a sparkler does in dark). This was the geometrical shapes of a cylinder, sphere and figure of eight; and the topological figures of a Borromean Knot and torus (or donut). The sounds themselves consisted of various rolling balls, a roulette wheel, a bee buzzing and what was often interpreted as a rumble, swoosh and crash of an ocean wave. The audience were invited to sit, lie down or wander around in the near-darkness as they pleased.

Figure 1 Audience in Julian Henriques' sonic sculpture Knots and Donuts, Tate Modern, 19th November 2011.

The specialist hardware and software used allowed the location and movement through space of a discrete auditory source to be controlled quite precisely.[4] This had the effect of converting sound - most often a diffused ephemeral effect - into a form of graphic expression - an "audiographic" medium, that is, writing with or in sound (as distinct from the phonographic writing of sound). But this audiographic line, unlike one on paper, was drawn in three-dimensional space. At the pre-performance programming stage, tracing out its path as visualised on a screen with a retro computer game joystick, felt like constructing a wire frame sculpture. The movement of sound sources across space (as with a marching band, or a carnival float) is not very often considered within the repertoire of musical or sound art composition techniques. But with Knots and Donuts sound became a sculptural material, in the way that wood, metal or marble is normally considered.

One inspiration for of the sonic sculpture was the avant-garde music tradition of Varèse, Stockhausen, Xenakis, Nono and others who treated the sound spatialisation as a compositional element. Another was Bernhard Leitner's sound sculptures.[5] But most important was the sonic engineering of the hugely powerful outdoor Jamaican dancehall sound systems.[6] Here, the engineers often make a point exploiting the circular travel of sounds around the triangular configuration of the three speakers stacks. These sound effects, often incorporating gunshots, sirens and the like, serve as the signature of a particular sound system. In addition, Jamaican and other music producers often talk of "building" a riddim (rhythm) track. So this idea of spatialisation of sound and the consequent sonification of space could be said to stretch from Trenchtown to the Tate.[7]

For the Ordinal 5 dance, the audience returned to their seats to view the performance on the light stage area they vacated. The mathematical concept danced was a commuting diagram for Ordinal 5, that is, the number five as counted out (Figure 2). Rotman's approach was distinctive in that it was the choreographic expression of a <u>concept</u>, rather than a geometric shape as such.[8] The danced expression of mathematical concept of Ordinal 5 requires: a minimum number of six movement directions (or dancers), a specific number of positions in the space (on the dance floor) and sequencing in time of coincidence between dancer and position. The dancers all start on the same spot and as long as they each get to their next assigned position and finish at the same spots the mathematical concept can be said to have been expressed – to exactly the same extent would be done with an equation or drawing a conventional pen on paper diagram (Figure 3).

Figure 2 <u>Ordinal 5</u> Commuting Diagram by Brian Rotman

The material from which both the sonic sculpture and the dance are built is embodied movement. With <u>Ordinal 5</u> this was the choreographed movement of the six dancers, including their vocal and facial expression and gestures, is readily recognised as transforming their bodies through space and time dance of the stage area. With <u>Knots and Donuts</u> the movement was at the more micro scale of the periodic motion of compression waves through the medium of the air. The point make here is this: while expression is dependent on <u>some</u> mark, gesture, sound or other noticeable difference, it is independent of <u>which</u> particular medium of expression embodies the transformation.[9]

Figure 3 Dancers in Brian Rotman's <u>Ordinal 5</u>

One reason for interest in this kind of event is methodological, as an experimental investigation. Audiences for the five performances were most forthcoming in the Q and A and informally afterwards. While sound alone is not particularly good for pinpointing location (and is typically used in cooperation with vision), the sound sculpture's novel demand for attentive listening was experienced as enjoyable. The auditory impression of the sound shapes proved to be quite a robust phenomenon. Several remarked on their being at the centre of the sound field and feeling its depth around them - rather than having sound frame a stage or screen at some distance from their point of listening. Another comment was that the naturally appropriate sound samples of roulette wheel ball, for instance, made locating its circular path through space quite easy. In addition, for several listeners the ocean wave sound evoked deep associations of childhood seaside memories specifically – as distinct from the more general kind of association that a listener might have for a particular piece of music.

The most important point to be made from the sound installation and dance, however, concerns the issue of embodiment for topology and mathematics itself. Embodying Transformation was inspired by the idea that mathematical thinking should be conceived as an accomplishment of an enminded body, doing what bodies do, such as making gestures or touching things, rather than any purely abstract processes (whatever that might be), generated by a mind isolated or even opposed to material extension of the actual world. Such a line of thought - entirely contra the orthodoxy of how most mathematicians might understand what they are doing - has been what Brian Rotman has been establishing through several monographs.[10] Rotman develops an argument that hinges on the distinction between, on the one hand notational media that depend on metaphor, similitude and language system, and on the other, capture media with their metonymy, synecdoche and analogue variation.[11] Embodied minds and enminded bodies then underpin what Rotman describes as:

> A psyche that is at once porous, heterotopic, distributed and pluralised, permeated by emergent collectives, crisscrossed by avatars and simulacra of itself. In short, a *para-human* agency which experiences itself as an 'I' becoming 'beside itself.'[12]

The challenge of this idea of mathematics as an embodied activity is addressed, not only to conventional ideas of the mathematical mind, but also to those about bodies themselves. Once the conventional divided subject of mind/ body has been dethroned, or decentred as it was once put,[13] then all manner of exciting possibilities are opened up. Topological bodies concern relationships, rather than as identities, qualities rather than quantities, subjectivities and objectivities at the same time, enfolded insides and outsides, together with pasts, futures and presents – all in transitions and transformations. As one slogan put it: "Occupy the Future."[14] The implications of this lead to the consideration of embodied, situated and social ways of knowing, the nature of knowledge itself as techné and phronēsis,[15] as distinct from more formal text-based epistemologies by which academic research still tends to define itself.[16]

Topological generalisation - sacrificing the measure and angle of Euclidean geometry for the invariance of relationships that survive transformation – has been taken as evidence for the fundamental even innate nature of topological relationships - rather than their abstract character. Jean Piaget argued that the child has a topological concept of space, before he or she develops the conventional idea of Euclidean space.[17] According to the mathematician Alexei Sossinsky: "the blind person who regains his sight does not distinguish a square from a circle: he sees only their topological equivalence."[18] Steven M. Rosen goes further, calling for a phenomenological topology, drawing on Husserl, Heidegger, Serres and others. "Topology… is rooted in the body"[19] he quotes Sheets-Johnstone; and Connor: "No matter how abstract it may become topology remains fundamentally bodily."[20] Rosen uses this topological body as a critique of the "categorical separation" of classical cognition, for which "the axiomatic base serving as its unquestioned point of departure is the self-evident intuition of object-in-space-before-subject."[21]

The idea of invariance in topological transformation is indeed particularly useful for undermining such traditional ideas of consistency as being based on objects with their properties. Rotman uses this to develop the idea of a "quantum self" that:

> exists as a co-occurrence of virtual states, an 'I' which becomes actual or 'realised' and fixed as an 'objective' whole precisely when it is observed, subjected to psychic measurement or social control, or otherwise called upon to act, respond, be affected, and project agency. Such an 'I' would be a mass of tendencies, an assemblage in a perpetual state of becoming, rather than a monolithic being (Rotman 2008:135).

It is also interesting to note that this and the idea of topological embodiment appears to be consistent with a Deleuzian conception of the body – which would most often be entirely antithetical to phenomenology. Brian Massumi in his account of the "body topologic" puts it like this:

> The problem is that if the body were all and only in the present, it would be all and only what it is. Nothing is all and only what it is. A body present is in a dissolve: out of what it is just ceasing to be, into what it will already have become by the time it registers that something has happened. The present smudges the past and the future. It is more like a Doppler effect than a point: a movement that registers its arrival as an echo of its having just past. The past and future resonate in the present… The past and future are in continuity with each other, in a moving-through-the-present: in transition.[22]

Topology thus comes to be about bodies, but perhaps not quite as we usually think we know them. This is not conventional idea of a body as something or somehow without mind, an inert object, the Cartesian res extensor, lump of flesh, or sack of organs. Rather, it is the enminded body. So, on the other side of the false dichotomy, the topological body has little to do with the mind as res cogitans, or the abstract disembodied faculty of mathematics. The conclusion that I draw from Embodying Transformation is that greater sensitivity to the senses, greater sense of embodiment for topology.

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[1] Embodying Transformation was part of the performance programme of Tate Topology talks series. It was staged on the East Room, Seventh Floor, Tate Modern on 19th and 20th November 2011, see http://www.tate.org.uk/modern/eventseducation/musicperform/24581.htm

[2] See, Jackson, Allyn (2002) The World of Blind Mathematics, Notes of the AMS, Volume 49, No 10, pp 1246 - 1251

[3] Marshal McLuhan is credited with the first use of the term "acoustic space" see McLuhan, Marshal (1989) Visual and Acoustic Space in McLuhan, Marshal and Powers, Bruce, R The Global Village, New York: Oxford, reprinted in Cox, Christophe and Warner, Daniel [2004: 67-72] Audio Culture: Readings in Modern Music, London: Continuum

[4] The sonic engineering for this consisted of pre-programmed multi-track audio spatialisation, see http://www.3daudioscape.org/homepage1.htm diffused over a twelve channel sound system.

[5] See Leitner, Bernhard (1998) Sound : Space, Osterfildern: Cantz Verlag
[6] See Julian Henriques (2011) Sonic Bodies: Reggae Sound Systems, Performance Techniques and Ways of Knowing London: Continuum
[7] The ideas underpinning have also been tested in a number of previous sound and topology projects, often in collaboration with Martyn Ware and Illustrious at Goldsmiths, University of London. The Future of Sound (March 2008), the Future of Light and Sound, Synaesthesia Symposium (March 2009), large Scale Immersive Audio Experiment (Oct. 2009), Performing Topology (March 2010) and the Media and the Senses conference with the Circle of Sound sculpture (May 2011).
[8] One notable example of this geometrical approach is Oskar Schlemmer's Triadic Ballet (1927), see http://www.youtube.com/watch?v=xMDtwC76HjA
[9] This is consistent with Stern's concept of "amodal" perception, see Stern, Daniel N. (1985) The Interpersonal World of the Infant, New York: Basic Books and also Chion's of "transsensorial" perception, see Chion, Michel (1994) Audio-Vision: Sound on Screen. trans. Gorbman. C.New York: Columbia University Press, pp 136 – 7.
[10] Brian Rotman's monographs include, (1987) Signifying Nothing: The Semiotics of Zero, London: Macmillan, (1993) Ad Infinitum: the Ghost in Turing's Machine – Taking God Out of Mathematics and Putting the Body Back In, California Stanford University Press; (2000) Mathematics as Sign: Writing, Imagining, Counting, Stanford: Stanford University Press; and (2008) Becoming Beside Ourselves: The Alphabet, Ghosts and Distributed Human Being. Durham: Duke University Press
[11] See Rotman (2008: 42).
[12] Rotman 2008:134.
[13] See, Adlam, Diana, Henriques, Julian, Rose, Nickolas, Salfield, Angela, Venn, Couze and Walkerdine, Valerie (1977) "Psychology, Ideology and the Human Subject" Ideology & Consciousness, No. 1, May 1977, pp 5 - 56.
[14] On the information tent, St Paul's, 18th December 2011.
[15] As discussed in Henriques (2011)
[16] This erosion of boundaries and dichotomies has methodological implications for the ongoing "practice as research," where in the academy the status of performance and exhibition has yet to be recognised as a valid research output on a par with publication, see, Sullivan, Graeme (2009) Art Practice as Research: Inquiry in Visual Arts, London: Sage and Barrett, Estelle and Bolt, Barbara (2007) Practice as Research: Approaches to Creative Arts Enquiry, London: I.B. Taurus
[17] Piaget, Jean and Inhelder, Bärbel (1956) The child's conception of space trans. from the French by F.J.Langdon and J.L.Lunzer, London: Routledge and Kegan Paul. This work has also been criticised, see Kapadia, Ramesh (1974) A Critical Examination of Piaget-Inhelder's View on Topology, Educational Studies in Mathematics 5 (1974) 419 - 424
[18] Sossinsky, Alexiei (2004) Knots: Mathematics with a Twist, Boston: Harvard University Press, p 13.
[19] Sheets-Johnstone (1990) The Roots of Thinking, Philadelphia: Temple University Press, p 42.
[20] Connor, Steven (2004) Topologies: Michel Serres and the Shapes of Thought, Anglistik, 15 (2004): 105-117, see also http://www.stevenconnor.com/topologies/
[21] Rosen, Stephen M (2004) Dimensions of Apeiron: A Topological Phenomenology of Space, Time, and Individuation, Amsterdam-New York: Editions Rodopi B.V. p 12.
[22] Massumi, Brian (2002) Parables of the Virtual: Movement, Affect, Sensation, Durham: Duke University Press, p 200.