Workshop on Music and Shape: Notes

The first Workshop on Music and Shape was held at King's College, London, on 10–11 March 2010. Presentations were given by the project team (Professor Daniel Leech-Wilkinson and Dr Helen Daynes), and guest speakers from the RNCM and the Universities of Edinburgh, Roehampton, Sheffield, and Sussex. Speakers were asked to talk about the ways in which their research shed light on the aims of the 'Shaping Music in Performance' project, which is part of the CMPCP. These notes provide a summary of the proceedings, and were initially taken by Helen Daynes; authors have checked and revised these notes where appropriate.

The broad range of subject matter covered by the workshop enabled a wide range of approaches to the topic, which was introduced by Daniel Leech-Wilkinson. As seen from the preliminary results of the questionnaire study presented here (Helen Daynes), musicians appear to link music and shape in multi-faceted ways. Similarly, there were multi-faceted approaches to the topic of music and shape from the invited speakers. Much of the content of this first workshop might be considered to be related to two categories of links between music and shape: firstly, a link between music and movement (e.g. dance, gesture); and secondly, a link between music and visual imagery. This brief introduction to the contents of the workshop will make an initial attempt to situate some of the material gleaned from the speakers' very valuable contributions within this dichotomous framework of links between music and shape. These categories are not intended to prescribe the direction of future research on the project; or to provide a comprehensive understanding of all links between music and shape; merely to find ways of linking the research discussed at the first workshop.

As Larry Parsons discussed here, and as others have noted elsewhere, both music and dance are universal human behaviours, and these behaviours are often performed together. Within his wide-ranging presentation exploring neuroscientific approaches to studying music and the brain, Parsons discussed how humans use both music and dance to perform mimicry and create narrative. Links may be observed not only in behaviour, but also at a neurobiological level: both dance and music involve rhythmic entrainment, a task performed by the cerebellum; and Parsons also mentioned that the cerebellum is involved in fine pitch discrimination. Basic links between music and movement seem to appear at very early stages of human development: as part of his talk, Trevarthen discussed movements that very young babies appeared to be making in response to musical stimuli. At a neuronal level, too, there may be links: David Lee discusses the idea of Tau-G guidance. He has found that neural firing, skilled movement patterns, and sound patterns (such as movements between pitches in skilled singers) correspond according to his time-based mathematical formula. Jane Ginsborg discusses how gestures are used when memorizing music, linking conceptualisations of music with movement.

Within the second aspect of this dichotomous viewpoint, Jamie Ward discussed synaesthesia, the direct connection of two senses (in this case music and visual images). Although synaesthetes' responses to music are often highly idiosyncratic, some similarities can be drawn, according to pitch and chroma. In addition, Ward discussed evidence to suggest that reproductions of synaesthetes' images in response to music were preferred over similar images produced by non-synaesthetes, and also to synaesthetes' images that had been altered in terms of their orientation. Finally, Adam Ockelford drew links between visual representations of music, their shapes, and used his zygonic model to consider the levels of similarity between music and shape in each instance.

This is not intended to be a prescriptive way of conceiving the links between music and shape; and it may be counterproductive to separate any of the apparent links into categories, particularly if there is a more basic link between all three domains (movement, visual imagery, and music). On the other hand, it may be that these categorisations might help to organise the diverse range of material included in this workshop, and thereby help us to understand some of the links between music and shape. The workshop has stimulated modifications to our original research design, as well as the investigation of new areas with several collaborators.

Daniel Leech-Wilkinson (KCL, Project Director): Introduction

- Purposes of the event
  - To outline the disciplinary areas that may be relevant to the research
  - To ascertain a suitable set of priorities for the direction of the project (including suitable areas for the forthcoming appointment of a PhD student and a second RA)
- Music and shape
  - Shape is a common metaphor
  - Used to describe the dynamics of musical sound, and the ways in which they change over time
  - Are there ways in which we can explore the links between music, shape, and the brain?
- An example:
  - 1928 recording by Alfred Cortot
    - Patterns of fluctuations in tempo and dynamics at multiple layers (bar-level, crotchet-level, quaver-level, semi-quaver-level)
    - In this case bar level seems most perceptually salient, and might be described to feel 'like turning a corner'
    - Are there links to breathing? To emotional shapes? To intensification?
  - A second recording by the same artist, done two years earlier, shows the same control of varying time spans with 'astonishing precision' – the rubato is fractionally different, but the structural points arrive at exactly the same moment in time (cf. Chaffin, Lemieux & Chen, 2005; Lisboa et al., 2007).
  - These recordings feel like physiological behaviour, but this raises questions:
    - Is it just one shape that is intensifying?
    - Are the listeners' perceptions more complex than this, responding to multiple interacting shapes modelled by different parameters of sound?
- A possible mechanism?
  - Audio data is decomposed by the brain into separate features (e.g. contour, rhythm, metre, harmony etc), not perceptible individually but only in combination (e.g. contour/pitch, rhythm/frequency). Yet the individual components may be mapped across domains.
  - Eitan and Timmers (2010)
    - Ask participants to relate pairs of adjectives from different cultures to high and low pitch. Very high level of agreement.
    - This suggests that they share an underlying understanding of component features.
    - Mapping through metaphor – common, but elusive
  - Perhaps shape is a means of understanding change?
  - Perhaps other musical metaphors may be understood within this model?

Lawrence Parsons (University of Sheffield): Brain bases of the generation of music and dance

- Primary research strategy
    - Elementary operations of the brain
        - Discrete brain areas
        - Function/Anatomical areas
        - Information about each part
        - Neurons' activities
    - Put these back together to create information
    - Interactions between 2 (or more) brains
- Certain behaviours (e.g. rhythmic entrainment) are specific to humans
- Human music and dance are universal (found in all cultures)
    - Involves all of the brain
    - Why might this be? Evolutionary advantage?
        - Emotion regulation?
        - Social reasons?
        - Rhythmic action, body sensation, gesture, dance, words
        - Cognitive control of emotion
            - Music activates old parts of the brain involved in many activities
        - Evidence from music-induced epileptic seizures – spreading activation of the brain from music
    - Evidence from comparative studies – a study of human song and bird song
        - Human song (unfamiliar language) vs. Bird song
        - Non-musician/Non-birder/Non-musician AND Non-birder
        - Birdsong uses human music areas of the brain, including the emotion areas
        - N.B. Brain correlate validation for music inspiring composition
        - Could birdsong have been a driving force for musical development?
    - Dance
        - Is the reward mechanism for standing (or the vestibular system) linked to dance?
        - (N.B. Dance is linked to narrative and mimicry)
        - Cerebellum is involved – cerebellar vermis (lobule III) and cerebellar lobule V are involved in entrainment
        - Motion, metre, tempo, pattern activate some of the areas for dance
        - Cerebellum also important for fine pitch discrimination (see Parsons et al. 2009, *Brain Research*).
    - Babies' cries correspond to musical intervals.
    - BA38 = representation of complex melodies
    - Improvisation of music and language:
        - Overlaps and adjacent and distinct areas of the brain
        - Common – melody, sentence generation for auditory perception, vocalization
    - N.B. Brain scanning technology is not perfect – higher resolution scanners reveal more and more complex patterns of activation
    - Interacting brains
        - MIDI – activates motoric areas
        - Live partner – activates more interesting areas; provides interesting correlations and synchornizations
        - N.B. Music is like conversation

- Conductors:
  - When identifying different kinds of errors in chorales, distinct areas of the brain are used
- Pianist
  - Comparison of Bach vs. Scales.
  - Shows surprising de-activations
  - There are areas of the brain that appear to be deactivated when you are engaged in a specific task
- Hypothesis:
  - During expert performance, emotions and executive function may be closely controlled (suppressed) to maintain attentional focus without distraction required for complex/motor task. But audience experience is enhanced by emotional expression, therefore performers 'fake' (or act out) the emotional expressions to generate empathy. Gestures may then form an aid for memory. It might be that the simulation of emotion is less taxing than the experience of emotion. Other kinds of emotions (older, ancestral emotions) may be experienced instead. The human brain is still evolving.

- Questions:
  - JR: Fake emotion does not correspond to experience as a performer – what is the evidence?
    - Brain areas were not activated (perhaps due to lack of true expectations of performative aspects of the music?)
  - Is the social situation different in a brain scanner?
  - (Scanned people were not asked to report their emotional states as this was not the original focus of the study)
  - Might the solution be performative states? E.g. evaluation vs. Concert vs. Recording
  - All perceptuo-motor activities are understood through the cerebellum

Jamie Ward (University of Sussex): Synaesthesia

- 1-2% experience colour-number synaesthesia
- Music synaesthetes much rarer
- What is synaesthesia?
  - Concrete perceptual experiences
    - Subjective
    - 'like seeing'
    - Imagining? Daydreaming? Not really.
    - Activates perceptual regions of the brain
  - Effects are elicited by a stimulus (they are not spontaneous), which may be internal or external
  - Automatic – cannot be suppressed (reaction times are slower with the 'wrong' colour)
  - Cannot be changed. Something that happens to synaesthetes rather than something they can control.
- 2 views of synaesthesia (possibly a mixture of the two?):
  - An extreme version of what we all do
    - With a continuum between weak and strong
    - An adaptation of normal thinking – use of common approaches in a different way
  - Special

        - Triggers
            - Runs in families – not the particular associations, but the tendency
            - Nearby structures in the brain?
            - Blindness
            - Drugs (LSD) – Mescaline (Kluwer, 1926)
            - Bresloff et al (2001)
- Auditory – visual synaesthesia
    - Via speech (see letters spelled out with colour)
        - Baron-Cohen (1993) – often the first letter or vowel that provides the colour
    - Via non-speech – colour, space, shape, texture, movement
        - Coloured music – Ward et al. (2006)
        - Chose colour for musical sound (with retest)
        - Internal consistency
        - Synaesthetes are more reliable.
        - Generally, low-high creates dark-light (but not when AP and octave equivalence comes into play).
        - Most saturated hues
            - Around middle C
            - For musical sounds (not sine waves)
    - Synaesthetes show a precise 1-1 mapping, which is automatic (not strategic), explicit, and perceptual (for controls, any colour association is in their imaginations).
- Auditory time and visual space and motion
    - People think about music going from left to right when listening
    - Is there a basic association between time and space? Similar brain circuits.
    - Low = left, high = right (related to reading/musical keyboard)
    - Low = bottom, high = top
    - Low = large, high = small
        - Not coming from language, but exploited by language (Peter ? from Lancaster?)
- Complex representations from synaesthetes were presented to others.
    - Some of the images were changed (colour/orientation)
    - People prefer the 'correct' synaesthetes' versions to the altered ones
    - People prefer synaesthetes images to controls' images
- What about the synaesthetes?
    - Synaesthetes with musical synaesthesia are
        - More likely than average to be involved with a musical instrument (they spend more time per week, on average, than others
        - More likely than average to be engaged with art
- What about auditory synaesthesia that this triggers by visual stimuli?
    - Auditory → Visual = well-established
    - Visual → Auditory
        - Sometimes happens, but to different people (not a two-way relationship)
        - Saenz & Kock (2008) – 4 out of several hundred people
            - Visual flash → Sound
            - Visual motion → Sound
            - Auditory system better at detecting temporal activity than the visual system
            - Morse code presented to auditory and then visual domains
                - Controls were better at auditory than visual

            - Synaesthetes were more similar in each domain because they also hear the visual input.
        - Generally, no response to stationary images
        - N.B. Kandinsky
        - Goller et al (2009)
- Summary
    - Synaesthesia can be seen as an adaptation of the normal multisensory (AV) development. We don't normally *see* the images we might imagine in response to music.
    - Several causal pathways
    - www.thefrogwhocroakedblue.com
- Questions
    - Is there evidence to suggest that we are all born with synaesthesia?
        - Possibly, but it is difficult to know. Infants seem to have similar associations, but it is difficult to know whether these are truly synaesthetic.
    - Do people think differently about musical shape after using programs such as Sonic Visualiser?
        - It might be that the brain creates a visual strategy to process music.
    - Is there structural connectivity in the brain?
        - There are differences in the right temporal lobes of synaesthetes, but not in low-level areas. Left parietal lobe, frontal lobe. Not just sensory cortex. Spatial elements.
        - N.B. See Audioserve (a game that visualises music).
    - What is the relationship between AP and synaesthesia?
        - If a synaesthete has AP, the colours they see in response to music are dictated by the absolute pitch of the note, not the pitch height. E.g. All Cs are red.
    - Is there a link between the feeling of the music and the way it sounds? Haptics?
    - Is there a link between this and emotion?

David Lee (University of Edinburgh): Sculpting musical sound

- A theory of action control in many different domains (e.g. moving, vocalizing, developing, making music, interacting with others, rehabilitation)
- Action gaps
    - Acting requires the control of action gaps between a current state and a goal state.
    - Controlling action gaps requires prospective sensory and intrinsic information
        - Info generated in the brain (guide) = intrinsic
        - Sensory information allows correction
        - (See diagram on slide for relationships between sensory, intrinsic, movement, action and external information)
    - Generally, there are multiple action gaps.
- Ʊ (Tau)
    - Principal informational variable for controlling an action gap
    - = time to close of an action-gap at the current rate of closure
    - Ʊ of X = x/derivative of x
    - An action-time variable
        - The tau of all gaps has the same dimension, time (like the nervous system)
    - Prospective informational variable
    - Universal variable

    - Directly perceptible
- τ-coupling
    - Keeping two taus in constant ratio (e.g. two hands at different heights that need to land together)
    - τ can be directly sensed through τ-coupling (i.e. stimulus and external τs)
    - Intrinsic guiding gaps
        - Should be simple and sufficient
        - Should be rooted in the physics of the world
    - τ in head guides movement = τ_G Guidance
    - TauG guidance parameters are
        - K = the 'oomph' of the movement
        - A = the amplitude of the movement
        - T = the duration of the movement
        - Evidence for support of this from the mean spike rate of neurons, i.e. neural power (rate of flow of energy).
            - Curves of neural power support the τ_G function.
    - Examples of τ_G Guidance
        - Humming bird and the gap closure between the beak and a feeding tube
        - Sucking in neonates (a few days old) (Gap = suction pressure)
        - Babies' gestures
        - Pitch-glide singing (Lee & Schögler, 2009)
            - Transitions between notes glide, even when intended as discrete pitches
            - These glides (in terms of physical movement of the larynx, and the sounds produced) are τ_G-guided
            - Comparison between emotionally important transitions (as indicated by the singer from the score) and 'neutral' transitions: k-value higher for emotional transitions than neutral ones.
        - Double-bass player
            - Bow-movement and sounds τ_G-guided
            - 'Sad' sounds had a higher k value than 'happy' sounds.
    - May be able to examine the power in the sound wave
- Questions
    - Can we get τ wrong, and if so, what has gone wrong?
    - Is there anything that is NOT τG-guided?
        - Neonates reaching out for a seen object
        - Unskilled movements by adults
        - Unintentional movements
    - Is there a link between forward models? David Wolpert?
        - Feed forward
- Other clarifications:
    - The k value allows skilled movements to be made with flexibility, so a good musical performance might be τ_G-guided, but different to another performance that is also τ_G-guided.

Helen Daynes (KCL): Music and Shape

- Initial research questions
  - Do performing musicians use the idea of 'shape' or 'shaping' music?
  - If so, how do they use these ideas?
  - Do the ways in which these ideas are used differ between different musicians?
- Our approaches:
  - Documentary evidence
  - Questionnaire study
  - Interview study
- **Documentary Evidence**
  - Gathering references to shape in existing materials
    - From choreographers, musicologists, composers, critics, and performers
  - Choreographers:
    - Movements fitting or not fitting with the music
  - Musicologists:
    - Music as form (Allanbrook, 1982; Bruderhans, 2006; Crocker, 1967) (N.B. diagrammatic representations of music seem to have only been used after c. 1825 (Evan Bonds, 2010))
    - Melodic shape (Bruderhans, 2006; Dobszay, 2008)
    - Geometry (Hodges, 2009)
  - Composer-musicologists:
    - Compositional features involved in 'shaping the musical surface in a meaningful manner' (Mahnkopf, Cox and Schurig, 2004, p.7)
    - Link with physical gesture of production (Cassidy, 2004)
    - Temporal nature of music makes amorphous music very difficult to generate (Claren, 2004)
  - Composer-performers:
    - Use of visual imagery to aid musical production ('shapes that won't settle') – Chopin
    - Shape as form – Britten
  - Critics (From *Gramophone*):
    - Shape as form
    - Shape as expression
    - Shape within the music
    - Shape given to the music by the performer
    - Performer miss-shaping the music
  - Performers:
    - 'Opportunities to shape the music' – Rachel Podger
    - 'shape or structure' – Anthony Marwood
    - Shape as form – Sir Malcolm Sergent
    - Steven Isserlis – music has curves – go with them (also Bernard Haitink)
    - Shape of a phrase – Maxim Vengerov
    - Shape as form – Lang Lang
    - Temporal shape (temporal relationships) – Haitink
    - 'Shape the phrases ...' - Fischer-Dieskau
  - Summary of findings:
    - Spontaneous references to the term 'shape' and to the idea of shape (important because of Holyoak, 2005)

        - Links between music and movement
        - Shape in relation musical form/structure
        - Shape in relation to expression
- **Questionnaire Study**
    - To allow more quantification
    - Open-ended and closed-response questions
    - Administered via Survey Monkey
    - Snowballing
    - Good gender balance; reasonable age-distribution; many keyboard, string and wind players – need more brass players and percussionists
    - Reasonable range of music genres; possibly need greater representation of pure popular music performers
    - 35.5% professional performers (others professional standard amateurs, teachers, students)
    - 90.1% (154) of respondents think about shape when thinking about how to perform music
    - 83.8% (140) of respondents think about shape when talking with others about how to perform music
    - Links between music and shape
        - Phrasing
        - Form/structure
        - Dynamics
        - Pitch height/contour
        - Multi-faceted
        - Analogy/metaphor
    - Agreement statements:
        - Shape used in a range of situations, including practising alone, teaching, etc.
        - Using shape feels natural
    - Preliminary conclusions
        - The idea of shaping music, or linking music with shape, is commonly used, and 'feels natural' to many performers
        - Musical shape is perceived to change over time
        - Strongly linked to phrasing and form, but multi-faceted
- **Next - Interview study**
    - Up to 30 performers, selected from the questionnaire respondents
    - Range of instruments
    - Range of responses

Jane Ginsborg (RNCM):

- Shape – some definitions
    - A particular kind of mental representation
    - Shape as structure
    - Pitch and contour of dynamic (in a broad sense)
- Memory expertise and structure
    - Memory a long-studied cognitive process
    - Expertise also studied
        - Chunking
        - Hallam (1997) – cognitive analysis of structure

        - Chaffin and Imreh (1997, 1999, 2002)
        - Ginsborg, Chaffin and Nicholson (2006ab)
            - http://www.htfdcc.uconn.edu/psychlabs/musiclab.html
            - Study your music practice: http://www.htfdcc.uconn.edu/psychlabs/SYMP.html
            - Performance cues:
                - Some features cease to be important with learning (some become automatic/others made redundant by a change of mind)
                - Attention to features that become performance cues determined what is practised and what is forgotten.
                - Example: 'Prepare' vs. 'expressive' cues
                - Attention during practice and rehearsal affects long term recall
                - Serial chaining (one thing after another in chronological order) vs. Content addressability (starting anywhere)
                - Conductor's conception of shape likely to be different to performers'.
                - Train signalling – block system vs. "centralised traffic control" overall system.
- How do cues relate to gesture?
    - Different kinds of body movement are associated with different stages of learning
    - Metrical representation = shape
    - Gesture = semantic
    - Shaping contour – bodily movements
        - Ginsborg & King (2009)
        - King & Ginsborg (2010)
        - Types of gestures (see slides)
    - Kinaesthetic memory/hand pulsing. Even pianists used gesture.
    - More gestures when performers are with familiar partners
    - Wider range of gestures in familiar partnerships
    - Gestures used to convey narrative information and musical information.
        - Expressive communication
            - (singers also for technical production of sound)
            - Keller (2008)
    - Effects of familiarity and expertise:
        - Combined rhetoric
        - Development of joint mental representations
        - Embodied mental representation
        - Shaping contour – bodily representation of musical structure
- Questions
    - Other effects:
        - Involuntary bodily movements as well as deliberate manipulation
        - Empathy
        - Performance convention
        - Self-driven – visual cues? Something else
    - N.B. very natural – music is shared before birth
        - Parncutt – link between carried and sounds produced
        - Alexander Piantelli – twins interact in the womb

  - Might the gestures be an external control device? Is there a need for a mental representation? The evidence from the "Beating Time" study suggests so!

Adam Ockelford (Roehampton University): Music and Shape in the mind

- Shape is culturally and individually determined
- Dynamic relationship through movement
  - more or less freely associated with sound
- Creating, causing or controlling sound

Perceptual domains

- Music = complex (see slides for elements)
- Domains may be linked in a single dimension, bi-directionally, or multi-directionally
- Relationships between domains
  - may pass people by, e.g. pitch and time
  - May be regular (isomorphic in the domain of 'shape')
    - Systematic mapping – must involve a non-domain-specific function – may involve a distanced relationship.
    - Requires abstract cognition
  - May be irregular (through association/repetition/indirect connection)
    - A) arbitrary (repetition), e.g. > = accent
    - B) indirect connection, e.g. a symbol for a desired sonic effect
    - C) synaesthetic – visual and auditory correlate
- Visual representation of sound

1	Children's picture scores (Bamberger, 1982)	Intuitive proportionate links – early and intuitive inter-domain mapping. Culturally specific? But easy to grasp regular mappings.
2	Welch (1981) Drawn representation on German film – raised line on plastic – untrained blind children	Variant between regular change in two dimensions
3	Conventional notation	Vertical (pitch) and horizontal (rhythm)
4	Braille music	No vertical or horizontal connection
5	Guitar tabs	Visual correlate to hand shape; auditory correlate
6	Graphic notation (e.g. Stockhausen)	Loudness, pitch, time
7	Synaesthetic responses to music	Systematic, sometimes symbolic

- Questions
  - Any changes in children's representations/mappings after learning music notation?
  - Are domains really separate? Is it just that one stimulus may be multidimensional?
    - Even if multidimensional, the sources from the brain are separate (auditory, visual, etc).

Colwyn Trevarthen (University of Edinburgh) (notes provided by CT):

The **Psychobiology of Music** studies the generation of shape in sounds made by the human body moving in communicable ways (Malloch and Trevarthen, "Communicative Musicality", Oxford, 2010. CM)

- All **animal movements** have 'shape'; they are regulated rhythmically in body-related space/time coordinates generated in the brain, and evaluated by emotion.
    - The 'prospective control' of movements in space and time (Nikolai Bernstein; David Lee), seeks sensory information from inside the body (visceral/ autonomic), from muscles, tendons and joints, skin (mechano-proprioception), from the vestibular system, and from the exteroceptive system (touch, vision, hearing), and exploits environmental affordances in 'embodied cognition', Andy Clark.
    - The consequences of action, for well-being of the body, are judged by emotions ('affective appraisal', Charles Sherrington; Jaak Panksepp on 'affective neuroscience')
    - Movement shapes have economy and grace dependent on the urgency and efficiency of their control by the integrated subject or Self.
    - They exhibit expressive "Vitality Dynamics" (Daniel Stern, Oxford, 2010) which are cultivated in the 'temporal arts' (Adam Smith) – theatre, dance, music, poetry.
    - These are cultivated in musical expression (Lee and Shögler, CM)
    - Complex bodies with many parts require more elaborate hierarchical polyrhythmic control. The 'liabilities of mobility' are controlled by self-awareness (Bjorn Merker)
    - Human bodies and human self-consciousness are the most complex.

- There is a **scale or 'spectrum' of body-related spatio-temporal 'shapes'** defined by the anatomy and functions of the body and brain:
        - From 'qualia' the 'grain' of which can only be measured by physical instruments (colour, pitch, weight, temperature);
        - just perceptible elements of space or event in time;
        - practical actions of locomotion, orientation and manipulation, in 'present space and time';
        - longer intervals of sustained effort to execute projects lasting tens of seconds, requiring imagination and memory;
        - episodes of action and experience stored in memory;
        - diurnal and seasonal cycles of vitality, to lifetimes.
    - All these are displayed in shapes of musical art, which cultivate the motives of movement for creation of a 'ritual culture' (Merker, CM), and the development of sophisticated representations (Brandt, CM).
    - Music and dance, with mimesis and play, evolved before language (Merlin Donald; Charles Whitehead; Cross and Morley, CM)

- **Movements of communication** (Semiosis, C. S. Pierce; Sebeok) exaggerate and 'embellish' the parameters of vital control (Poly-Vagal Theory, Stephen Porges -- the vocal range around Middle C evolved for mammal commuication in the Age of Dinosours; it is too low pitched for reptiles to hear)
    - They transmit information as 'signs' about motives, interests and emotions, 'inter-subjectively'.
    - This leads to the evolution of expressive organs and 'ritual displays' by which cooperative social life is regulated. (see Animal Ethology)
    - Self-regulatory movements become 'public' social displays and are cultivated in creative cultural activities of dance and music, which go beyond 'gratification of bodily appetites' (Adam Smith on *The Temporal Arts*)

- **Infants have innate musicality** (Malloch and Trevarthen, CM).

- Their movements, of eyes, arms and hands, face and voice, are rhythmic, with measures matching those of adult actions, gestures, expressions and vocalisations
  - They are receptive to speech, song, expressions of head, face and eyes, and gestures of the hands and are capable of imitating them in dialogue from birth (Emese Nagy, 2010)
  - They show 'innate intersubjectivity' (Trevarthen; Daniel Stern)
  - Within a few weeks mother-infant proto-conversations develop which have the dimensions or shape of 'Communcative Musicality' (Malloch and Trevarthen, CM)
    - *Pulse*: A rhythmic sense of time (syllables, beat, phrases and longer elements).
    - *Quality*: Sensitivity for temporal variation in intensity, pitch and timbre of voices and instruments. (Hearing cheerful pitch above Middle C is innate; depressed mothers speak in the octave below)
    - *Narrative*: Emotional development of the melodic line, supporting anticipation of repeating harmonies, phrases and emotional shapes in music – allowing sharing of purpose in passing time.

- **Developments in communication** demonstrate human motivation for learning narrative rituals and conventional practices of both Technique and expressive Art
  - The infant's behaviours motivate change in adult responses, stimulating cultural learning.
  - As the infant is more, active proto-conversations transform into games, action songs and jokes, which prove that infants sense and seek to play with expectancies in other persons' minds, without, language or 'theories of mind' (Reddy, 2008).
  - Pulse and phrasing are varied to generate pleasure of surprise and discovery which enrich self-consciousness in the presence of others (Vasudevi Reddy, 2008)
  - Igor Stavinsky calls a violation of expectancy in harmony an "allusion". Conventional rules of harmony, melody, etc. in the Western diatonic system, "possess no absolute value" ("Poetics of Music", p. 36)
  - By the end of the first year an infant is learning artefacts of vocal plus gestural communication (proto-language), how to use tools (including musical instruments) and social mannerisms.
  - Gradually the metaphorical/'analogical' patterns of intersubjective communication are defined in 'logical' combinations of learned discrete 'digital' elements (syllables, musical notes) (Brandt, CM)
  - But the dynamic analogical frame remains as a 'grammatical foundation expressive of intentions and feelings, and interpersonal emotions (Ivan Fonagy, "Languages Within Language")
  - Toddler exhibit an effusion of creativity with new-found hyper-motility. Their expressive movements and vocalisations generate a culture of theatrical sound and dance in 'children's musical culture' (Bjørkvold)
  - They are making and sharing inventions in shapes of sound and moving that tell stories in 'temporal art' which can be celebrated in 'theatre for babies' (Custodero, CM; Rodrigues et a., CM).

- Infant communication and play depends on perception of emotions in **'vitality dynamics'** that transcend the differences of experience between touch, hearing and site.
  - This is not an acquired 'synesthesia' – it is multimodal or 'amodal', revealing the intrinsic or core motive processes of the brain
  - For example, the case of a blind 5-month-old girl conducting a mother's song with her left hand, anticipating the melodic phrases).
  - The shapes of music give direct information of the autonomic/visceral regulation of vitality in movement, permitting transfer of intentions, experiences and 'affective appraisals' between performer and listener, or between musicians making music together.

- The time-shapes of music, from tremulo, arpeggios, through the beat to phrasing and composition of a song depend on the **innate 'chronobiology' of animate life**, determined inside the body and brain (Osborne, CM).

    - The innate pulse of human action rules the spaces between single controlled acts lasting *between 1.0 and 0.3 seconds* – walking very slowly to running; *largo* through comfortable *andante* to *allegro* and *presto*; syllables of speech.
    - A phrase of speech or music, or a line of poetry, lasts *around 3 to 6 seconds* – this corresponds to breathing or a 'breath cycle'.
    - A stanza, a melody, or a paragraph carrying attention over a longer temporal shape of *about 30 to 50 seconds* is a simple narrative – it corresponds with a regulation by the brain of the functions of the vagal nerve that modulates breathing, heartbeat and associated vital activities over this space of time.

- The **emotional modulation of life** is shared between all humans, which means that musical shapes from a totally alien cultures are perceived with the same emotions as in the culture of origin (Tom Fritz)

- **Musical education** requires respect for the learners instinctive musicality and 'zest for learning' (Flohr and Trevarthen, 2008; Bannan and Woodward, CM)

Discussion: Suggestions for future work

D.L.

- Contour structure of music
- Amodal perception
    - Representation of sound in visual/tactile form
    - Common phenomena
        - What are they?
        - What are the amodal variables? (Which features exist as components of different domains?)
        - How does the brain match the analysis of phenomenon a) to the analysis of phenomenon b)?
        - Not within their own metrics. Ratio is important, but not the dimension (search for dimensional equivalence), e.g. time/change of parameters over time

L.S.

- ATOM – a theory of magnitude

E.C.

- Do people make the relationships as reliably as we think they do?
    - Check between people and over time
    - Find links between actual specific shapes and music
    - Specific functions, e.g. quadratic
    - Ask where a phrase will end, and/or how convincing it is.
- N.B. William Gaver What/How in the world do we hear?

C.T.

- The whole-body shape of experience, for all modalities, is mediated in the parietal cortex, and is engaged with initiatives of movement initiated in the pre-frontal parts of the cerebral cortex. All perceptuo-motor regulations in the cerebral cortex are shaped in time and space for bodily actions and depend upon sub-cortical 'maps and clocks' of action space in the brain stem and cerebellum.
- The brain is one integrated system representing the body by virtue of 'somatotopic mapping' in all components and interconnections.
- Social cooperation depends upon shared emotions: evaluations of the shapes of action -- *aesthetic* (judging the harmony of object qualities) and *moral* (of interpersonal engagements). These apply to musical shapes.

Others

- Expectations of critics
- Shape is unspecific – what does it really mean? Look at the use of the word 'shape' in other time-dependent domains, such as wine-tasting or perfume reviews. (L.P.)
    - Difficulty of an undefined word (there are others, e.g. beauty, love)
    - Wittgenstein
        - Something with shared principles, or underlying properties ...
        - Something not linguistic?
    - Shap*ing* – more like a gesture?
- Is there anything without a shape?
- Does something which is shapeless have a shape?
- Is the perception of shape in music different to anything else?
- Possibly explore words for other domains in music, too.
- Who is our target audience? Academia? Normal people(!)? General population?

L.P.

- Ethnography – ethnomethodology – how do the natives use the term?
- Forming a model for predictive tests
    - Garden-path tests
    - Is it pleasing?
    - Looking for consensus
- Brain activity data – powerful evidence needed beforehand (behavioural information)
    - Find two convincing alternatives and test carefully
- Or a logical argument
    - E.g. Link between facial expressions of disgust at 'unfair play' in a game and true disgust.
- Current approach limited to Western Classical music – expand?

Others

- Lakoff & Johnson
    - Nature of metaphors
    - Relate metaphors to schemata, then to embodiment
    - Cataloguing
    - Find when shape is and isn't used, both within a musical context and outside a musical context.