Kinetic consequence: from mind to body
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Introduction
The concept of being ‘moved’ by music is as old as music itself, the language we use to describe the emotional effects of music is that of movement, a ‘soaring’ crescendo for example. This is by no means coincidence as the sounds that we bring together in solo performance and orchestras are a product of physical movement of a human being, either interacting with an instrument or their own body, music is undoubtedly a product of bodies in motion.

Research at the Perception in Action Laboratories in Edinburgh has begun to examine the flow of information between artists, by applying ecological principles of perceptuo motor coordination (Bernstein, 1967; Gibson, 1966) to study how musicians and dancers ‘move together’ to create a performance or artistic exchange. A musician moves to make sound with their body or an instrument, those sounds are then perceived by a dancer and they respond with body movements interpreting those sounds.

Methodology
There is something about the way we move, particularly in relation to others that is informative and expressive. Manfred Clyne’s work on sentic forms (1973) illustrated the underlying emotional content in movement and an individuals ability to perceive and identify it. General Tau theory (Lee, 1998; 2004) provides an opportunity to directly measure that something in the creative/expressive behaviour of the artists as they sing/dance/pluck/strum or strike. Tau theory offers a theory of prospective control that allows us to study how we move with purpose and grace. By studying how we move in a communicative context (Schögler, 2003; Trevarthen, 1999), it is hypothesised that consistent and systematic differences in the movements used to create expressive gestures will be measurable through the application of tau coupling theory to recordings of those movements. The application of tau theory involves a mathematical analysis of how actions are guided in space and time (\( \tau \times x = x/(\text{rate of change of } x) \)). Tau is an invariant changing array of information that has been demonstrated to govern the prospective control of animal movements (Lee; 1998, 2004). Tau provides the perceptual system with dynamic temporal information about the changing state of the system in relation to an anticipated goal state, and these can be conceived of as ‘motion-gaps’.

The ‘motion-gaps’ in an exchange between musician and dancer can be transcribed for analysis by recording: the sounds and movements each performer makes to both create and respond to
those sounds. This is done using state of the art 3-d motion capture facilities (qualysis) and digital audio multi tracking facilities (pro-tools tdm).

Hand to body – exchange between a percussionist and a dancer in improvisation.

A percussionist (djembe) and dancer (contemporary) were placed in a room and asked to improvise together. The percussionist was given the lead role and the dancer stood in front of the percussionist. The dancer was directed to respond to the sounds made by the percussionist. Two sessions were recorded and in each session the percussionist was asked to maintain a single coherent mood/emotion. Each session was characterised by a distinctly different mood/emotion a. relaxed and b. agitated. The dancer was unaware of this manipulation until after the experiment.

The motion gaps analysed in this study were: vertical hand motion and attack phases (intensity) for the percussionist and the recordings of the dancers movement was limited to the upper torso and head in order to try and access more global aspects of body movement.

It was hypothesised that the tau-coupling information of the hand movements of the percussionist would be identifiable in the movements used by the dancer to engage with the music and that there would also be measurable differences in this information between the two sessions pertaining to the shift in emotion/mood of the piece.

Results Key:

All analyses involved a tau coupling analysis employing an intrinsic tau guide - tauG derived using the following formula: tau-G = 0.5(t-T^2/t), where T is the duration of the pitch slide and t is time % of coupling (degree of fit).

\( K \) a measure of the manner of the fit, describing the changing kinematics of the particular movement.

Kappa is a moment to moment measure of \( K \) as the movement unfolds and gives a temporal description of the pattern of control of the movement. As we move we adjust our behaviour to keep our movement tau in a fixed/proportional relationship with an intrinsic or internal tau guide. The graph of \( K \) (or Kappa) shows the results of our adjustments to our movement as we employ this strategy to control or movements.

Results:

Tau-coupling analysis with respect to an intrinsic tau guide was employed. A recursive regression procedure was used to test how well each particular movement fits a predicted tau-guide, this provides several variables (see Lee 2004);

It is important to note that in all the movements analysed (562) in all modalities hand, head, torso movement and intensity, general tau theory provided a robust description of the co-ordination and control of that behaviour (\( r^2 < 0.95 \), and mean % coupling = 99.21. sd=3.153).

This paper will focus on differences \( K \) the coupling constant and kappa -information regarding the temporal form of the controlling information.

I: the drum.

A significant difference in the \( K \) of hand movements (percussionist) was found between the two conditions, with the agitated condition showing a significantly higher mean \( K \) value for all hand movements in relation to the drum \( t (125) = -2.552, p<0.05 \). This difference is not apparent in the attack phase of the sound, indicating that the variation in hand movements is used to vary other
aspects of the acoustic flow such as the tone/pitch/timbre. However, the attack phase of the sound does follow the same pattern of control as the hand movements used to create them, as illustrated in Figure 1, and these showed a significant correlation (r=0.642, p<0.01).

Figure 1: "Line graph showing the mean Kappa profiles for downward hand movements and the attack of the sound produced in condition a. (blue) and condition b. (red). The solid lines represent the hand movements and the dotted lines represent the attack of the drum sounds. The temporal form of the control of the hand movement the attack of the sound are the same; hand and sound show a significant positive correlation (r=0.642, p<0.01)."

II: the dance.

The interpretation of the dancers movements proved to be a more complex situation. No bulk differences were found regarding K. However the general pattern of behaviour across conditions does produce a more 'literal' reflection of the two moods relaxed and agitated. Figure 2 shows boxplots for the k data for head, torso and drummers hands in the two conditions, condition B shows a marked decrease in variation and an increase in k.

Figure 2: "Boxplots showing the central tendency and spread of K values for hand movements across the two conditions. There is a general increase in k for the agitated condition in all movements, but this was only significant in the drummer's condition (b) in all movements, but this was only significant in the drummer's relaxed condition demonstrating a marked more variation in the possible transmission of this mood reflected in the movements being more relaxed, and of control described in the kappa plots of control described in the kappa plots."

The complex nature of the dancers response, i.e. with whole body articular joints and elastic tissue all moving in one continuous pattern of response, requires a careful micro analysis of each constituent part and a translation of the micro into the macro, this is currently underway. An example can be seen in Figure 3 illustrating the mean kappa graphs, with error bars, for the dancers downward head movements. The decrease in variation was found to be significant (F(49) = 9.5, p< 0.01), illustrating that the dancer's style of control of vertical head movements changes from very free to a repeating, rigid almost practiced movement.

Figure 3:
Summary and conclusions:
The tau variables $K$ and $\kappa$ were found to systematically and consistently varied across the 2 conditions. With the agitated condition (B) showing a marked increase in the $K$ of the drummer’s hand movements and significant decrease in the variation of $\kappa$ profiles for the dancer’s head movements. The en masse differences illustrated in the rather simple case of the drummers movements was not reflected en masse in the dancer’s movements but it is reasonable to assume that this is due to the complex nature of the dancer’s response and further analysis is required to fully interpret this in terms of tau.
References