Densities of Agreement: making visible some intangible properties of dance

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INTRODUCTION

Human movement analysis is a research field pursued by different disciplines in both art and science. Approaches include the physiological study of walking, anthropological research into non-verbal communication and the practice of choreography when it involves observing, describing and representing dance. The shared aim is to break down movement into parts that can then be re-described in relationship to some whole. As a part of this process, movement analysis makes use of various instruments or tools for recording movement from the humble pencil to 3-D digital motion capture technologies.

The recording process results in representations ranging from individual drawings to numeric signs and standardised notation symbols. Any of these will contain some selected subset (features, properties or affordances) as a product of the analysis process. These representations of movement work at differing levels of abstraction, fulfil different functions and the degree of standardisation and usage varies greatly, even within disciplines. An abstraction will be referred to as notational at the point that it tends towards becoming part of a larger syntactic system. Some representations undergo a further process of analysis eventually becoming diagrams meaningful within a particular expert area, e.g. biomechanics. The process of dance analysis and notation eventually may result in a score that is usually assumed, as with a music score, to be awaiting translation back into the live performance.

Despite various disciplines sharing this research interest in movement analysis; no method or approach has passed the threshold of usage or achieved the cultural status to make its notational representations a "universal" standard; as has occurred with music, mathematics and language. Instead we have a proliferation of different approaches to movement analysis, some competing some complimentary. One discipline may even try to borrow ideas from another. For example, French philosopher and architect Paul Virilio was interested in whether dance notation could provide alternative measurements of architectural space, a tool for an architect to “qualify volume” instead of only measuring spatial surfaces. (1) Choreographers may seek to collaborate with specialists in computer-based machine learning building notational structures as part of research into human gesture.

Even without a single accepted standard, the different disciplines do ask similar fundamental questions and share senses of possibility for achieving a better understanding of the complexities of human movement. In addition to adding to current knowledge such as orthographic refinements of an existing notation system, what researchers in this field aim for are ***innovations*** that give rise to new thinking. These may range from the development of a new motion capture technology to the creation of an interactive multimedia educational platform such as choreographer William Forsythe's *Improvisation Technologies CD-ROM*, subtitled "a tool for the analytical eye". The overall picture here is one of ongoing adaptation and change, trial and error, inquiry and creativity.

This context frames our interdisciplinary "viewing and parsing" exercise in movement analysis, recording and representation involving choreography specialists, ten dancers, psychologists and a statistician. In a previously published essay, we discussed this exercise and its results in relation to a question many in the dance field have been exploring for some time: "what is in a dance phrase?" (2) In this essay, we will focus on new graphic ***visualisations/ representations*** of the exercise results and how they might support discussions surrounding contemporary dance analysis and notation, as well as augment the choreographic process itself. We also draw attention to the potential of tool-supported observation to stimulate new modes of thinking about movement.

MEANINGFUL REPRESENTATIONS

To be meaningful, the results of movement analysis and recording, whether drawings, measurements or standard notation, must be interpretable and enable productive developments whether in thinking, experiments and instrument refinement, writing or on the stage. Both these terms, meaningful and productive, have different implications across disciplines, e.g. sciences such as physiology, biomechanics and ergonomics use notations to support computer modelling of human movement. Architects superimpose movement representations onto site models looking for new approaches to incorporate gesture and locomotion into space-making. In cognitive neuroscience schema detailing the cortical areas involved in vision and processing biological motion further our understanding of the perception of movement. And visual anthropologists have experimented with inventing, however controversial, their own systems of movement analysis and representation, e.g. Kinesics and Choreometrics.

As creative progress in choreography in the early 1900s expanded the range of dance movements beyond the fixed conventions of ballet, notation systems such as Labanotation and Benesh aimed to be able to record every possible kind of movement. One of the outcomes is that these notation systems, while meeting these aims quite comprehensively, are themselves complex and difficult to read and write. They are interpretable and productive only after a long period of study, and then only within a limited community of "users". This time commitment is disproportionate to the practical use of the system in the context of contemporary dance. Unlike music notation, to which it is often compared, dance notation systems are rarely used for the creation of a new choreography or the real-time generation of performance (the equivalent in music to sight-reading). It appears that the complexity of the systems themselves diminishes their practical functional value for dancers and choreographers.

This does not reflect, however, a lack of enthusiasm amongst choreographers to engage in acts of individual representation in the drawings and sketches they may generate in the context of making dances. While not producing a transmittable record of the dance as standardised notation systems do, some would declare these sketches equally if not more meaningful than standardised systems because they bear the mark of the individual maker. However, within our definition as stated above, to be ***meaningful*** these drawings and sketches must contribute to the productive development of the choreography. They can do this by stimulating and supporting the creativity of the individual choreographer as well as collaborative making processes. As a record or documentation of the creative process, the choreographer's drawings are occasionally made available to a public via an exhibition or publication, but generally there is little access to their significance in relation to the making of the dance itself. In this case, these drawings become aesthetic objects in their own right devoid of any productive or meaningful function in the sense we use them here.

Complex notation systems and choreographer's sketchbooks mark out the two main areas where varying approaches to movement analysis and representation are explored and tested in the dance field. (3) It is in the context of this field that we will discuss the outcomes of the "viewing and parsing" exercise in relation to a set of questions. In what ways do the representations we will discuss support discourse about dance and dance making? Do they support discussion that other representations don't? If other approaches to notation, drawing and representation are not supporting certain discussions, what are the possibilities to invent new ones? Can dance be representing systematically, retaining and rendering complexity and variability visible and yet still be meaningful/ readable with a minimum learning effort?

Can this support choreographers and dancers to understand themselves and their audiences better and thus enable the creative process?

THE VIEWING AND PARSING EXERCISE

This interdisciplinary exercise involved London based choreographer Wayne McGregor, ten dancers from his company, Random Dance, psychologists and a statistician from the Cognition and Brain Science Unit of the UK's Medical Research Council in Cambridge. (4) Following two sets of specific instructions provided by McGregor, four dancers from the company generated eight short movement sequences (two each). Four sequences were developed following a set of *points in space* instructions and the other four from instructions that were *graphic* and image based. First created and set (not improvised) by the dancers, each sequence was performed immediately three times and videotaped; with one performance of each sequence selected for the viewing exercise. These eight selected sequences varied in duration from 25 to 120 seconds and were digitised in a video format to be viewed using Quicktime™ software (Figure 1). This made it possible to directly control playback using the control buttons, cursor keys or direct manipulation via the playback head. In addition the 'movie information' window showed the time of the current frame being displayed, and the soundtrack was deleted to leave only motion cues for the viewers.

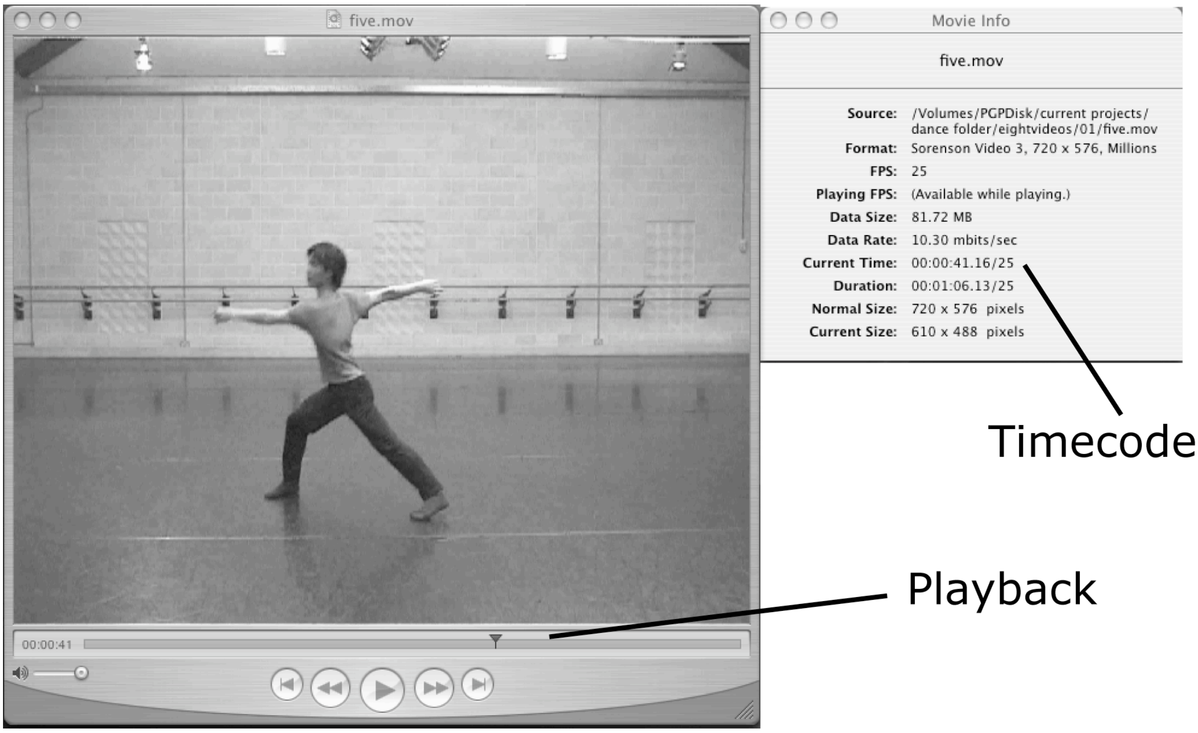

Figure 1. The Quicktime™ software used for the viewing and parsing exercise.

After this digitisation, McGregor and the ten dancers were shown the eight sequences in a two-stage procedure. In the first stage they were asked to familiarise themselves with the sequences – simply viewing each in turn without pausing. The viewing order of the eight sequences was randomised separately for each viewer. In the second stage they dealt with each piece in turn in four passes. In the **first pass**, they were again asked to watch the sequence without pausing. In the **second pass**, they could pause the action or move about the sequence using the player controls. Only on the **third pass** were they asked to 'parse' or divide the sequence into units of their own choosing. On a **fourth and final pass** they were asked to review and confirm their unitisation. At this point they were also asked to take a subset of the sequences and make brief notes about the bases of their unitisation.

The key pass was the third one when they were asked to ‘parse’ or divide the sequence into smaller units. We did not wish to presuppose anything about phrases or structure so our instructions left it entirely up to them to determine what a “unit” was; they were simply asked to specify the time at which a unit began and ended. Start and end times were read from the Quicktime ‘movie information’ window and entered onto a pre-prepared response sheet. The response sheet was organised into three columns (marked a, b & c) which allowed for units to be organised hierarchically or subdivided using different bases. Once again, it was left up to the participants to decide if they wanted to use a single basis for unitisation or multiple ones. The dancers did the exercise in two groups and each group took well over two hours to complete the process. The first afternoon McGregor participated in the viewing exercise and the second afternoon happened to include three of the dancers who had also created the sequences. At the end of each afternoon that day’s participants were debriefed and invited to comment upon what they felt they had got out of viewing the sequences in this way, and this discussion was tape-recorded and transcribed.

PYRAMIDS, PIANO ROLLS AND OVERLAP TRACES

The collected data from this exercise specified start and end times for “units” of movement, the brief notes the participants were asked to make and their tape-recorded post-session discussion comments. The latter are extensively discussed in the aforementioned published essay "What's in a Phrase?". These start and end times (as numeric signs) can be used to do certain basic calculations – average durations of “units”, for example. Such calculations could tell us something about whether varying instructions systematically alters what the dancers made; or at least how what they have made is perceived. A typical scientist might want to know if the *points in space* instructions gave rise to units of shorter or longer duration than the more *graphic* instructions. A typical choreographer might then justifiably ask how this question might influence the making process or precipitate engaging discussion of the products of making. We invited a statistician, Ian Nimmo-Smith, to analyse the collected numeric data. The results of his work, the graphic visualisations shown on the following page, contain interesting answers for both scientist and choreographer.

This page shows representations derived from three different sequences. The upper half of the page relates to two sequences of 30 and 60 seconds duration that were generated from the *points in space* instructions. The lower panel shows a single sequence of 120 seconds duration generated following the *graphic* instructions. For each of these sequences, a group of three separate representations (referred to here as pyramids, piano rolls and overlap traces) are presented that capture different facets of how the movement was “seen.” The representations that are most direct are the piano rolls that appear in middle of each group. Here there are eleven horizontal black lines depicting the individual coherent units identified by each viewer/ participant (one choreographer and ten dancers). We know from the collected qualitative data (the brief notes and the post-session discussions) that different strategies were used. Some viewer identified units at multiple levels and for simplicity we have not included these here. One viewer (line number 6 in the piano roll) was the choreographer, Wayne McGregor, who used a highly selective viewing strategy as evident from the white space in his line. “The things I kept in were things I felt were in some way articulate choreographic motifs. They were things that existed with a framework and a kind of a sensibility and a cohesion.” (5) For McGregor the black sections represent more than a simple unit, for him they demarcate a unit of particular interest.

The piano rolls ***emphasize variation***; clearly no two viewers saw exactly the same units in a given sequence. However, our analysis of the qualitative data (in the previously published

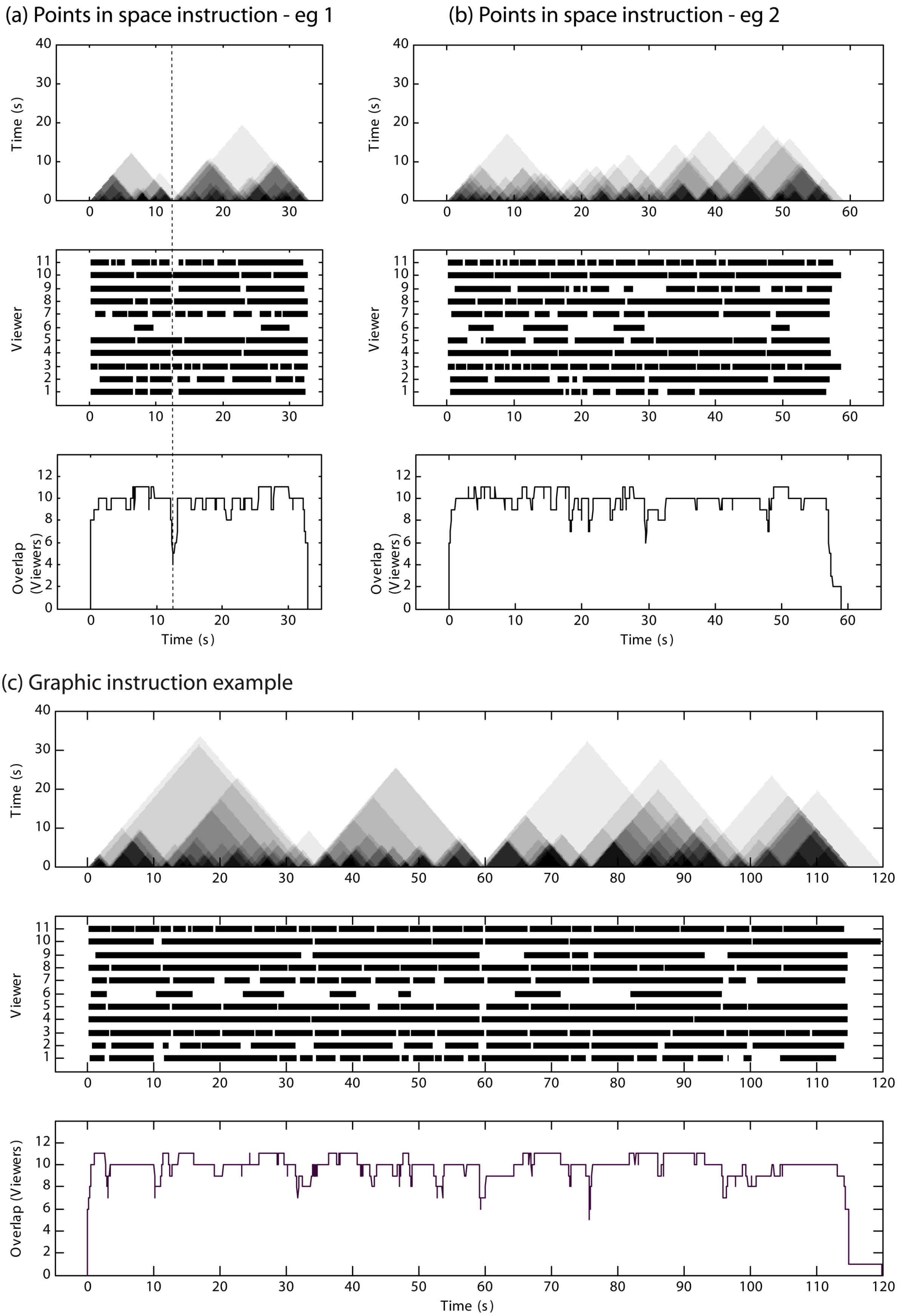

Figure 2 – Pyramids, Piano rolls and overlap traces for three short pieces: (a) &(b) – points in space and (c) graphic instruction

essay) indicated an interaction in the unitisation procedure between the dance and the viewing exercise itself. The selections the viewers made were clearly influenced by the specific task context of the exercise involving a rigorous viewing process. In looking at and analysing movement away from this context, the dancers may not be aware of some of the properties that made a particular unit cohere for them during the exercise. Thus, the piano rolls reveal variation as a product of a specific discovery process.

Immediately below the piano roll depiction is a continuous trace. Here the vertical axis represents the number of viewers who agree that two adjacent frames of the video are part of the same unit. This visualisation emphasizes the ***fundamental continuity*** in movement over time; and shows that the vast majority of the time most viewers (between 8 and 10) were “seeing” continuity rather than discontinuity. Since most are agreeing there is little scope for this to rise further. Most downward fissures are of modest size, indicating that a particular bounding property is agreed by rarely more than one-half of the viewers, and the more extreme fissures are likely to capture gross rather than subtle changes (e.g. a period of stillness).

The third form of visualisation appears as pyramids or a mountain range stretched out over time. Here the vertical axis represents time and the darkness of shading also represents the number of viewers who agree that two adjacent frames of the video are part of the same unit. The key attribute here is that time is on both axes of the graph. The shades of grey are what give this visualisation its unique property; it emphasizes the ***densities of agreement***. A completely black triangle of 5 seconds duration on both axes says everyone agrees that this is a coherent unit. (This does not mean that all viewers agree on where the unit starts and stops.) The pyramids provide what amounts to a statistical phrase structuring (hierarchical organisation) for movement sequences. They show all the different parsings simultaneously and via density indicate where there is major or minor agreement over the temporal extent of all the units in the piano rolls.

The pyramids also capture essential attributes of both of the other visualisations. The deep fissure in the trace for 'points in space eg 1' (at approximately 13 seconds) is very clearly reflected in the division between pyramids at the same point in time. Longer undivided segments in the piano rolls can typically be mapped directly to the lighter grey triangles in the pyramidal visualization. But it is not just the mapping; inspection of the three different examples shown in the figure reveals that there are time zones with different characteristics where the darker pyramids are simply embedded in lighter ones, or where there are left-branching or right branching structural decompositions, and combinations of all these.

Of course, in any particular instance we could speculate about the particular property (i.e. change in dynamic, intention, level or direction) that the individual viewer happened to be paying attention to in making his or her selection; and we could return to the original video to investigate this. However, this is not necessary for the pyramids, piano rolls and overlap traces to stimulate a discussion about dance analysis and representation as well as choreographic construction. For example, would different populations of viewers (e.g. non-dancers, audience members, etc.) select units differently and, if so, might exercises such as ours reveal meaningful differences? What might a participating choreographer learn from his or her selections in relation to others? There would be a range of answers to any such enquiries, and we discuss some of these below.

SUMMARY

One thing of key importance at this stage is that these visualisations capture features of the movement sequences in a way that could not readily be described in words or numbers. One can look at many possible structures at once and grasp an instant picture of their relationships as well as helping articulate organisational properties of perceived movement structure in time. And they are readable with a minimum of explanation; one of our requirements for a broader and more practical significance across the dance field than currently is the status of dance notation systems.

However, it is clear that these representations are not notational in the syntactic sense; nor do they resemble marks usually found in the choreographer's personal sketchbook. For the choreographer, they might function more as a single lens of variable focus on the movement itself. Choreographers may describe basing their choices on the idea that they "recognise something when they see it". What these representations do is make information available that might stimulate the choreographer to ask him or herself questions about what determines these "recognisable" changes in movement dynamic or form and their impact on the viewer. These graphic visualisations enable the choreographer to engage independently from his or her own assertions as to intention and to gauge whether what he or she considered salient was reflected in the selective attention of an audience (the viewers). They render explicit the otherwise intangible; and they do this in an unusual way.

Another aspect of what is unique about these representations is that they capture multiple perceivers simultaneously. The pyramids in particular constitute a single representation of one movement sequence as seen through the eyes of eleven viewers. Due to the visual layering, these are more evocative than the piano rolls or trace. This integration of the perception of a subset of viewers is something existing forms of dance notation and representation do not do. Normally, the practice associated with the dance notation systems discussed earlier foregrounds the score as an accurate depiction of a dance produced by the objective eye and hand of the notation expert. The choreographer's individual sketchbooks are more likely to represent a subjective perception; but this will tend towards being that of the individual artist and not the audience. In general, contemporary dance practitioners lack tools for systematically discussing the perceptions of their audience; something our representations make possible.

This simultaneous representation of viewers might have interesting consequences for someone taking a course in choreography. The student maker may be encouraged not to get lost in the detail and to maintain an overview of the range of possible meanings of any one particular moment in a dance phrase. Our representations imply that while viewers are unlikely to agree on particular moments; they do agree quite a lot in more general ways and that these overlaps of agreement can be featured hierarchically. The additional information derivable from the pyramids makes it possible to discuss more than one level of "seeing" or noticing and how different levels happen simultaneously in any one viewer or viewing group.

As mentioned in our introduction, aspiration towards a better understanding of the complexities of human movement drives research innovation across many disciplines. In the sciences, this has led to the development of advanced visualisation methods using computer animation; some of which could be applied to our representations. For example, the pyramids could be animated in real time the same way speech signatures can be viewed on particular timescales. (6) A thirty-second summary window could dynamically represent the emergence and dissipation of alternative 'parsings' as the piece progressed. These could additionally be marked by colouration reflecting other attributes (space traversed/ energy expressed). However, such a project would require time and money; and it is speculation if this would be effective and for whom. At the outset of this paper, we expressed our concern with the need for meaningful productivity to be associated with movement analysis and representation. Sophisticated computer visualisation methods might be applied, but to be meaningful and productive in a choreographic context, these methods should relate directly to the development of dance and how it impacts potential audiences.

It could be that small-scale research exercises such as ours might reap more immediate benefits. Increasing the overall value of our project is the fact it emerged from an unusual interdisciplinary collaboration between artists and scientists. This essay itself is the manifestation of that unique mixture, a rare convergence of ideas from very different domains of practice.

The authors wish to acknowledge the crucial contribution of Anthony Marcel to the design of the viewing and parsing exercise.

ENDNOTES (all URLs accessed 11 November 2005)

(1) see: Paul Virilio (interview with Laurence Louppe and Daniel Dobbels). "Gravitational Space". in Louppe, Laurence, ed. *Traces of Dance: Drawings and Notations of Choreographers*. Paris: Editions Dis Voir, 1994. pp. 35-59.

(2) Scott deLahunta and Phil Barnard. "What's in a Phrase?". in: Tanz im Kopf: Jahrbuch 15 der Gesellschaft für Tanzforschung. Wilhelmshaven: Florian Noetzel-Verlag, Autumn 2005. pp. 253-266.

(3) For an in-depth development of these two concepts in relation to each other see: Laurence Louppe. "Imperfections in Paper". in Louppe, Laurence, ed. *Traces of Dance: Drawings and Notations of Choreographers*. Paris: Editions Dis Voir, 1994. pp. 11-33. It is interesting to consider how these two areas relate to movement analysis in the context of Dance Science, an evolving field concerned with the overall health, treatment and prevention of illness and injuries in dancers and drawing on fields such as biomechanics and psychology. See http://www.iadms.org/.

(4) The exercise took place during Choreography and Cognition, a joint research project initiated by Scott deLahunta and Wayne McGregor to engage practitioners from the field of cognitive science in seeking connections between creativity, choreography and the scientific study of movement and the mind. See http://www.choreocog.net.

(5) From "viewing and parsing exercise" transcripts of the post-session discussion, 27 January 2004.

(6) See the auditory image modeling work of Roy Patterson, Centre for the Neural Basis of Hearing, Physiology Department, University of Cambridge, UK. See http://www.mrc-cbu.cam.ac.uk/~roy/.

AUTHOR URLS

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APPENDIX

Representations of Segmentation Data (explanations contributed by Ian Nimmo-Smith)

Segmentation Data

A segmentation of the interval [0, T] is a sequence of sub-intervals S = {[s1;e1], [s2;e2], ..., [sm;em]} for some positive m, where 0 <= s1 < e1 <= s2 <e2 <= ... <= sm < em <= T. m is called the length of S. The ith segment [si, ei] starts at si and ends at ei. The interval [ei,s(i+1)] is called the ith gap, which may have length 0.

In the present study each of 11 viewers was asked to generate a segmentation of a videoed dance sequence. Ses denotes the segmentation data from viewer e on sequence s, and mes its length.

We have used three graphical methods to represent different aspects of this structurally rich dataset. These are described in the following sections. Each graphic is constructed out of the set of segmentations for just one dance sequence.

Piano Rolls

The piano roll is the simplest graphical representation, and is equivalent to the raw data. Each viewer's segmentation is represented on a separate horizontal line. Each segment [s,e] is drawn as a solid bar between the points s+eps and e-eps. Here eps is a small positive number that enlarges each gap by 2 eps in the segmentation to make it visible. In the graphics that have been generated this corresponds to 8 frames or just over 0.25s.

Overlap Traces

In the overlap graphic we graph against time the number of viewers who put that that time point into a segment. The overlap function is bounded below by 0 when everyone is agreed on a frame which is outside any segment, and above by 11 (or 10) in the case that all agree it lies in a segment. Rises in the overlap function correspond to starts, and falls to ends.

Pyramids

The pyramid graphic is a two-dimensional density plot. It is generated by assigning to each segment [s, e] a triangle D(s,e) with height e-s (i.e. the segment's length) and base the interval [s,e] and density 1. These are then summed and rendered as a graphic using a gray scale (or some preferred colour scale) to indicate the density. The minimum for the pyramid function is 0 (rendered white) and the maximum is 11 (or 10) (rendered black). The pyramid function combines information about the starts and ends of segments, the length of segments, and the extent to which they overlap with other segments.