Dancing the Dow:
Accounting and Financial Information Embodied

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This paper will be accompanied by a recorded live performance and by a computer animation to illustrate the conversion of accounting and financial information into dance.

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Abstract

There is no such thing as purely propositional knowledge; embodied knowledge is a necessary part of all of our knowledge. It's not only a matter of being unable to know anything about the world without our body's senses, it's a matter of being unable to comprehend the world without our body's experiences. For example, we graph accounting and financial data in order to transform numbers into physical objects; we do not just read and interpret graphs, we viscerally relate and react to their shapes as we would to other physical objects in the world. And if for this reason graphs enable us to make better sense of numerical data, there is every reason to expect that music and dance will as well. The dominance of the visual in our modern culture has not reduced the importance of the aural and the corporeal senses, it's simply blinded us (a telling metaphor itself) to their importance.

Dancing the Dow:
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I. Introduction

We inhabit an increasingly *visual* culture. (Levin, 1993) The sense of sight supplies the familiar metaphors “point of *view*,” “out*look*” or “per*spec*tive” for the mental model of our environment we are imagined to create out of all of our sensory perceptions and for intellectual activities in general. (Sweetser, 1990) And we largely employ visual methods to study our environment. (Hoskin and Macve, 1986) To show patterns in data, for example, researchers revise the textual layout—draw graphs—which they treat as “real” representations of that data when in fact the graphs are simply the outputs of arbitrary algorithms for the translation of numerical data into visual forms. A recent paper “Listening to Accounting” (Bettner et. al., 2010) concludes that with appropriate education and examination, it might be equally possible to discover patterns in aural representations of numerical data, patterns that would not be apparent, or *as* apparent, in visual ones. Sights and sounds are processed differently within the human brain—sounds tapping more into the emotional centers than sights—and sights and sounds represent space and time differently—sounds making time explicit and space implicit and sights the opposite.

As radical as it sounds to *listen* to financial information—to translate numerical data into a piece of music—the paper’s rationale for doing so is limited and conservative. According to Bowman (2004), this perspective is quite common.

> On these views, music’s meanings are non-discursive; however, they are accomplished by the same cognitive mechanism as (linguistic, Propositional) discourse. So music’s cognitive function is, like language’s, to represent aspects of reality that otherwise elude us; to render the world clearer, more comprehensible, more compatible with cognitive ideals of control and certainty. And the body’s role remains subservient to that of mind. (*Ibid*., page 35)

Two important consequences of our embodied minds are ignored. One is the phenomenology of perception, that our sensory inputs are not analyzed piecemeal but necessarily packaged as integrated, meaningful wholes.[1] The other is embodied knowledge, that intelligence is not a monopoly of the human brain but resides throughout the human nervous system. The artificial Cartesian distinction between the mind and the body marginalizes the importance of the phenomenology of perception and embodied knowledge. We see and hear (and smell, touch, and taste) simultaneously a world which has meaning for us, and we know it with our entire being. Therefore, the knowledge to be gained from the aural representation of data is likely to be at least as much a consequence of music's physical effects on what we call the "body" as its intellectual and emotional effects on what we call the "mind." It is not only that it is impossible to make music without movement and it is impossible to listen to music without explicit or implicit movement entrained with its rhythms, but also music itself—its timbre—is vibration which moves the body. (Bowman, 2004; Cass, 1999) Music is a corporeal as well as an aural experience, engaging the muscles as well as the ears. (Cross, 2001; Trevarthen, 1999)

In the arts, though, movement is more closely associated with dance than with music, so if music is a source of physical knowledge, dance should be too. Just as we can translate numerical data into sights with familiar graphing algorithms and sounds with computer algorithms such as the one referenced in Bettner et. al., we can translate numerical data directly into movements, that is, directly into dance. Merce Cunningham, a choreographic collaborator of John Cage, did it from random numbers in a manner similar to the composition of aleatoric music. Having done so, though, one is left with not one but two representations, one accessible to the dancer alone (Sheets-Johnstone, 1981) and one that the audience sees. Dance can be another form of visual representation—not at all a graph—for someone not doing the dancing. To complicate the process, it is unusual for dance not to be accompanied by music (Cass, 1999; H'Doubler, 1998), and indeed music and dance share prehistoric origins, as the rhythmic sense required for muscle coordination for bipedalism is thought to have led to both (Mithen, 2006; Trevarthan, 1999) as well as to speech itself. (Barthes, 1985) The two also have profound consequences for the facilitation of social interaction. (Malloch, 2005) A dance with musical accompaniment can be created either *from* the music or *along with* the music; one can either sequentially translate numerical data into music and then into dance or simultaneously translate it into music and dance. Dance is rarely if ever translated into music. Most dances then are both corporeal and aural experiences for the dancer and visual and aural experiences for the audience. Some dance theorists contend that a dance performance also generates sympathetic kinesthetic responses in audience members. (Stevens and McKechnie, 2005; Hagendoorn, 2004) In short, when we translate numerical data into a graph, we get a visual

[1] Material concerning the phenomenology of perception in this paper has been drawn from the work of Maurice Merleau-Ponty and commentaries on this work. (Merleau-Ponty, 1961; Merleau-Ponty, 2004; Langer, 1989; Marshall, 2008; Hass, 2006; Matthews, 2006).

representation; when we translate it into a piece of music, we get an aural and corporeal representation; and when we translate it into dance, we get a visual, aural, and corporeal representation.

This is still a simplification, however. We cannot break down a dance, a piece of music, or a graph into its sensory components unless theoretically reconstructing the experience after the fact. Furthermore, nothing, not even a graph, is perceived by a single sense. Although one sense might be dominant, all other senses are engaged as well, and all contribute to the formation of the representation. (Bowman, 1998; Berleant, 1964) This is referred to as synchronesthetic or inter-modal perception, and it is artificial to differentiate between visual, aural, and corporeal representations. (Van Campen, 2008) And we cannot separate a dance, a piece of music, or a graph from its meaning for *us*. Everything has to be perceived *by* someone, who necessarily interprets it in light of their experiences, their values, their preferences, their intentions, etc. To take some general examples, music, like dance, is a different representation for performers than for audience members. (Stubley, 1998; Cusick, 1994; Barthes, 1985) Music and dance both are different representations for musicians/composers and dancers/choreographers in the audience than for non-musicians and non-dancers. (Stevens and McKechnie, 2005; Bowman, 2004) Graphs are different representations for mathematicians than for non-mathematicians as a consequence of their differing educational experiences.

Some work has already been devoted our embodied knowledge of accounting and financial information, but it hasn't been recognized as such. Studies of the structural presentation of financial statements (ex. Quattrone, 2009; Tebeaux, 2000; Hoskin & Macve, 1986), studies of the visual presentation of financial information (ex. Benschop and Meihuizen, 2002; Maclean and Hoskin, 1998; Graves et. al., 1996), and studies of accounting and financial metaphors (ex. Walters, 2004; McGoun, 2003) all concern value being represented in spatial, temporal, and linguistic terms that our embodied minds have evolved to comprehend. The blocks and lists and titles and headings and footnotes of financial statement create objects with implicit categories and hierarchies with which we are familiar. The juxtaposition of financial information with photographs and illustrations integrates it with the implicit narrative of the imagery. And from the pioneering work of Lakoff and Johnson (1980), we are well-aware of the bodily bases of all metaphors.

We can translate numerical data into graphs, into music, and into dance creating different visual/aural/corporeal representations of the same material, and the reason for creating such different representations to is to engage different parts of the brain and different parts of the nervous system in order to get to *know* the numerical data in different ways. This statement raises some difficult questions: What really happens as a consequence of these translations and are there really different sorts of knowledge—not just engagement of different parts of the brain and rest of the body—to be acquired from them? Even in the simplest—or at least most familiar—translation of numerical data into a graph it is not so evident what happens, and Section II suggests that graphs create physical objects our minds and bodies have evolved to manipulate. Therefore, the knowledge we have learned to see in numerical data by graphing it is effectively a form of the embodied knowledge described in Section III. Although it is beyond the scope of this paper to explain just what we might know from dancing the Dow or other sequence of accounting or financial data, Section IV explains how to do it. And Section V is a brief conclusion regarding the multi-sensory dimensions of a seemingly "pure" accounting for space, time, and value.

II. Numbers as Graphs

A familiar definition of a graph is that it is a visual representation of numerical data. What happens, though, when we draw a graph? Consider a simple graph that is one of the most common representations of economic, financial, and accounting data that is taught throughout the world through the familiar routines of instruction, examination, and assessment. In the familiar Cartesian coordinate system there is on a horizontal axis (time) and a vertical axis (the value of a variable such as the Dow-Jones Industrial Average (DJIA)). Such a combination of horizontals and verticals has an apparent neurological basis; humans are more sensitive to such lines as a result of their predominance in the natural world (Coppola et. al., 1998) and consequently exhibit a preference for them. (Latto, 2004; Latto and Russell-Duff, 2002) On this graph, the arrow of time points from the left to the right, and the value of the variable increases upward. These directions are not simply conventions; the dominance of right over left and upward over downward is omnipresent across cultures. (Frandsen and McGoun, 2010) The future is always to the right of the past and larger values are always *higher* than smaller ones, literally as well as synonymously. When we draw such a graph, we transform dimensionless numbers that record a date and the value of a variable on that date into a physical object. The dates and values generate physical one-dimensional lines, and the two together generate a physical two-dimensional plane. Selected points in this plane correspond with the extant combinations of specific dates and their corresponding values.

What happens when we draw a graph is that abstract time and abstract value are transformed into concrete objects in space. Although we can construct them from sensory data, time and value are not directly accessible to any of our senses. In the language of phenomenology, they are" moments," that cannot be intended separate from wholes. (Sokolowski, 2000) Time and value must be parts of something. On the other hand, objects are explicitly accessible to our eyes. In this form, the numerical data can be input in one of the ways humans have evolved to input data from the environment—through the eyes. Although we can certainly see written times and written values, it is not the times and values themselves that we see, it is their inscriptions. In graphs, we see times and values and time/value combinations themselves as objects—lines and planes. If nothing else, alternative transformations of numerical data into music and dance enable it to be input through other sensory pathways—through the ears and the muscles—that humans have evolved to acquire data.[2] We do not, however, just *see* the objects that are created when numerical data is graphed. For example, we imagine what the graphed data would feel like if we ran our hands over it, thereby engaging our muscles and our sense of touch. And we perforce associate the graphed data with objects with which we are familiar and endow it with their attributes, a process which can be manipulated through color schemes of graphs, for example. We cannot help but do this; we cannot just *see* a graph, and we cannot perceive it as just a graph. Only *after* having taken it in can we imagine having done so in that way.

Human minds have evolved to identify certain patterns of points in their visual fields as specific objects; the simpler the shape outlined by the points, the more likely that it is the shape of an object of human, not natural, origin. And objects of human origin always elicit a response that is intellectual, emotional, and visceral. Likewise, the simpler the line along which the points on a time-series graph appear to lie, the more likely that that line is evidence of an underlying non-random generative process. We are well-aware that this apparent non-random generative process elicits an intellectual response identifying it as linear or exponential or sinusoidal etc., but it also elicits other responses of which we might well be unaware but cannot help but have. We know in our minds *and* our bodies that *something* is *there*, and we have feelings about it. Without the concrete representation of numerical data in the form of a graph, we are unable to make use of the cognitive skills that we have acquired to survive in a physical world. These cognitive skills have both emotional and visceral components along with the intellectual ones. It was never sufficient for survival to just see something and *think* something, it was also necessary to *feel* something and *do* something. And all had to occur quickly and simultaneously. In effect, graphing is a too for the transformation of numerical data into a visual metaphor, and with having had the appropriate educational experience we then react to the data as if it were the part of the world it is like.

Graphing numerical data enables us to have the sorts of experiences with the data with which we are familiar in our usual interactions with the world. The data is transformed into a thing which we can see and

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[2] This of course suggests that we might also make explicit use of the senses of smell, touch, and taste, although there is as yet no sufficiently well-developed symbolic notation for these senses into which numerical data could be translated.

imagine hearing, smelling, touching, tasting, and moving or being moved by. The data is transformed into a thing with which we can make contact, with which we can engage, to which we can relate our prior experiences, and towards which we have feelings. We form value judgments concerning these things. For example, there are “good” shapes and “bad” shapes. In the world, things that grow are better than things that shrink, so graph shapes that slope upward to the right are “better” than those that slope downward to the right. In the world, things change gradually, so graph shapes that are curvilinear are “better” than those that are jagged.

The phenomenon is similar to what Cass (1999) has written concerning choreography.

> All of these forms relate to feelings as do the shapes, lines, contours and *colors* of paintings and sculptures. Balance and symmetry are stable; asymmetry restless; unbalance disturbing. Straight lines can be plain, or dull, or secure. Curved bodies on rounded spatial paths would be felt to be harmonious or aimlessly meandering. Sharp, jagged and opposing lines tend to project a feeling of attack or anxiety. (*Ibid*., page 84)

Werner and Kaplan (1963) provide an extended discussion of physiognomic apprehension, that is, that lines and shapes are interpreted as if they were generated by the movements of bodies. In effect, we might literally personify graphs and feel towards them as if they were persons. Merriam (1964) reports a similar phenomenon as a form of synesthesia or cross-modal perception in which people in a non-random way associate the stimuli of one sense with the stimuli of another.[3] For example, certain shapes, such as those that might be found in a graph, are associated with certain musical compositions.

In a technical sense, no matter what we do with data, we cannot any*thing* to it. We can, however, change our perceptual experience of it. This is the real reason why we graph data, not the usual reason that it somehow “simplifies” the data. When we graph data, we change the perceptual experience from the one we have with just the numerical data. We might even argue that we graph the data in order to have any sort of meaningful perceptual experience with the numbers at all, since in their raw form they are just inscriptions, just text. When we graph data in different ways, we generate different perceptual experiences. And when we translate data into music and/or dance, we generate much different perceptual experiences. The important point is that we are interested in knowledge, not data. With different perceptual experiences comes different knowledge. And knowledge is embodied. It is emotional and corporeal as well as intellectual. It is in *us*—in our brains and in the other parts of our bodies. It is knowledge that some unique one has of some unique thing for some unique purpose. It is not out there in the world; it is within each of us and different for each of us.

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[3] In true synesthesia, stimulation of one sense results in a response appropriate to another. For example, colors are “seen” when musical notes are heard. (Van Campen, 2008) The related phenomenon of intersense modality refers to the “linguistic transfer of descriptive concepts from one sense area into another” (Merriam, 1964, page 94), that is, as in “hot” color, “hot music,” and “hot” sauce.

III. Embodied Knowledge[4]

What is "embodied" knowledge, and how does it differ from "regular" or "articulated" knowledge that we are accustomed to acquire through the educational processes of instruction, examination, and assessment? Certainly the whole of epistemology concerns just what this regular knowledge is, but putting it simply, regular knowledge is propositional, that is, it consists of true statements. The key implications of this simplified definition of knowledge are (1) that knowledge must be expressible in language ("statements"), which requires it to be a product of the mind and (2) that knowledge must correspond with the world ("true"), which requires that there be an objective world outside the mind and a model of it within the mind. The role of the body and its senses, which role it unfortunately performs imperfectly, it to mediate between the world and the mind. This is the essence of Cartesian dualism. According to this view, what a graph does for us is assist our sense of sight in some way and enable us to "see more clearly" for example a linear change in a variable over time, thereby making it possible for us to make a statement that the variable changes by an amount ΔX for every change in time ΔT. As we discussed in the preceding section, however, it is not so obvious what a graph does—how, or even *if*, it does indeed assist our sense of sight and enable us to see more clearly. Our explanation there was that the graph does not assist our sense of sight and enable us to see more clearly; rather, its conversion of the data into a physical object enlists our experiences with changes in things over time and enables us to interpret the behavior of the variable in analogous terms. In other words, our knowledge of the change in the variable is derived from our knowledge of our prior experiences with similar changes.

This knowledge of our prior experiences is not, however, propositional knowledge. We might try to cast it as such, that is, we might try to make a comprehensive list of statements regarding our experiences with changes. But of course that list could never be exhaustive. One reason is that we've all had innumerable experiences with changes, all of which have had an effect on our knowledge of changes but most of which we would be unable to consciously recall. Another reason is that spoken and written language is unable to express much of this knowledge of changes. "Feeling" is the experience of movement and of change, both physical change and emotional change (Cass, 1999; Damasio, 1994), and feelings are notoriously difficult to put into words. Yet our living bodies know our feelings, and this is what is meant by the concept of embodied knowledge. We are often able to make different, useful sense of numerical data when it has been converted into

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[4] Bowman (2004), Thompson (1996), Damasio (1994), and Varela et. al. (1991) inspired the initial development of this section.

a form, a graph, that is able to tap into our pre-existing *embodied* knowledge. Our subsequent encapsulation of that sense in a mathematical equation is then *regular* knowledge, which is a weak distillation of the more comprehensive embodied knowledge from which it was derived.

Scholars have made strong arguments for the central role of movement in cognition. (Parvainen, 2002; Sheets-Johnstone, 1999; O'Donovan-Anderson, 1997) If so, transforming numerical data into a piece of music or into a dance would enable us to tap into different reservoirs of embodied knowledge than a graph enables us to do. The problem, of course, is that it is difficult, if not impossible, to distill those other reservoirs of embodied knowledge into regular knowledge. (Parvainen, 2002) We've still made some new senses of the numerical data, but we cannot express those senses in mathematical equations or other statements of spoken or written language. At this point, we are unable to say for certain why we cannot. It might be that there is a way to do it, but given the biases of our educational systems we have not learned how to do it. We have not learned how to state what we know about music or know about dance. Or it might be that there is indeed something different about this knowledge that defies expression in the form of statements. We might be able to feel what we know about music or about dance but we the language does not exist in which to say it. This is not to say that the knowledge is useless, however. We are certainly capable of responding to feelings; we can certainly act on embodied knowledge as we can act on propositional knowledge.

We routinely respond to the perception of patterns that we would never be able to describe, something that is so much a part of daily life that we pay no attention to it. For example, all of us are able to say that we "know" a person we are close to[5], but we would never be able to put more than a little of this "knowledge" into words, and even those would likely be barely comprehensible to someone else. Yet we are able to respond to this person quite successfully, making sense of her or his facial expressions, body language, voice inflections, etc and acting accordingly. Others of us are able to say that we know how to play golf or play the guitar, but once again, however, accomplished we are at such skills, we could never communicate more than the bare rudiments to someone else in the form of statements. These are perhaps the most familiar examples of embodied knowledge, and where we have gone astray is our failure to recognize that all knowledge works in this way. Interestingly, English is a rare language in that it has only one infinitive "to know" for knowledge of a fact, knowledge of a person, and knowledge of a skill. In Slovene, for example, to know a fact is *vedeti*, to know a

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5 English is a rare language in that one word "know" means both propositional knowledge and this particular sort of embodied knowledge, knowledge of a person. Most other languages have very different words with very different roots.

person is *poznati*, and to know a skill is *znati*. In fact, the Slovene word for science (*znanost*) is derived from the word for knowledge of a skill and not knowledge of a fact.

Merleau-Ponty's concept of the intentional arc concerns the embodiment of skills. (Merleau-Ponty, 1961; Dreyfus and Dreyfus, 1999) The phenomenon of physiognomic perception (Sample, 1996) links our embodied knowledge of persons, the acquisition of which having obvious evolutionary advantages, with our knowledge of other things.

> What is physiognomic perception? Essentially, it lies in discerning in the environment expressive qualities such as those that we attribute to the faces, gestures, and vocalizations of other persons: mood, intensity, affect, texture, coloration, rhythm, etc.-qualities expressive of subjective character. We note, for instance, that a circle drawing is sad, a landscape threatening, a line of music dancing, a motion heavy or flowing, inner- or outer-directed, that a scent is silky or thick, a color brassy, et cetera. Physiognomic perception is often synesthetic, or cross-modal, as in the last examples. (*Ibid.*, page 115)

What this means is that humans have an innate tendency to know other parts of the world, including graphs, as if they were human faces. This is more far reaching than, but along similar lines as, Chernoff faces, in which measurable attributes of a phenomenon are used to specify the dimensions of a face, intended to present an overall impression of the phenomenon. The idea behind Chernoff faces is to exploit physiognomic perception very directly. Although at once time this method made an appearance in the accounting literature (Stock and Watson, 1984), it does not appear to have caught on there or in any other application.

Given that language itself is the product of an embodied mind, what passes for pure propositional knowledge necessarily incorporates embodied knowledge along with it, especially when that knowledge is communicated in person. One aspect of this is that our metaphorical conceptualization of abstract concepts is derived from our experiences with living in our physical bodies in a world of physical objects. (Johnson, 1987; Lakoff and Johnson, 1998; Johnson, 1999)

> Our more abstract concepts are developed via metaphorical extensions of these basic sensorimotor structures, and our abstract reasoning involves inferences that are basically structure-preserving projections of sensorimotor inferences. (Johnson, 1999, page 85)

Another is that verbal communication cannot occur without the non-verbal, pre-propositional content enumerated in the earlier quotation from Sample.

> It is by grasping physiognomic aspects of kinesis, vocalization, and facial expression, by associating meaning with these sensuous qualities, that we understand the meaning of a felt context. In all communication, there is an indefinite horizon of such associations of physiognomic meaning. Because it exists in that horizon, the use of a shared language is always individuated by a felt context arising out of the language of sensual, interacting bodies in

> the world. (Sample, 1996, page 119)

That some elements of this non-verbal communication can be analyzed using the terms and concepts of notional systems as used to record dance (Sample, 1996; Davis, 1979) at least suggests that the transformation of numerical data into dance be explored further.

IV. Dancing the Dow

The rationale for the conversion of accounting and financial information into dance, then, is that it casts it in a form that can be experienced by someone. It's a way to transform and communicate information in such a way that it can be better—or at least *differently*—understood by an embodied mind.

> . . . the art of dance is the expression and transference through the medium of bodily movement of mental and emotional experiences that the individual cannot express by rational or intellectual [propositional] means. . . . The movements of the dancer's muscles are transferred by kinesthetic sympathy to the muscles of the spectator; and because he is used to associating movements with intentions, the spectator is able to arrive by induction at the intention that lies behind the original movement. (Copeland and Cohen, 1983, page 3)

Just as a graph converts numerical data into a sort of object that we have evolved to interpret, so also are music and dance other sorts of such objects.

> The presentation of perceptible time, moreover, is fundamentally reliant upon a sense of 'spatialization' conferred by rhythmic schemata because "time cannot be measured except by movements in space." By conferring spatiality upon succession or duration, musical rhythm renders time perceptible. To the extent music exists in time, it appears as an object. (Bowman, 1998, page 266)

It's beyond the scope of this paper explore in depth just *what* can be exposed through the transformation of numerical data into dance, but the preceding has made the case that it's worth doing and it's within the scope of this paper to describe *how* it might be done. Merce Cunningham's method for the composition of a work was to delineate paths on the stage and prepare charts of steps, leaps, positions, and elevations of the body along with tempos, durations, and other variables for the movement of dancers along those paths. Chance procedures were used to determine the specific combinations of these variables from which performances of the work were to be assembled and the sequences in which these combinations would be executed. (Jowitt, 1988; Cass, 1999)[6]

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[6] Examples of these charts are in Cunningham (1968).

Although Cunningham used random numbers to create these *aleatoric* dances, he could just as easily have used other, non-random sources of numbers or letters to create *algorithmic* ones as did the choreographers Trisha Brown and William Forsythe. (deLahunta and Bevilacqua, 2007; Livet, 1978; Kaiser, 1999) The music that accompanied these dances was independently composed and unrelated to the dances, the two simply being performed simultaneously.

Cunningham's was a manual method in which each work employed a different set of his charts. In effect, the charts were the work. For the analysis of numerical data, it would be useful to employ automated methods, in which a computerized algorithm transforms the numerical data into a dance. One partial method is to generate music from numerical data via a computerized algorithm such as the one found at The Eastern Washington University (EWU) web site http://musicalgorithms.ewu.edu/algorithms/import.html that was referenced in Bettner et. al. (2010) and then manually choreograph a dance from it. The advantage of this approach is that it necessarily results in a real dance; however, its disadvantage is that it inserts the interpretation of a choreographer into the creation of the dance from which an interpretation is supposed to be extracted by the audience. This confounds what is in the data with what is in the choreographer, and it's not possible to regard the human choreographer as just another piece of the algorithm. Shiratori et. al. (2006) and Kim et. al. (2007) both have developed algorithms for the transformation of music, whatever the source, into the movements/dances of animated characters. It's an open question what differences there might be acquiring information from an animated character rather than a real dancer, but this then raises the parallel question what difference there might be acquiring information from recorded music rather than live music.

There are numerous notational systems for recording dance by Arbeau,(1588), Feuillet (1700), Saint Léon (1852), Zorn (1887), Stepanov (1892), Morris (1928), Laban (1928), the Beneshes (1956), Eshkol and Wachmann (1958), and roughly 75-80 others, not to mention suggestions that the ancient Egyptians and Romans had also made such attempts. (Hutchinson, 1970; Guest, 1984; Guest, 1989) Of these, Labanotation and Benesh Movement Notation are the most prominant. (Turnbaugh, 1970) One of the problems with any notational system for dance is that one sufficiently comprehensive to specify all movements would be too complicated for practical use, and one that is useful would not be able to capture all of the nuances of the dance. (Hall, 1983) Unlike music, dance exists not only in time but also in space, and more variables are required to describe the positions and movements of the body than the attributes of sound. And of course, as dance evolves, the vocabulary of movements that a system is required to express expands. (Hutchinson, 1970)

There are programs for writing in dance notation and creating animated dances from it (Nadel and Strauss, 2003; Guest, 1984), and as early as 1964 Beaman and Le Vassure wrote a computer program to randomly make selections from sets of movement variables and produce verbal descriptions of dances, similar to what Merce Cunningham had done manually. (deLahunta and Bevilacqua, 2007; Guest, 1984; Beaman, 1965; Le Vassure, 1965) Nonetheless, a notational systems could theoretically be used to choreograph from numerical data in more sophisticated ways. There is no guarantee, however, that the output is something that a real dancer could perform, limiting what can be communicated. There are no restrictions on the translation of numerical data into music; any pitch can follow any other pitch at any rhythm. This is not true for the translation of numerical data into dance, whether through the medium of music or not. Positions/movements of real dancers are constrained by their prior positions/movements. We might of course make use of the animated characters, whose movements are far less constrained, just as electronic music can exceed the capabilities of the most skillful musicians. Once again, though, we must ask how well these can convey bodily knowledge, regardless of how lifelike the imagery or realistic the sound might be.

V. Conclusion

Even if a skeptic is willing to concede that there is such a thing as embodied knowledge along with the more familiar propositional knowledge, it is still too easy for that person to imagine dance at one end of a continuum in which embodied knowledge is important (after all, dance certainly seems to be all about the body) and accounting and finance at the other end in which knowledge is purely propositional and embodied knowledge is irrelevant. This paper has exposed the errors in that image. There is no such thing as purely propositional knowledge; embodied knowledge is a necessary part of all of our knowledge. It’s not only a matter of being unable to know anything about the world without our body’s senses, it’s a matter of being unable to comprehend the world without our body’s experiences. For example, we graph accounting and financial data in order to transform numbers into physical objects; we do not just read and interpret graphs, we viscerally relate and react to their shapes as we would to other physical objects in the world. And if for this reason graphs enable us to make better sense of numerical data, there is every reason to expect that music and dance will as well. The dominance of the visual in our modern culture has not reduced the importance of the aural and the corporeal senses, it’s simply blinded us (a telling metaphor itself) to their importance.

Throughout this paper, we’ve used the terms “numerical data” or more specifically “accounting and financial data” as if they were unproblematic, that is, as if those numbers were just “out there” somewhere, and this common-sense understanding is sufficient for the purpose of the paper's thesis. We must not forget, however, that the origin of this numerical data was some*one* naming and counting somet*hing*. Numerical data is a collection of *named numbers*. What this means is that prior to the translation of numerical data into graphs, music, or dance, the world had to be translated into numerical data. Therefore, the nature of the knowledge that we hope to extract through the translations discussed in this paper is inevitably a consequence of others' prior embodied knowledge and its use in their constitution of the world of objects that were named and counted. Whatever we might do to numerical data, the original naming and counting remains unchanged, and we are unable to penetrate beneath it.

There is, of course, considerable work to be done to determine whether music and dance can indeed enable us to make better sense of accounting and financial information. Although there is a limited number of them now available, there are countless computer algorithms that might be written for the translation of accounting and financial information into music and/or real or animated dance. And in each one of them, there are countless input settings for its conversion parameters. This problem, however, is not insurmountable. It has already been addressed for graphics; there are many types of visual representations of numerical data and many variations within each one. It's simply a matter of sufficient effort being devoted to the task. A more serious problem, though, is how the non-visual senses have been forced into the background in our culture and more specifically in our educations. We not only do not consider embodied knowledge to be as important as propositional knowledge, but we also do not consider embodied knowledge to be knowledge at all. We believe we know what graphs mean when we have transformed accounting and financial information into one, but we are wholly unaware of what music or dance from the same origin might mean. We are completely unequipped to interpret them as knowledge.

One definition of "dance" is that it is "any patterned, rhythmic movement in space and time." (Copeland and Cohen, 1983, page 1) Another is that it is "the expression and transference through the medium of bodily movement of mental and emotional experiences that the individual cannot express by rational or intellectual means." (Martin, 1975, referenced in Copeland and Cohen, 1983, page 3) According to both definitions, the non-verbal aspects of conversation constitute "dance." They're clearly patterned and rhythmic, and they clearly express what cannot be expressed by other means. We've already noted that they can be recorded using the same notational systems that are used to record what is more obviously "dance." Frandsen's (2004 and 2009) work has explored how accounting comes to enter people and shape their movements, in effect, choreographing these movements and creating dances. Once again, these movements—in Frandsen's case those of the nurses in a psoriasis clinic in which new accounting systems have been implemented—are clearly patterned and rhythmic, and they clearly express what cannot be expressed by other means. One might well argue, then, that Taylor's scientific management (Taylor, 1998, originally published 1911), for example, was a form of choreography, and Rudolf Laban, the creator of the Labanotation choreographic notation system, conducted time-motion studies in British factories during WWII. (Davis, 1979) We have been dancing accounting, albeit in not such a transparent way, for quite some time.

As described in the introduction, we already know quite a lot about our embodied knowledge of accounting and finance, and all we must do is make it explicit. Were we to do so, we might discover that we do indeed already listen to it and dance it. As this paper has asserted, we cannot just *see* something. What we see triggers experiences during which our other senses have been activated as well. When we look at a financial statement or read an annual report, we do so with synchronesthetic or cross-modal perception, although we might not be consciously aware of it. We hear it and touch it and move to it as well as see it. When we talk about accounting and finance, we do so not in a pure propositional language, because there is no such thing, but in a language that depends upon our bodily experiences to make sense of the words. There is already more to accounting and finance than literally "meets the *eye*," and the frontiers are not even in *sight*.

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