Imagine the (Im)possibilities: The Role of Constraints on Dance Creativity

Edward C. Warburton

This essay considers the role of constraints on creativity in dance. I introduce a choreographic research project, Three Bodies, based on the Pythagorean Three-Body Problem. I ask, what are the possibilities inherent in dance when creativity is constrained by a particular problem space? An important goal of this essay is to build on Patricia Stokes (2005) research on creativity from constraints. Using a practice-based research method, I show how this artistic case study "makes research" as a theoretical inquiry into human creativity and the role of constraints. I present two historically significant case studies of creative choreographers—Balthasar Beaujoyeulx and Merce Cunningham from the Italian Renaissance and the modern 20th century eras, respectively—who used constraints on movement invention and compositional structure to advance the art of dance. I consider lessons learned from these cases, and consider them in light of the choreographic challenge of the Three-Body Problem. I conclude with thoughts about the role of constraints on dance creativity in art-making and education.

A few years ago, I was approached by an astrophysicist working on a demonstration of something called the Pythagorean "Three-Body Problem." First posed in 1893 by the mathematician Ernst Meissel, this classic astronomical "problem of three bodies" is very easy to state and very hard to solve. What happens when three masses, with masses 3, 4, and 5, are placed at rest at the vertices of a 3, 4, 5 right triangle and allowed to fall in toward one another due to their own gravitational attraction? This simple physical situation would occur if you take, for instance, three planets and put them into space with the correct masses and distances.

Upon stating the problem, Meissel claimed that these initial conditions will lead to periodic motion in which the three particles oscillate in a regular, fully repetitive pattern. He gave no evidence, however, in support of this conjecture, and thus, not surprisingly, the sheer audacity of his claim generated considerable interest in determining the solution (Burrau, 1913). The problem was finally solved by Victor Szebehely in 1967. It turns out that these bodies do not simply collide

and collapse. Instead, they execute a series of complex interactions and spatial patterns (Figure 1).

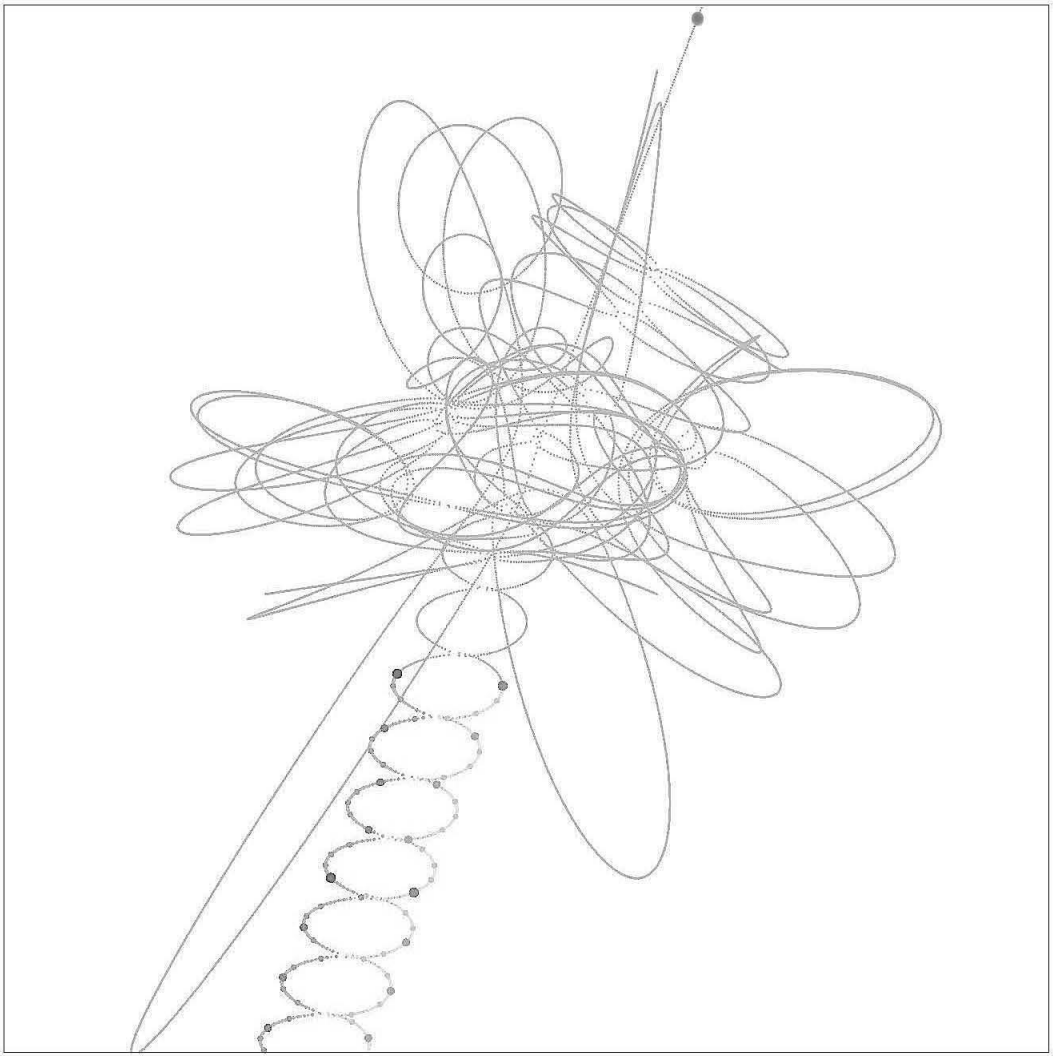

Figure 1. *Szebehely's solution to the Pythagorean Three-Body Problem*

Just as the three bodies are repeatedly flung apart by the same gravitational forces that draw them together, the solution ends up with bodies 4 and 5 leaving in a circling binary orbit (at bottom) and body 3 being ejected alone into empty space (at top). My astrophysicist colleague noted that Szebehely's (1967) calculations are fully correct. They provide an authoritative disproof of Meissel's conjecture, but there is something keenly inelegant in the brute-force method by which the problem was solved. The bigger problem, my colleague continued, is that the solution to this

problem is as difficult to comprehend in theory as it was to solve in practice: it's too abstract. He believed that a physical embodiment of the elliptic-hyperbolic solution to this classic physics problem would capture better the emotion that he found implicit in the differential equations, rendering it more comprehensible to a general public. It would make a great dance, he told me.

I found the invitation to choreograph the Pythagorean "Three-Body Problem" to be a creative challenge and of great research interest. Not unlike many practicing artists whose art is integrally bound up with research, I engage with creative opportunities from a practice-based research perspective. The purpose of practice-based research is to bring into the open some of the qualities which distinguish and illuminate the general and specific processes at work in dance. This approach is not bound by traditional methodologies, but seeks to "facilitate the relation of reflection to practice" (Margolin, 1998, p. 168).

I recognized immediately that the given conditions of the three-body problem would place precise constraints on spatial arrangement and acceleration, timings and trajectories of the dancing bodies. The diagrams based on the mathematical solution literally proscribed *exactly* when and where movers must travel. As we collaborated on *Three Bodies*, I began to reflect on the nature of choreographic cognition in the context of constraints on creativity. What are the possibilities inherent in dance when creativity is *constrained* by a particular problem space? This question led me to an inquiry into the history and psychology of dance.

The purpose of this essay is to unpack the ideas and historical examples that informed our creative process and final product. In what follows, I describe how our artistic practice "makes research" as a theoretical inquiry into human creativity and the role of constraints, the search for historically relevant case studies, and a reflection on the development of a creative practice that embraces constraints. I describe the historically significant examples of two dance makers who adopted unusual perspectives based in part on mathematical principles. I show how the choreographies of Balthasar Beaujoyeulx (1535-1587) and Merce Cunningham (1919-2009) can be understood as devising creativity from constraints in the Italian Renaissance and the modern 20th century eras, respectively.

An important goal of this essay is to build on Patricia Stokes (2005) research on "creativity from constraints" in the domains of advertising, architecture, fashion, literature, music, and visual art. To underscore the problem solving nature of creativity, she posits the "creativity problem" as both structural (domain-based) and strategic (cognitive-based). In contrast to unfettered "possibility thinking," she shows how truly creative work across multiple domains involves selecting (the strategy part) paired constraints (the structure part) that preclude reliable responses and promote surprising ones. I explore these ideas in dance history and apply them to the choreographic challenge of the Three-Body Problem.

By placing precise constraints on interactions, pathways, and timings, *Three Bodies* ignited a generative debate amongst collaborators and, unexpectedly, a novel solution. I believe that the lessons learned from the past and present about the role of constraints on dance creativity in art and education facilitated our progress. I also learned firsthand that, while unfettered PT may be good for the novice, it can be detrimental to experienced makers seeking originality. I conclude with a summary discussion about the ways constraints can help experts structure and solve new creativity problems.

Practice Makes Research

The practice-based approach to contemporary arts research involves practitioners engaging with their own creative work. For many practicing artists, research is integrally bound up with their art. Both the art practice and the artwork itself can be considered as research, or at least as an integral aspect of the research, because they are indispensable parts of the investigation. The application of the research skills of reflection or theorizing is "not something that is done either before or after work has been made, but is crucial to the process of making" (Blauvelt, 1998, pp. 74-75). Art practice thus is generally based upon an active process of inquiry.

One can distinguish between the kind of routine research undertaken in the course of everyday artistic practice and an academic research perspective being brought to bear on creating art. The practice-based creative arts researcher is "obliged also to map for his or her peers the route by which they arrived at" their products (Frayling, 1997, p. 13). This approach augments and complements the more established or conventional research approaches *into* or about the arts, which focus upon the finished "forms" of art works, their historical and theoretical contexts, and their broader socio-cultural impacts. It is also distinguished from research *through* creative arts practice, which centers on the production of a finished work, and where the documentation of the process is taken as a significant component of the research (Warburton, 2014).

The practice-based research methodology illustrates how the creative work arises, develops, and extends knowledge of and about the particular arts discipline. The commentary has a pivotal role in distinguishing professional practice from practice-based research. It can evidence how the work extends practice in the field, in some sense invigorating it, by outlining the ways it asks new questions of the field of engagement, of the materials and forms, and developing new sources of inspiration for ongoing creative activity. If the function of developing and extending knowledge is based "essentially on investigatory, exploratory, speculative or analytical processes" (Strand, 1998, p. 34), then practice-based

research is quite consistent with the classic method of research in the physical sciences, social sciences and humanities.

Investigating how something new is produced requires us to try to examine not merely the workings of creative practice in the arts, but also to problematize dance creation: to unpack our very concept of what creative practice represents. It is hardly surprising to suggest that a dance practitioner-researcher might go to more established bodies of research, both within the creative arts, and in other disciplines in developing, situating, and contextualizing something of the originality (or lack of it) of their creative practice. This is certainly not without some methodological difficulties. It requires an "art of thought": a mental wayfinding by which artists might track their movements into the unknown. Simply put, it requires finding a new way (or rediscovering an older way) of considering the relation between knowing and doing. In so doing, I hope to represent something of the thought at the root of our art form called dance.

Problematizing dance creation

My creative and research interests intersect at the nexus of the cognitive and relational practices that support (or undermine) the doing, making, and watching dance. I take a cognitive view of dance experience, viewing artistic activity as involving mental processes fully as powerful and subtle as those used in any other area of inquiry. In this sense, I study philosophical, psychological, and conceptual issues in creativity and cognition in dance.

Although the concept of creativity has a long history, systematic study of it began only at the turn of the last century. The early years of the twentieth century saw a move toward empirical investigation of creativity within the new discipline of psychology (Gardner, 1985). There were four major traditions in which this took place: the psychoanalytic tradition, including Freud's theories of personality; the cognitive tradition, including Guilford's exploration of divergent production of ideas and products; the behaviourist tradition, including Skinner's discussion of chance mutation in behavior; and the humanistic tradition, including Rogers whose discussions focused on the self-realising person. A particularly rich and influential period of research in creativity occurred during the 1950s, which led to three major lines of development: work on personality, cognition, and how to stimulate (or educate for) creativity (Ryhammer & Brolin, 1999).

Traditionally, the phenomenon of creativity has proved an elusive one to pin down. Most of the dominant writers on creativity acknowledge a broad spectrum of activity which can be described as creative. Stokes (2005) cites a widely accepted understanding of creativity as happening when someone does something *new* that is also useful or generative or influential (Csikszentmihalyi, 1996). *Useful* means that the new thing solves a problem. (A pedestrian walk

becomes the solution for a compositional problem in a choreography class.) *Generative* means that the new thing leads to other ideas or things. (A solution facilitates solving the next problem.) *Influential* means that the new thing changes the way people look at, think about, or do, things like it. (Postmodern dance makers and theorists hailed the use of "everyday movement" as a valid performance art and advocated novel methods of dance composition based on it.)

One major distinction made by researchers is that between high or "big-C" creativity and ordinary, everyday, "little-c" creativity (Kaufman & Sternberg, 2010). Little-c creativity includes everyday problem-solving and the ability to adapt to change: it is useful or generative or influential. Big-C creativity, on the other hand, is far more rare. It occurs when a person solves a problem or creates an object that has a major impact on how other people think, feel and live their lives: it is useful and generative and influential.

There is very little recent research investigating the nature of creativity in dance, although some commentators suggest that creativity can be developed (Press and Warburton, 2007). While there is a dearth of conclusive research evidence suggesting how creativity can be stimulated, it is clear that practical strategies depend on the theory of creativity which underpins pedagogical approaches. One of the most common examples in dance education emphasizes a single-strategy approach that opens up the range of choices and options all around us.

"Possibility Thinking" (PT) represents a process that may be common across creativity in differing domains of inquiry and across life (Craft, 2002; Craft et al., 2013). PT is encapsulated as the posing of the question "what if" in different ways and contexts, together with perspective taking, or "as if" thinking. PT is particularly applicable in contexts that seek to stimulate creative thinking amongst children, youth, and novices of all ages. The inherent value of thinking through possibilities will not come as a surprise to dancers, dance makers, educators and researchers (e.g., Chappell et al., 2009, 2012). For many of us, PT is the ground upon which we have played for years. Much of my advanced dance training and education relied on PT and the shift from "what is this and what does it do" to "what can I or we do with this"?

Constraints on creativity

As one acquires choreographic experience, however, originality can be increasingly hard to achieve: too often, walking into an empty dance studio on any given day, everything seems possible and nothing seems possible. Many expert dance makers struggle with how to simultaneously stay open and not fall back on hard won, predictably fine methods for making. It is important to note that, in creativity studies, it is commonplace to refer to the problem solving nature of creativity as the "creativity problem" (Gardner, 1985; Kaufman and Sternberg, 2010). In this vein,

researchers interested in more cognitive approaches have investigated the use of constraints to promote creativity: they argue that the more constrained the solution paths, the more variable, the more creative, the problem solver (Stokes, 2005). (They exclude, as Stokes points out, constraints that promote conformity, e.g., copy or perform correctly.)

To understand how and why creativity from constraints might work in dance making, we have to understand dance as a domain of knowledge. Learning and skill acquisition take place within domains, those specialized areas of knowledge with agreed-upon performance criteria. The criteria are based on goal, subject, and task constraints that can be practiced, mastered, and then advanced through the act of creation (Abuhamdeh & Csikszentmihalyi , 2012). Goal constraints specify styles, like ballet or Butoh dance. Subject constraints involve content, e.g., the use of movement in time and space. Task constraints are concerned with materials and their use; for example, how a bodily action is modified by an effort quality. In this way, the solution to a creativity problem in dance requires thinking through its domain of knowledge.

When formally trained, novices master constraints in an order determined by others (teachers, coaches, critics). For example, a ballet teacher articulates the goal (style), specifies the subject of basic arm positions (syllabus), and sets the task of how to properly execute *port de bras* (technique). Experts understand the ideas, concepts, and features of their domains and can use them to good effect to solve problems, such as how to perform swan wings with classically trained ballet arms. Truly useful-generative-influential originality, however, requires something more than substituting knowledge for ignorance, skill for ineptness. The creativity problem is both structural (domain) and strategic (cognitive). It involves selecting (the strategy part) paired constraints (the structure part) that preclude reliable responses and promote surprising ones (Stokes, 2005).

Constraints for creativity in dance involve substitutions: new for old, exploratory for tried-and-true. While substituting "new" for "old" may be necessary, it is not sufficient to creating original work. In what follows, I build on Stokes' research on creativity from constraints to consider the domain of dance in three case studies. I present two historically significant cases of creative choreographers who used constraints on movement invention and structure in direct opposition to previous approaches. I then pick up the story of *Three Bodies,* describing how this arts and astrophysics collaboration unfolded based on the precise constraints of the classic Pythagorean Three-Body Problem. I conclude with a discussion about the role of constraints on dance creativity in art and education.

Case Studies

In the relatively brief history of Western theatrical dance, many creative individuals have employed constraints to break from traditional methods and ideas, and become useful, generative, and influential in the art of dance. In what follows, I focus on two seminal characters: Balthasar Beaujoyeulx (1535-1587), who signals the dawning of theatrical dance in 16th century Europe, and Merce Cunningham (1919-2009), who serves as a catalyst for the evolution of American concert dance in the modern era and beyond. These historical figures shared an interest in metaphysics, math and dance that resonated with the Three Bodies project. The identification of the "constraint path" of these two dance makers allows us to re-create the structure of their original solutions; it can also provide inspiration for a dance practitioner-researcher. The third and final case study returns to the classical astrophysics Problem of Three Bodies as I applied in practice what I learned from dance history.

Celestial Dances

The Italian Renaissance was a pivotal period for the assertion of dance as art: a time in which the philosophical and aesthetic foundations were established for the development of a complex and sophisticated performing art in Western civilization. Enter Balthasar Beaujoyeulx. Beaujoyeulx was particularly influenced by the idea of a Numerical Principle underlying the whole of creation and the metaphor of the celestial dance (Carter, 1992). These beliefs originated in the ideas of Pythagoras, a 6th century BCE philosopher, who believed that the key to understanding the universe lies in mathematics (Carter, 1987). Plato was one of the most influential heirs of the Pythagorean system. In his dialogue on the creation of the world, *Timaeus*, Plato relates how God created the universe by reducing chaos to harmonious proportion and orderly motion. He refers to this god as the Great Geometer, describing the planets and stars as gods dancing, living beings motivated by reason (Broadie, 2011).

Through the Platonic academy, Pythagorean thought gets developed and then translated to Hellenistic philosophy, from where it made inroads into Roman culture and Christian thought to the Renaissance period. The philosopher Lucian of Samosata (125-180 CE) promotes the idea of dancing as inextricably linked to the cosmos and a creative, ordering principle (Zarifi, 2007). Neoplatonic thought in the 5th and 6th centuries makes central to its ethics the triadic rhythm emanating from God of giving, receiving and returning (Rorem, 1993). For early Christian Church Fathers, the move from dancing gods to dancing angels was a relatively straightforward transition; they describe the holy mystery of the angelic hierarchies in terms of a "never-ending" dance of exultation and rapture that unites man most fully with God in the eternal heavens (Berghaus, 1992). This dancing Chain of

Being is created by innumerable circling and spiraling dancers, hand-in-hand, linked by reciprocal love, both giving and receiving. The superior beings reach down to raise up and perfect their inferiors, the inferior beings strive to perfect themselves by imitating the dance of the circle above them. This simple carole dance corresponds to an organic and graded universe of celestial intelligences where each created order, down to the very lowest, aspires to imitate the dance of the order above.

Just as dancing developed in the Middle Ages from the relatively simple carole to more complex couple dances, Italian Renaissance dance masters devised ever more elaborate court dances. These large scale spectacles were designed to embody the mystical significance of the Platonic-Pythagorean philosophy of numbers. When Beaujoyeulx moved to Paris in 1555 and became a servant at the court of Catherine de Medici, he encountered a burgeoning dance form on the cusp of cohering into a theatrical domain of knowledge in which choreography was sometimes compared to a written text. Earlier pantomimic dancing was an art not only of changing and forming but also of holding poses—the dancer moved, and froze, moved and froze—and the spectators "fixed their attention not so much on the dynamism of the dance as on it static poses, which they would read one by one like words in a sentence or glyphs in an inscription" (Miller, 1981, p. 228).

In contrast, Renaissance dance masters choreographed "geometrical dance," which acquired its name from geometrical and symbolic patterns that were designed to be seen from above as if they were horizontal or flat on a page. Nicknamed the "Great Geometer," Beaujoyeulx' choreography of *Le Balet comique de la Royne* (1581) is often cited as the most significant early example of this form. As Franko notes, "its structure involves a dichotomy between geometrical dance and dramatic narrative as well an attempt to transcend that dichotomy" (2015, p. 9). In this way, the Great Geometer's "celestial dances" on earth were viewed as a visual expression of the movements of the spheres and the triadic rhythm of giving, receiving and returning that reflected not only the order and movement of the whole universe but of the ideal society (Carter, 1992, p. 26).

From a constraints-on-creativity perspective, Beaujoyeulx solved a number of problems in early theatrical dance, foremost among them the structural constraints of meanings and movements in time and space. When Beaujoyeulx began to choreograph, the accepted styles shared two related criteria that geometrical dance shattered. Early Renaissance dance masters worked from a first person stance with a predominant perspective, like a landscape painter. Dance makers would differ somewhat in steps and compositional form, as landscape painters vary in pallette and brush stroke. But most dances were made to be seen at ground level, from a relational point of view, most often straight ahead as in a ballroom. (Or, in the case of a prince, a step or two above ground at "throne" level.) Non dancing viewers would be looking into spaces of varying depth wherein

timing, the second criteria, would order the movements of circling, winding, and spiraling, and thereby define the volume and changeable nature of motion in three-dimensional space.

What Beaujoyeulx and others like him attempted to choreograph was what they knew from multiple viewpoints. They strove to create pattern from the trajectories and rhythms of spatial relationships rather than timings of movements and gestures. Geometrical dance made extensive use of "figures," which could refer to both static (tableau vivant) as well as mobile aspects of pattern making (pathways). With the location of the viewer elevated above the action, the performing area would appear as a flat backdrop replacing three-dimensional space of court dancing. First person becomes third person omniscient. Exaggerating values of dancers' motion toward and away from one another would create a rhythm that moved the viewer's eye around the surface of the backdrop. An overall pattern or "text" would emerged from the bodies marking points in space. Taken together, the focus on choreographic figures and rhythmic motions presented dancing bodies more as physical metaphors than individual personalities. These dances could thus be "read" by an educated public as written characters or symbolic designs on a two dimensional surface (Franko, 2015).

In contrast to earlier geometrical figures in dance, late Renaissance choreography distinguished itself by selecting the paired constraints of spatial perspective and rhythmic measure to help audiences decipher the underlying choreographic narrative. Beaujoyeulx "pushed the conceit of a bodily writing to its ultimate visual consequences" (Frank, 2015, p. 15). In the end, the syntactic possibilities of choreography were enriched immeasurably. Beaujoyeulx' new something, Celestial Dances, emphasized the coordination of patterning and phrasing as constraints on the new style of geometrical dance. He thereby discovered the discursive possibilities of *dance as text*. He can be read as creative according to all three of our definition's criteria. It was useful in solving the problem of devising a legible choreographic score for the burgeoning art of dance. It was generative in leading to variations on that solution. It was influential in changing how people (patrons, spectators) looked at and thought about the static and mobile aspects of pattern making in dance, and how other people (choreographers) later made dances. Beaujoyeulx' approach expanded the domain for all subsequent dancemakers.

No Fixed Points

Fast forward several hundred years to the Modern Era. This time period, often referred to thematically as "modernism," began in the 19th century and continued on as the dominant cultural force in the artistic and intellectual circles of Western culture well into mid-20th century. Like all epochs, modernism encompasses many competing individual directions and is impossible to define as a discrete unity, totality, or style. The chief characteristics emphasized radical aesthetics, technical

experimentation, spatial or rhythmic rather than chronological form, and self-conscious reflexiveness, as well as the search for authenticity in human relations, abstraction in art, and utopian striving (Childs, 2008).

Traditionally, artists have worked within a style, but artists have not always thought of themselves that way. We either equate our style with art itself or else offer universal reasons for stylistic choices (Childs, 2008). For example, classical styles were often defended on the grounds that the ancient Greeks had discovered universal principles of beauty and representation, based largely on mathematical proportions. The Italian Renaissance "rediscovered" those ideas and created new visual and performative forms. Then, at the dawning of modernism, it became obvious to sensitive observers that all art depicts the world through a style, that styles differ from time to time and place to place, and there is no independent aesthetic standard that makes one better than all the others.

Beginning with the modern era, everyone is a stylist (Childs, 2008). There are no longer objective aesthetic questions. To make a dance becomes an entirely different matter. Every artist develops a manner of her or his own and creates works that appear, first, as art objects; second, as products of a particular artist, and last (if at all) as representations of something. Thus "modernism" recognizes that all past ways of representing the world have been arbitrary and culturally relative styles. In early modern dance this breakthrough was achieved by abandoning the external references that characterized Renaissance, Baroque, and Classical ballet traditions. This is not to say that 20th century artists avoided representation of the human condition. Martha Graham's *Lamentation* (1930) is a prime example of the ways choreographers created a dancing body that sought to express the universality of feeling that transcended individual experience. It is a work not about an individual's grief at the loss of a particular person or thing, but about grief as an experience that everybody could (supposedly) recognize. In rhetorical terms, the expressionism of early modern dance continued to present the body in a metaphorical way (Phelan, 1993).

Enter Merce Cunningham, who began where modern dance at mid-century left off. Born in Centralia, Washington, Cunningham received his formal dance and theatre training at the Cornish College of the Arts. He met there his future life-partner and influential collaborator, the music composer John Cage. From 1939 to 1945 Cunningham performed as soloist in Martha Graham's dance company. He presented a first New York solo concert with Cage in 1944. Reportedly inspired by Albert Einstein's words "there are no fixed points in space," Cunningham developed a method of creating dance known as "Chance Operations," which he refined in close collaboration with Cage.

Following Marcel Duchamp (and Dadaism more broadly), Cunningham used chance as a key strategy through which he attempted to reunite art and everyday life by minimizing his own involvement in the process of art creation

(Copeland, 2004). He would often create a number of dance phrases and then use methods such as thrown dice, tossed coins or sticks, or the *I Ching* to set the order, number of repetitions, direction and spatial relation. Often Cunningham would invite Cage to create a score and a visual artist to create a scenic environment while he created the movement. Each would work separately and unite the elements for the first time on stage before an audience to create an indeterminant composition of dance and musical form.

Cunningham's investment in accidental creation in the 1950s and 1960s commenced a period of more formal, abstract dance aesthetics and performative presences. The documentary film *498, 3rd Ave* made in Cunningham's studio in 1967 shows him at work on *Scramble*. The film suggests that Cunningham carried out the chance procedures to determine the content of movement beforehand, and then he put the dancers into rehearsal situations where they had to make decisions about how to perform the material. Cunningham's unwillingness to offer explanation about tempo, in particular, is deliberate. Apparently, at their individual rehearsals, he had given each of them different tempi. As the dancers struggle, Cunningham whispers to the filmmakers that he was waiting to see what the dancers would make of it on their own. He accepts the accidental qualities that his dancers unintentionally, through lack of direction, bring to the development of his choreography. He accepted these contributions with a similar indifference to the tossing of dice.

Cunningham's rehearsal pedagogy also had other unintended consequences. One of his dancers, Steve Paxton has suggested that the blank face, which Cunningham's dancers adopted when he was a member of the company, was a response to the lack of concrete direction and expressive intention in the work. Cunningham's chance dances left some people emotionally in a void: "Once you remove the human elements, once you remove the human messages to other humans from a dance work you don't know how to invest it with emotion and there is a great quandary how to perform it" (Paxton, 1996). Ramsay Burt surmises that what Paxton and his fellow dancers discovered through performing the work was "in effect, an absent performative presence, which was the accidental by-product of Cunningham's secretiveness and reluctance to explain his intentions to his dancers" (2006, p. 44).

From a constraints-on-creativity perspective, Cunningham solved several problems in modern theatrical dance. Like Beaujoyeulx, when Cunningham began to choreograph, the accepted styles shared related criteria that chance dance shattered: what Trisha Brown later called "all those soupy questions that arise in the process of selecting abstract movement according to the modern dance tradition—what, when, where, how…" (Livet, 1978, p. 51). Cunningham worked with chance to reveal previously inconceivable kinds of materials and practices. The little direction his dancers got from Cunningham shows clearly that his method

was not a souped-up "what if" approach, but the use of accident-as-constraint-on creating dance.

The random choices that Cunningham accepted in an indifferent way not only affected those aesthetic aspects of the creative process over which the choreographer as author would conventionally have controlled, but also the creative outcome. Where mid-century modern dance choreographers valued concrete exposition and the presence of performative presence, Cunningham asks the performer to realize, and the spectator to perceive, the clarity and directness of movement unembellished. Performers began to pay more attention: the significance of the act of performing took on new meaning when considering the work's value. Audiences had to abandon conventional expectations and develop new structures of perception.

Early modern choreographers made use of abstraction and embraced the formal concerns of "pure dance," but choreography in the latter part of the twentieth century distinguished itself by selecting the paired constraints of movement choice and choreographic structure to reunite performing art with the unpredictability of everyday reality. Cunningham's new something, Chance Operations, employed randomness as a constraint on the selection of movement content ("subject constraint"). He constructed a new, indeterminate approach to dance composition and performance.

Cunningham's approach was creative according to all three of our definition's criteria. It was useful in solving the problem of devising new choreographic procedures, structures, and performative presences. It was generative in leading to variations on that solution. It was influential in changing how people later made dances, and how other people looked at and thought about the puzzle of presence and absence that Cunningham presented to his dancers. Cunningham's work expanded the domain for all subsequent dance works. The new genre of "chance dance" gave rise to "postmodern dance" as several of Cunningham's company dancers—Judith Dunn, Deborah Hay, and Steve Paxton among them— deliberately chose to explore similar modes of reuniting art and everyday life in their own work in the 1960s and beyond.

Three Bodies

For students of dance creativity, the reconstruction of a choreographer's constraint path "re-creates" and illuminates the structure of its solution. It can also provide inspiration. *Three Bodies* began as a dance studio-based exploration with three dancers, choreographer, and astrophysicist. Our goal was to work with the given conditions of the problem—precise constraints on spatial arrangement and acceleration, timings and trajectories— to create dances that explore feelings of longing, connection and isolation as moving bodies are flung apart by the same gravitational forces that draw them together.

Constraints on Dance Creativity

We began the initial movement research phase using William Forsythe's *Improvisation Technologies*, a contemporary dance technique that elaborates the genre of improvisation to create a unique dance style (Forsythe and Sulcas, 2003). *Improvisation Technologies* focuses on designing lines in space around one's personal kinesphere, shaping movements that could then travel along the pathways. The fundamental insight of *Improvisation Technologies* is that movement can start at any point in the body and travel through space to another point in the body. Visually, this point-to-point movement can be perceived as a line drawn in space. Thus, it has been called the "point-point-line" method and describes movement in geometric terms; that is, movement through space from a point to another point, from point-to-line, line-to-plane, and on and on. We used our devised inscriptions of geometry, interactions and dynamic qualities to create movement motifs that could be organized by the nonlinear differential equations into a longer choreographic expression.

Even as we experimented with improvisational tasks and movement qualities to design what (actions) and how (efforts) we could dance in and through the problem of three bodies, questions arose about the literal nexus of artistic intention and mathematical certainty. Exactly where (and when) would dancers be traveling. More particularly, when (and how) should they experience the onset (or offset) of increased gravitational attraction? To drill down to this layer of precision, graphical representations were produced using an algorithm known as "Bulirsch-Stoer integration," which numerically solves the equations of motion to extremely high accuracy. Ultimately, our timing interpretation envisioned a 137.5 measure framework in 4:4 musical time with four beats per measure at 120 beats per minute in order to define the grid for a performance lasting 4 minutes 35 seconds.

We found immensely helpful the production of precise and detailed graphical representations and animations that could be projected onto the dance studio floor and followed in a precise manner. Participants recognized that the biggest performance payoff would come from the acquisition of an improved body memory of the sequence that diminished reliance on the floor animation. A great deal of time was thus spent on understanding the overall pattern, choreographing from our initial improvisations, building longer movement phrases, and repeating them again and again. Perhaps predictably, what we considered a triumph over constraints failed to inspire creative expression.

Once our team understood clearly the patterns of physical interactions and sequences, confusions about artistic intent arose. Midway through our research process, performers began asking questions about intention with increasing frequency. Questions like, "why am I gliding around this body in this way?" posed hard questions about creative interpretation. Dancers wanted direction: a feeling or narrative that could motivate interaction, or suggest an initiation point, for the movement. Somewhat at a loss for explanation, choreographer turned to

astrophysicist, who returned us to the source of the solution. He located concrete answers in the differential equations themselves. In a series of particularly insightful written notes and studio sessions, performers observed as astrophysicist described and demonstrated a series of narrative interpretations that we came to think of as a creative nonfiction retelling.

It is fair to say that our performed solution was more little "c" than big "C" creative. Judging by the artistic and scientific community's reaction, our choreographic solution worked as a straightforward analogy of the underlying physics (Scudellari, 2016). For me, the more affirmative success was found during the process of confronting the creativity problem itself. The influence of an outside domain (physics) provided novel subject constraints on our improvisational choices, effectively governing the possibilities of time and space in our devised movement. It gave rise to the creation of an unusual three body dance. Working in this way, I found that our solution embellished the potential uses of Forsythe's unique *Improvisation Technologies* style and opened up a novel method (and outcome) for dance making.

Discussion

The foregoing case studies reveal the sometimes important role that creativity from constraints plays in dance. In this context, constraints are most succinctly and completely defined as tools that come in pairs which are hierarchically organized and specific to domains (Stokes, 2005). The domain provides both the things that one can work with—the body, movement, space, time—and the things one can work against. The most important constraints, located at the top of the hierarchy, are goal constraints, which specify artistic style. Subject and task constraints follow from them. Subject constraints speak to contents of domains: in dance, they involve the use of movement in time and space. Task constraints are concerned with materials: the materiality of the body and its use in dance (breath, weight, energy).

For the individual striving for creativity, only one thing can be done: work against currently successful solutions. Creative choreographers make work that extend or counter accepted goal criteria and stylistic standards for what a dance should be. Both Beaujoyeulx and Cunningham worked to expand the choreographic imagination, in geometrical and modern dance, respectively. They both wanted to disrupt those received styles. In particular, they used subject constraints—the received contents and arrangements of movement, space, and time—to generate new knowledge and perspectives on dance that advanced the field.

As suggested by Stoke's (2005) research, we can understand better the nature of choreographic cognition as involving goal-directed specifying of paired constraints. One precludes (or limits search among) familiar, reliable responses; the

other promotes (or directs search to) novel, surprising ones. Beaujoyeulx can be understood as precluding familiar ways of perceiving the geometrical style of dance by substituting a direct, eye-level perspective for an elevated, bird's-eye view and promoting an intensive rhythmic phrasing. Together, these paired constraints engendered a non-intuitive framing of a new dance style as a rhetorical modality that could be deciphered by learned patrons. Cunningham can be understood as precluding reliable responses in himself (and his dancers) by substituting chance for choice in movement selection, and promoting novel choreographic structures. The paired constraints of serendipity and indeterminacy on movement content and form oftentimes led to happy accidents, which surprised everyone including the critics.

In this way, the specification process structures the problem space, producing a solution path that simultaneously defines and satisfies a novel goal criterion. The specification of constraints turns an initially ill-defined problem—how do I make a new dance—into a well- defined one, such as embodying a belief in the Great Chain of Being or the influence of Einstein's theory of general relativity. Since well-defined problems can be solved with little search and little variability, great creators who have high habitual variability levels (i.e., the habit of being variable) proceed to preclude their newly realized goal criteria and promote further novelties. For example, upon Beaujoyeulx' arrival to the French court of Catherine de Medici (and King Henry II), he was encouraged to embellish "ballet de cour" in new and more expansive ways. His disposition to stage innovative entertainments led to the evolution of ever more grand geometrical devices, as exemplified by the first major court ballet *Le Balet comique de la Royne.*

The specification process can also be opened to outside domains. It is impossible to imagine Cunningham's innovations without acknowledging his debt to Cage's musical genius or the ideas of visual artist Marcel Duchamp. Likewise, the influence of movement theorist Rudolf Laban (1879-1958) on 20th century dance cannot be overstated. Laban initially studied architecture at the Écoles des Beaux Arts in Paris. As a result, he became interested in the relationship between the moving human form and the space which surrounds it, which led to the development of a structured description of movement in space and time (Maletic, 1987). His theories of choreography and movement became foundations of modern dance.

In these days of rapid technological innovation, creativity abounds. It may seem counter-intuitive to advocate for constraining anything or anyone. Constraints on creativity have often been equated with curbing motivation or restricting pathways to success. My research and experience with *Three Bodies* suggests otherwise. Constraints can help experts structure and solve new creativity problems. However, learning to choose and use con-straints does not guarantee creativity. What it does is clarify and direct the creative process.

Researchers of creativity admit that common sense tells us that the challenge of originality requires thinking outside the box. But folk wisdom does not necessarily led to creative solutions. The preceding case studies show that, sometimes, advancement beyond skilled outcomes to truly useful-generative-influential work in a domain of knowledge, like dance, requires something more. It demands imagining beyond possibilities to the seeming impossibilities posed by constraints on creativity. I contend that the fields of dance, dance education and dance studies need to reconsider the role dance creativity from constraints. That process would mean a more explicit, in-depth thinking through the ways we instruct creative minds and movers in dance styles (goals), contents (subjects), and materials (tasks). This perspective suggests that, perhaps, what dance educators need to provide for our creative next generation is less possibility thinking *outside* the box of our discipline and more rigorous thinking *inside* it.

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