

Perception of Movement Qualities Associated with Expertise in Dance

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Abstract

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It is believed that participation in the arts is a vital component of development, and that dance education can support the understanding of human movement as an important source of meaning. However, psychometric measurement in the arts, which would help substantiate this claim, is not widely practiced. This research, contributes to the quantitative research foundation in dance education by investigating perceptual-cognitive differences associated with expertise in dance. In this dissertation, novice and expert contemporary dancers watched pairs of video-recorded short contemporary dance phrases, which were either the same choreography or contained a single manipulation to an element of the choreographic phrase associated with Shape, Time, or Space. After watching each pair, participants were asked to select from one of four options they felt best reflected the quality that had been changed between the videos: Shape, Time, Space, and No Difference. Participants' responses were summed within categories and group means were compared. No differences were found between novices and experts in the

discrimination of manipulations to Shape, however, significant differences were found between novices and experts in the discrimination of manipulations to Space and Time.

Although reliability analyses indicate that further instrument development is required before strong conclusions can be drawn, the data initially support the idea that contemporary dancers are able to discern spatial and temporal elements of contemporary dance better than novices. This is consistent with research from neuroscience that suggests experience modulates neural processing in areas of the brain responsible for the comparison of production and perception through simulation. Further, this data suggests that processes of simulation provide unique access to spatial and temporal information. It is the hope of this researcher that once the perceptual-cognitive skills associated with experience in dance are better defined, they can be used to support the framing of dance education, not just as peripheral, but integral to the cognitive and social-emotional development of all students.

TABLE OF CONTENTS

Chapter 1: Introduction	1
Chapter 2: Relationships between Perception and Production	5
Theoretical Accounts	5
Neural Substrate for Perception-Production Integration.....	10
Production and Perception across the Life-Span	12
Conclusion	16
Chapter 3: Perceptual-Cognitive Mechanisms of Expertise	18
General Expert-Novice Distinctions	20
Expertise in Chess.....	23
Expertise in Sport	25
Expertise in the Performing Arts	28
Conclusion	31
Chapter 4: Dance in Experimental psychology	32
Dance Expertise in Sports Psychology	35
Dance Expertise in Neuroscience	36
Dance Expertise in Motor Cognition	42
Conclusion	46
Chapter 5: Terminology	48
Modern and Contemporary	48

Movement Analysis: A Framework.....	50
Chapter 6: Rationale for Current Research.....	55
Pilot Study #1.....	56
Pilot Study #2.....	57
Research Question and Hypothesis.....	58
Chapter 7: Methods.....	60
Methods.....	60
Chapter 8: Results.....	68
Results from Comparison of Means.....	68
Results from Error Analysis.....	70
Results from Qualitative Analysis.....	71
Chapter 9: Discussion.....	73
Implications for Instrument Development.....	74
Implications from Group Comparison.....	76
Limitations.....	81
Future Directions.....	83
Conclusion.....	89
References.....	91
Appendix.....	104

LIST OF FIGURES

Figure 1. Instructions, sample response option, and short answer question.....	64
Figure 2. Results from comparison of means.....	69
Figure 3. Error analysis.....	70
Figure 4. Manipulation to Shape.....	104
Figure 5. Manipulation to Time.....	104
Figure 6. Manipulation to Space.....	105
Figure 7. No Difference.....	105

LIST OF TABLES

Table 1. Grid for determining which movement was manipulated with which quality.....	61
Table 2. Reliability analysis.....	66
Table 3. Mean confidence ratings by group and category.....	66
Table 4. Comparison of performance by block.....	67
Table 5. Mean correct answers by group and category.....	68
Table 6. Correlation matrix.....	68
Table 7. Frequency of strategies reported in short-answer question by group.....	72

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CHAPTER 1: INTRODUCTION

It is often a complicated question to answer when asked why dance should be taught in schools. Some teach dance as way to explore multi-cultural aesthetics (Phillips-Fein, 2011; Streets, 2011; Wakamatsu, 2011), others teach dance as a tool to support reading and math skills (Benzwie, 2011; Moffett, 2012; Moore & Linder, 2012), and others as a mode of emotional expression (Aceto, 2012; Kearns, 2010, Mainwaring & Krasnow, 2010), etc. With such varied purposes, processes, and potential outcomes, it is difficult to speak broadly to the role of an education in dance. This confusion also leads to complications in the funding and logistics of dance education. A granting organization that funds an arts unit for African American Heritage Month might have a very different philosophy on the role of arts in education, than, say, a granting organization that funds a dance unit to increase students' levels of physical activity. This plurality of purpose potentially leads to the misconception that dance is recreational rather than academic, a way to pass time during the school day, and not a vital part of a student's development.

As a way to combat this perception, the Clinton administration defined the arts as one of eight core disciplines in education and funded the drafting of the *National Standards for Art Education* (Consortium of National Arts Education Associations, 1994). The *Standards* are a way to acknowledge and bring together the varying agendas of arts education. From these documents, *Standards* for the different disciplines within the arts (Music, Theater, Visual Art, Dance, etc.) were also drafted. The authors of these documents hoped that the adoption of the *Standards* would ground educators in discipline-specific core knowledge and skills, and an intentional pathway for their development. Within the *National Standards for Dance Education* (National Dance Association, 1994), an educator can find frameworks for dance education, not

merely as a recreational activity, but as a rigorous skill based, communicative, cultural, and intellectual curriculum.

Overarching all the goals of the *National Standards for Arts Education*, is an incredibly compelling statement that concisely describes why the arts are integral to social-emotional and cognitive development: “The arts help all students to develop multiple capabilities for understanding and deciphering an image- and symbol-laden world.” Further: “In an increasingly technological environment overloaded with sensory data, the ability to perceive, interpret, understand, and evaluate such stimuli is critical.” One source of meaning, or symbol, in this world is human movement. It could be argued that human movement is not simply one symbol among others, but one in which we are constantly immersed and is responsible for our understanding of the social and physical world (Meltzoff, 2007). An education in dance, focused on the cognitive aspects of being an author, performer, and audience-member, could help students decode and encode this symbol system of human movement, in a way that other, more traditionally academic, subject matters cannot.

Ideally, this dissertation would be reporting results on how a dance curriculum contributed to an improved cognitive or social-emotional competency, or how skills learned in the dance classroom were enduring and transferrable. Unfortunately scientifically based empirical research from psychology or dance, that would provide a conceptual foundation for the cognitive and perceptual skills underlying such results, has not been systematically developed. Although the perspective in the *Standards* that an education in dance can help students “decipher an image and symbol laden world” is most likely true, this is a theoretical perspective, not an empirical one. The mechanisms that would support this skill are not fully understood. The purpose of this research, then, was to better understand the cognitive and perceptual skills

associated with experience in dance at a more basic level. By contributing to this body of empirical evidence, the author hopes to participate in the building of a more solid research base from which translational research can be conducted, that is, research that would frame dance education, not simply as recreational, but integral to the social-emotional and cognitive development of today's students.

In order to advance this goal, this research investigated the differences in how Contemporary dance experts and novices mentally represent dance movements. Research on expertise proposes that the structure of mental representations is a primary difference between experts and novices across domains (Chi, 2006). Current research on mental representation of movement associates expertise with the parsing of perceived actions into a greater number of progressively smaller segments: a quantitative distinction (Blasing, 2010; Schack, 2010). The hypothesis for the current study was that the mental representations of movements are, not only quantitatively, but qualitatively different for novices and experts. This hypothesis is based in part on neuroscientific data in which it has been shown that experience in dance strengthens the response of the Action Observation Network (AON) or Mirror Neuron System (MNS) while watching familiar dance movements (Calvo-Merino, Glaser, Grezes, Passingham & Haggard, 2005; Calvo-Merino, Grezes, Glaser, Passingham & Haggard, 2006; Cross, Hamilton, & Grafton, 2006). These systems, AON/MNS, are associated with processing spatial and procedural information (Milner & Goodale, 1995).

In this study, it was hypothesized that experts' representations of dance movements included spatial information to a greater degree than novices' representations. Novice and expert dancers were shown dance phrases that had been manipulated to contain a change to an element of Shape, Space, or Time. Shape referred to relatively discrete postural forms made by

the body. Space referred to changes in the body's orientation, level, and pathway. Time referred to duration of movement and accent (emphasis). It was hypothesized that there would be no differences between novices and experts in the discrimination of shape elements, but experts would perform better in the discrimination of spatial elements. No hypothesis was made about time.

Dance is a complex, continuous, ephemeral unfolding of shapes through space and time. Is expertise simply the ability to parse finer and finer packets of movement, essentially creating a higher resolution in mental representation? Or is the quality of the representation different for the novice and the expert? By analogy; is there a shift from black and white to color?

Fundamental to understanding of the role of dance in issues of cognition and perception, is an understanding of the interactions between sensori-motor and representational systems. Chapter 2 will review theoretical, physiological, and behavioral accounts for the integration of production and perception in cognition. The study of expertise and expert performance has become a common paradigm in identifying discipline specific perceptual-cognitive skills; this literature will be reviewed in Chapter 3. In the final part of the literature review, Chapter 4, research that connects dance and experimental psychology, more broadly, will be reviewed. Collectively, these background chapters make the case for why the current study was conducted and will serve as a framework for interpreting the results.

CHAPTER 2: RELATIONSHIPS BETWEEN PERCEPTION AND PRODUCTION

The primary purpose of this dissertation was to investigate how physical experience with Contemporary dance affects the quality of mental representations of Contemporary dance. This was tested through participants' ability to perceive manipulations to dance movements. In a broader sense, the question being investigated is: how does the ability to produce an action affect the ability to perceive an action? As production and perception are functions of the motor and sensory systems, respectively, this chapter will begin by clarifying the mechanisms through which interactions between sensory and motor systems occur. This review will begin with theoretical accounts of sensori-motor integration and will then go on to review physiological evidence for sensory-motor integration, and finally will review behavioral evidence that indicates sensory and motor systems remain an integral part of mental representation across the life-span.

Theoretical Accounts

One kind of cognitive representation is semantic and stored in Long Term Memory (LTM). Semantic representations link words (or other symbolic codes) with concepts but also with afferent information from sensory systems, first processed through perceptual filters, creating the mental semantic representations. In the process of recoding information from sensory to perceptual to semantic codes, the links to the peripheral sensory systems may be lost or in some cases the links to the original sensations in the peripheral sensory system may be retained. If so, bodily states, situated action, and simulation may connect the embodied experience of the world to its mental representation (Barsalou, 2008).

Piaget's theory of cognitive development exemplifies the first type of mental representation in which semantic representations are decoupled from perceptual systems. Though his account begins with an integration of sensory and motor systems, maturity is

achieved when actions transcend the physical plane and become operations in the mental plane (Piaget, 1950). During the first year and a half of life, in the sensori-motor stage, the filtering or modification of sensory information to existing expectations, or schemas, is called assimilation. The modification of internal schemas, which, at this stage, are restricted to motor-schemas, is called accommodation. Through a continual process of assimilation and accommodation, perception and production provide a foundation for the development of higher-order concepts such as object permanence, classification of objects, and causality. At the end of the sensori-motor stage, though, motor-schemas are internalized as mental representations. The process of intellectual development, for Piaget, then continues through childhood until the child achieves formal operations, a stage at which knowledge can be represented as a logical construction of abstract symbols, which is qualitatively different than the initial integration of sensory and motor schemas (Piaget & Inhelder, 2000). The transition from action to operation divides perception and production from mental representation.

The second type of cognitive representation, in which embodied experience is retained, is proposed by the emerging field of grounded cognition. A forerunner of this line of research was Gibson whose account of visual perception proposed that perception and action are evolutionarily coupled. Perception is a means to action, action a means to perception, and the brain has evolved to transform information between the two modalities. In his theory, he introduced the term *affordance*, referring to an object's quality that exists in the liminal space between sensory perception and motor production. According to Gibson an affordance is the opportunity for interaction implied by the qualities of an object (Gibson, 1979). For instance the raised, solid, perpendicular surface a chair affords sitting in, it also affords standing on, and depending on how heavy it is, it might afford throwing at. Water affords swimming through and

floating in, but it does not afford walking on. Because an affordance is both a perceived quality and an implied action, it cuts through the dichotomies of physical and psychical, body and mind, allowing room for both to be present in mental representation. The deconstruction of the strong divide between mind and body opened the door for further theories of grounded cognition that rely on embodied states, situated action, and simulation as critical components of mental representation.

Embodied States

Research on embodied states has shown that gestures and postural cues affect cognitive processing, for instance, it takes longer for people to respond to positively valenced words with a pushing action than it does to respond with a pulling action. Pushing is associated with retreating and pulling is associated with advancing. The differential times taken to coordinate the action with the words might indicate that the movement itself contributes to the mental representation (Chen & Bargh, 1999). In social embodiment research it has been shown that perceived social stimuli affect bodily states and that bodily states affect cognitive states. Postures, arm movements, and facial expressions, for example, play a central role in social information processing (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). In Damasio's Somatic Marker Hypothesis (1994), bodily and affective states are referenced during decision-making in complex or uncertain circumstances. The body is always present in human activity. Over time, bodily states become associated with an emotional valence. Triggering of a bodily state, then, can invoke an associated affective state. And triggering an affective state can invoke an associated bodily state. Research on embodied states indicates that, at least in online cognition, cognitive states incorporate information from movement, posture, and affect.

Situated Action

Research on the role of situated action in cognition proposes that there are no fixed mental representations. Instead cognition arises as a function of multiple systems such as perception, action, goal management, reward, affect, and learning. As these systems combine over time for the purpose of achieving a variety of goals, they become coupled, and present themselves in consciousness as a unified whole (Barsalou, Breazeal, & Smith, 2007). In robotics for instance, a robot could be programmed to move around the floor, detect cylindrical objects, and use a sweeping arm to collect them. This robot might appear to be collecting aluminum cans with intention, but it is actually the accumulation of independent systems for action and perception that drive its behavior (Brooks, 2002). Theorists from situated action propose that, despite the presence of central executive functions, a portion of human cognition is driven by independently running processes.

Simulation

Research on simulation has, by far, become the most prominent paradigm in grounded cognition. Theories from embodied states and situated actions are often criticized for not being able to adequately account for the development of abstract concepts. Theories from simulation, though, overcome this criticism by employing a common-coding mechanism in which input from perceptual, motor, and interoceptive states is integrated at a higher cognitive level. Barsalou's (1999) Perceptual Symbol Systems (PSS), for instance, proposes that schematic representations of holistic perceptual states are extracted through the use of selective attention and stored in memory. Mental representation occurs when schemas are simulated in the same neural system as perception and action from which they were drawn. As schemas organize around a frame, they implement a simulator and simulators in turn compose a basic conceptual system,

facilitating symbolic functions such as type-token binding, inference, productivity, recursion, and proposition which were previously thought to function only with amodal symbol systems.

Meltzoff and Moore's (1997) Active Intermodal Matching (AIM) is a process through which information from perception and action are not directly compared but referred up to a supramodal representation system. Almost from birth, infants are able to imitate facial gestures of adults. This imitation can be delayed, corrective, and intentional, indicating that it is not a function of simple motor resonance, but that imitation involves simulation of both self-behavior and other-behavior. Meltzoff (2007) proposes that this simulation occurs in a supramodal representational system in which, a) perceptual events are preserved and simulated, b) information about one's own bodily movement is preserved and simulated, and c) these two sources of data can be compared to see if they match. Through simulation of self-action in comparison to other-action AIM accounts for important social developmental milestones.

Not belonging to the broad categories of embodied states, situated actions, and simulation, other theories in grounded cognition also propose strong links between perceptual and motor systems. Hommel, Musseler, Ascherleben and Prinz's (2001) Theory of Event Coding (TEC) claims that perception and action-planning are functionally equivalent in that they both act as internal representations of external events. O'Regan and Noe's (2001) Sensorimotor Contingency Theory argues that sensation is not something that happens to people, it is something they actively seek. Therefore, all sensation requires action. Lastly, Mandler's (2010) theory of Perceptual Meaning Analysis (PMA) proposes that, first, spatial relationships of objects and events perceived in infancy and, later, the action plans construed from these perceptions, provide the foundation for the development of our cognitive system.

Although theories from grounded cognition range from explaining ephemeral interactions between somatic and affective systems to describing high-level conceptual structures, they are all united in proposing that mental representation is founded on, and continues to incorporate, information from perception and production in their original modalities, that is, without being transduced to amodal symbols. The functional integration of these systems provides a framework for explaining bottom-up changes, in which experience with perception and production alters mental representations, as well as top-down changes, in which mental representation alters perception and production.

Neural Substrate for Perception-Production Integration

Bolstering simulation theories is physiological evidence from cognitive neuroscience that the activity from action observation found in the inferior parietal lobule (IPL) is highly correlated with activity from action execution in the ventral premotor (PMv) and supplementary motor areas (SMA). This indicates that both observing movement and executing movement activate similar parts of the brain. This, in monkeys, is what is known as the Mirror Neuron System (MNS) and in humans is often referred to as the Action Observation Network (AON) or simulation circuit. Many researchers believe that this connection between action and observation is vital to understanding the development of important cognitive and social-emotional achievements. Accordingly, much attention has been given to better understanding the relationship between action observation and action execution.

Mirror Neuron System

Studies with macaque monkeys demonstrated that neurons in the PMv, a region typically associated with motor-planning, became active when the monkeys observed a hand grasping a cup (Rizzolatti & Gentilucci, 1988). The activity in PMv, though, did not lead to a motor

response, suggesting that its activity during action observation is most likely ascribable to mental simulation or rehearsal of the observed act. Importantly, these neurons were not active during individual movements like contraction and extension of the fingers. They were only active when the movement was goal directed, such as reaching for or manipulating an object with the hands. These neurons, known as Mirror Neurons, are believed to act as a neural substrate for the simulation and comparison of action and perception in order to understand other's intentions (Gallese & Goldman, 1998).

Action Observation Network

This system is more broadly considered as the Action Observation Network (AON) in humans for whom perception of a stimulus can lead to wide-spread neural activity across what were previously considered functionally separate regions of sensory and motor cortices. For humans, the simulation circuit is active not only during action observation. It is also active during incomplete or failed action observation and it even activates at the sight of an object on which an action can be performed (Grafton, Fadiga, & Arbib, 1997). The simulation circuit, then, is not simply a translator of actions, but can be used to infer goals. It has also been shown to be modulated by familiarity with an observed action (Calvo-Merino, Glaser, & Grezes, 2005). The AON could be considered the physiological counterpart to PSS and AIM, integrating perception and production through transformation of perception into action, mental rehearsal of action, and storage of physical knowledge (Grafton, 2008). Given that this circuit activates for a wide variety of actions, can infer intention from incomplete or failed actions, and is modulated by experience, it is hypothesized that the AON facilitates rapid learning through covert imitation.

Production and Perception across the Life-Span

If mental representations are developed in sensori-motor processes during infancy, but then transcend the physical plane to become mental operations at the end of childhood, as Piaget proposes, then it would be expected that physical experience would affect mental representation in infancy, but not through adulthood. If, however, mental representation remains connected to perception and production, then it would be expected that physical experience would affect mental representation across the life-span. The following studies will support the second claim by showing that the production of action causes the development of novel representations throughout infancy, childhood, and adulthood.

Infancy

Cognitive and motor milestones often occur during developmentally sensitive windows. When these windows co-occur it is difficult to disentangle cause and effect. For instance, between five and six months of age, infants become sensitive to goal directed behaviors, at the same time, the sophistication of their reaching and grasping behavior improves (Woodward, 1998). Essentially, development of the production and perception of goal-directed behaviors co-occurs, but it is unclear if production precedes perception or if perception precedes production. In order to more clearly determine the role of action production in the development of mental representation of other's goal-directed behavior, Sommerville, Woodward, and Needham (2005) gave a boost to infants' grasping abilities.

In this study, three-month-old infants wore mittens that had Velcro on them while playing with toys. At three months, an infant's ability to reach out and grasp toys is not fully developed, adding the Velcro allowed infants to achieve the goal of 'grabbing' a toy earlier than the motor system would normally allow. Infants also took part in a visual habituation procedure in which

they watched a mittened hand repeatedly reach to a specific location for one of two toys. After they became uninterested in this event, the hand either reached for the same toy in a new location, or a different toy in the same location. If the infants were more interested in, looked longer at, the change of toy than the change in location, it is assumed that the increased interest was due to recognition that the actor had changed goals. The ability to mentally represent other's goal directed behavior does not normally develop until the fifth or sixth month; however, it was found that the three-month-old infants who were given practice with the sticky gloves were more interested in the change in goal than the change in location. The authors claim, therefore, that the production of goal directed behaviors facilitated the ability to perceive goal directed behaviors in others.

Childhood

The production of actions continues to influence the development of novel representations during pre-school years. Boncoddio, Dixon, and Kelley (2010) showed pre-school children images of gears and asked them to predict the direction of rotation of a final gear based on the direction of rotation of an initial gear. During the testing phase, researchers coded the movement of the participants as their fingers traced through the alternating directions of the gears. This behavior was called force-tracing. The outcome measure was how quickly the participants recognized the higher-order relationship of alternation between the gears as evidenced by switching to verbal or movement cues referencing 'left-right' or 'this way-that way'. It was found that participants who used more force-tracing behaviors more quickly adopted the alternation strategy. The authors claim that the production of force-tracing behaviors grounded the representation of alternation and that motor production facilitated the development of the novel representation of alternation.

Also investigating the role of sensori-motor experience in pre-school children, a study by James (2010) used fMRI to measure brain activity while pre-literate children looked at letters. It has been well documented that specific regions of the brain respond selectively to specific visual forms such as faces and words (Kanwisher, McDermott, & Chun, 1997, Cohen & Dahan, 2004). Letters, for instance are perceived in the left fusiform gyrus (James, James, Jobard, Wong, & Gautier, 2005). It is not clear whether selective activation, called functional specialization, is due to recognition of category specific features, or, due to general perceptual processes that lead to recognition. In order to clarify this distinction, the researcher had groups of children, for whom functional specialization for letters had not developed, either practice printing letters (sensori-motor experience) or practice identifying letters by pointing to them (visual only). It was found that there was an increase in activity in the left fusiform gyrus only after sensori-motor experience. The author claims this increase in neural activity supports the idea that the process of physically producing letters may lead to the functional specialization for letter perception.

Working with older children, Goldin-Meadow, Cook, and Mitchell (2009) demonstrated that gestures can influence math learning. Nine and ten year old children were pretested on grouping math problems such as $6+3+4= _ +4$. Afterward, they learned a verbal script to accompany the solving of the problem. In one group, students were also taught a gesture, pointing with two fingers to the numbers that needed to be combined (6 & 3) and then one finger to the blank on the other side of the equation. A second group was taught the same gesture but with two fingers pointing at the wrong numbers (3&4), and a third group was not taught to gesture. After twelve practice problems, all students were given a post-test. It was found that students taught the correct gesture solved more math problems accurately than the group taught

the incorrect gesture, which in turn solved more problems accurately than the group taught no gesture at all. The authors claim that producing the action of reducing two fingers to one simulated the grouping operation present in the math problem. This indicates that children continue to extract meaningful information from their movement in the development of novel mental representations.

Adulthood

Although it is more difficult to explore the development of novel representations in adulthood, researchers have investigated the continued influence of perception and production on cognition. For instance, Knoblich and Flach (2001) demonstrated that adult participants were more accurate predicting the results of a dart throw when they were watching video of themselves throw the dart than when watching another participant throwing a dart. This, the authors claim, indicates that prediction was aided by both perception and action. In another study, Franchak, van der Zalm, and Adolph (2010) asked participants to judge whether doorways that varied by a matter of millimeters would allow passage. One group was given physical trials of passing through the doorway and another group made only perceptual judgments. It was found that participants more accurately predicted their success or failure if they had been given physical experience. Again this indicates that prediction was aided by both perception and action.

If mental representation remains connected to perception and production, then it would be expected that physical experience would affect mental representation across the life-span. The research reviewed above indicates that this is the case. Whether it is the development of representations of goal-directed behavior, physical concepts such as alternation, or

mathematical functions; meaningful information can be extracted from the production of movement and applied to mental representation.

Conclusion

In theories of embodied cognition, mental representations are founded on, and remain functionally connected to processes of perception and production. Simulation, in particular, is proposed to be an embodied mechanism for transformations between perception and action. This transformation occurs in a supramodal system where concepts are abstracted and, when recalled from memory, are experienced through simulation in their original modality. Simulation theories are supported by physiological evidence of a simulation circuit in the brain that acts as a common-coding mechanism for production and perception.

Research in developmental social psychology has shown that physical experience with producing goal directed behaviors affects the perception of goal directed behaviors in others and changes mental representations of goal structure and intentionality. The ability of sensory and motor experience to influence the development of novel mental representations has been documented through-out childhood in a variety of domains and indicates the continued influence of perception and production on cognition.

Although evidence for the relationship between production and perception exists in a variety of disciplines, dance is uniquely situated to offer insight into the broader world of production-perception relationships and social cognition. In infancy, a primary cue for the infant's social identity and interaction is the movement of the people in her environment (Meltzoff, 2007). She must make sense of the continuous, rapid, and fleeting actions occurring around her. It has been shown that infants are actually quite adept at extracting an actor's intention from movement, often this intention is object-directed or instrumental (Meltzoff,

Williamson, & Marshall, 2013). Similarly in learning dance, the student must make sense of a sequence of continuous, rapid, and fleeting movements. Although movement in dance is not object-directed, it is intentional. In dance, movement is used to express ideas and emotions. Looking at learning in dance, then, provides an alternative to developmental approaches in understanding how humans use movement to understand the social world. This research, therefore, adopts an embodied cognition perspective, hypothesizing that experience producing dance movement alters the mental representation for dance movement as evidenced by differences in ability to perceive qualitative manipulations to short segments of choreography. The precise nature of that qualitative difference will be explained in the following chapters.

CHAPTER 3: PERCEPTUAL-COGNITIVE MECHANISMS OF EXPERTISE

Expert is defined as: ‘having, involving, or displaying special skill or knowledge derived from training or experience’, and expertise is: ‘the skill of an expert’ (Merriam-Webster.com, n.d.) The study of expertise, by this definition, covers an enormous intellectual territory. From systems of guild organized craftsmen in the Middle Ages (Epstein, 1991), to the training of Olympic level athletes (Bloomfield, 2004), to virtually any educational text; there has been a long history of codifying the skills and training methods associated with achieving improved levels of performance in specific disciplines. It has only been in the last century, though, that the field of psychology has taken an interest in identifying common characteristics found in the structure and acquisition of expertise and expert performance across disciplines (Ericsson, 2006).

Sources of data for expertise research have traditionally fallen into three categories: *historical*, *developmental*, and *laboratory* (Ericsson, 1996). Since it is often difficult to identify world-class experts, until after they have already achieved expert status, the *historical* approach relies on publicly available records to identify characteristics of expertise. For instance, an analysis of experts’ ages, across disciplines, at the time they achieved exceptional accomplishments indicated that at least ten years of training was necessary to achieve elite levels of performance (Simonton, 1996). The *developmental* approach focuses on conditions and techniques involved in acquiring expert status. Research from this line of inquiry has revealed that it is not enough to simply practice. Practice must be on an appropriately difficult task, with informative feedback, and the opportunity for repetition and correction. This is what is known as deliberate practice (Ericsson, Krampe, & Tesche-Romer, 1993). Finally, the *laboratory* approach seeks to isolate and replicate the mechanisms of expert performance. Research on the characteristics of expertise in chess, as an example, led to the theory that expertise is associated

with the ability to group together, or ‘chunk’, individual items into a single unit of analysis for efficiency of recall and response (Ericsson & Kintsch, 1995). In this way, laboratory research is primarily interested in the cognitive structures of expertise, whereas historical and developmental research are focused on the acquisition of expertise.

Another important distinction is the definition of *expert* employed by researchers. In one line of research truly exceptional individuals such as chess Grandmasters, Olympic level athletes, or innovators in medicine, science, and mathematics are studied. This research requires the identification of objective measures for expert performance, such as ranking systems or a peer acknowledgement of contributions to a field as truly noteworthy (Ericsson et al., 2009). In this paradigm, expert is defined as one who is truly remarkable; one whose accomplishments distinguish him or her from the masses (Chi, 2006). Identification of an objective measure is not always possible, however, and so, in the second paradigm, a more subjective comparison is made between experts and novices. In this paradigm, expert is defined as one who has acquired proficiency above and beyond the novice, but at a level, nevertheless, which the novice is capable of achieving (Chi, 2006). In this research, a set of discipline-specific tasks are identified and researchers attempt to capture qualities uniquely associated with experts’ performance. This research covers a variety of domains and is of particular interest to educational theory because it assumes learning expert performance is possible.

A third distinction in the cognitive research suggests two mechanisms for expert performance: superior cognitive processing and increased depth of semantic knowledge (Abernethy, Burgess-Limerick, & Parks, 1994). The original studies on expertise from chess largely focused on cognitive processes such as stimulus-interpretation and decision-making. Operating under the hypothesis that expertise is domain-general, involving encoding, pattern

recognition, and decision-making processes, some researchers posited that expertise exists independent of the context in which it is being exercised. In the knowledge-based paradigm it is hypothesized that experts develop an extensive knowledge base that facilitates more nuanced recognition and categorization, thus situating expertise as domain-specific (Williams, Ford, Eccles, & Ward, 2011). Current theories about the cognitive nature of expertise blend these two aspects, framing expertise as both acquired knowledge and improved ability to structure and organize that knowledge (Ericsson, 2006).

To situate this dissertation research in the above paradigms, the cognitive structures associated with expertise in dance were investigated utilizing a laboratory approach. The incredible variety between dance genres' skills, aesthetics, and training methods, make dance a field in which it is difficult to measure elite expertise objectively. This research, therefore, employed a relative definition of *expert* and studied the differences between experts and novices restricted to a single genre, contemporary. Finally this research focused less on the semantic knowledge base of dance experts and more on perceptual-cognitive skills related to stimulus-interpretation. In the following review, preference will be given to research that employs similar goals and methodologies.

General Expert-Novice Distinctions

Before considering the evidence for perceptual-cognitive skills associated with expertise in specific domains, it is worthwhile to briefly consider more general findings that distinguish experts from novices. The following list is drawn from Feltovich, Prietula, and Ericsson's (2006) review of psychological perspectives in the study of expertise.

Expertise is domain-specific and does not easily transfer. Those who achieve truly elite levels of performance in one domain rarely achieve similar levels of expertise in other domains.

For instance, expert GO players perform poorly on memory tests in Gomoko, even though both games use the same board (Eisenstadt & Kareev, 1979). This goes against the naïve belief that talented individuals show superior performance across activities.

The content of the expertise is important. Efforts to understand the nature of expertise have shown that domain-specific content affects the general cognitive processes of learning, reasoning, problem solving, and concept formation. For instance it was shown that participants with more declarative knowledge about the game of baseball had higher recall and recognition of new material about baseball as well as superior inference abilities with partial information (Chiese, Spilich, & Voss, 1979). Although this connection between content and process might seem obvious, it helps to discredit a theory that expertise is due to domain-general cognitive abilities and that domain-specific knowledge is a nuisance variable.

Expertise involves chunking. As experts gain experience in a domain, regularities between perceptually available information allow experts to group elementary units into larger organizations called chunks. These chunks act as a single unit, facilitating storage in Short Term and Long Term Memory. This will be discussed in more detail later.

Experts' knowledge is functional and abstracted. Experience allows experts to incorporate information in deeper or more principled structures. For instance when physics teachers and physics students were asked to categorize experiments, teachers tended to organize the experiments according to the principles they embodied, whereas students tended to organize them according to superficial characteristics, such as which apparatuses or methods that were used (Chi et al., 1981). Functional abstraction of information aids in retrieval, integration, evaluation, and analogical reasoning.

Expertise is automatic. As one gains experience with a task, cognitive operations, that initially required conscious attention, become automatized. Automatization allows for improved speed and smoothness of operations and reduces cognitive demands, freeing resources for other, often higher, functions. For instance, it is important that children's encoding and decoding of individual letters becomes automated early on, so that cognitive resources can be dedicated to the higher order process of language comprehension (Lesgold & Resnick, 1982).

Experts attend to relevant information. Processes of chunking, abstraction and automatization allow experts to efficiently extract meaningful event features while suppressing irrelevant information. In medical expertise, for instance, when a doctor is attempting to diagnose a patient, he or she must integrate multiple sources of information, scan them for regularities, abstract symptoms to a larger framework, and accept natural variation. Experts rely on education and prior experience to select the most relevant information and provide more accurate diagnoses (Norman, Eva, Brooks & Hamstra, 2006).

Expertise involves metacognition. When experts are operating within their domains of expertise the abstraction of relevant information and the automatization of cognitive processes allows experts to evaluate their own performance and adjust strategies to specific contexts. When expert and novice physicians, for instance, fail to provide accurate diagnoses, the experts are at least able to integrate the available information and explain how they arrived at their diagnoses. Novice physicians' explanations are less well integrated and focus more on individual features (Groen & Patel, 1988).

Taken together, these characteristics suggest that expertise is an adaptation to compensate for limited resources in Short Term and Long Term Working Memory. Experts interpret domain-specific information in larger units more automatically, circumventing memory

limitations and allowing for metacognitive management and evaluation. In the remainder of this chapter attention will be given to how expertise manifests across a variety of disciplines.

Expertise in Chess

In the 1930s and 40s the study of expertise in chess coincided with, and supported, two agendas that contributed the rise of cognitive psychology. The first agenda sought to distance psychology from the reliance on the stimulus/response paradigm of behaviorism. Instead of framing intelligence as externally driven, researchers proposed the information-processing model as an internal mechanism for the development of intelligence. The second agenda was the attempt to build an artificial intelligence, one capable of symbol recognition and complex problem solving (Feltovich, Prietula, & Ericsson, 2006). The prevailing opinion at the time was that expertise in chess, and by implication intelligence, was due to a greater cognitive capacity for mentally searching and making decision about chess moves. It thus seemed an ideal tool for investigating models of cognition based purely on computation (Ericsson, 1996).

A dissertation written by Dutch psychologist de Groot, originally published in 1946 and translated into English in 1965, stands as a seminal work in the study of the cognitive mechanisms of expertise. He demonstrated that expertise in chess is not associated with greater general computational abilities, but is associated with more immediate perceptual processing (Chase and Simon, 1973). In this research, de Groot presented expert and novice chess players with arrangements of chess pieces on a board and then asked them to talk aloud as they evaluated options for play. It was found that experts made more effective, or 'correct', decisions than novices. However, de Groot's think-aloud method revealed no significant differences in skills associated with decision making: the number of moves considered, patterns of search, or depth of search for effective moves.

De Groot, however, did notice differences in memory capacities between experts and novices. In a follow up study, experts and novices were shown arrangements of pieces on a board for five seconds and then asked to recreate the arrangements. It was found that experts more accurately recalled and reproduced arrangements of pieces, but only if the arrangements were structured. Here, structured was defined as configurations of pieces that would be expected to occur during gameplay. If the pieces were unstructured, defined as configurations that could not occur during gameplay, then novices and experts performed equally. This, potentially, indicated that expertise was not associated with depth of processing, as was previously assumed, but with differences in perceptual processing. And further, the superior perceptual processing was highly dependent on domain-specific regularities.

These findings were later replicated and refined by Chase and Simon (1973). The researchers again showed expert and novice chess players arrangements of pieces for five seconds and asked them to recall and recreate the arrangement. It was shown that experts recalled arrangements of pieces more accurately than novices but, again, only if the pieces were in structured arrangements. The differential performance by experts on the structured and unstructured tasks ruled out differences in Short Term Memory (STM) capacity as a potential mechanism for expertise. By analyzing participants' performance on the recall task with both talk-aloud and visual search data, the researchers determined that experts were able to maximize limitations in STM by grouping several individual chess pieces into a single familiar item of analysis. Experts were able to 'chunk' visual information based on relations of mutual defense, attack, proximity, and color. By more quickly recognizing meaningful associations between pieces, and chunking them, experts increase the amount of information stored in STM, allowing

them to sort through and evaluate play options more efficiently than novices (Chase & Simon, 1973).

Expertise in Sport

Sport, was an early adopter of psychological methods of investigating expertise. As a field of study, it shares several unique characteristics with the field of dance, warranting an examination of the literature on sports expertise. First, sport and dance are both movement-based domains requiring expertise in not only stimulus-interpretation and action choice, but action execution as well. Second, dance and sport are time based, placing severe constraints between the processing of stimulus and coding of response. Third, within the broad domains of sport and dance, a great deal of variety exists in terms of the type of sport or genre of dance, affecting qualities of expertise (Hodges, Starkes, MacMahon, 2006). Although a good deal of attention has been devoted to understanding the development of sport expertise (Ericsson, 1996; Starkes & Ericsson, 2003), in line with this dissertation research, the following review will focus on studies investigating the perceptual-cognitive or stimulus-interpretation aspects of sport expertise.

Perception of Groups

Initially sports psychologists sought to replicate the findings from chess on structured/unstructured recall. Instead of showing athletes chess pieces placed around a chess board, though, expert and novice athletes were presented with configurations of players on fields, courts, pitches, etc. Allard, Graham, and Paarsalu (1980) showed expert and novice basketball players static slides for 4 seconds of either offensive plays in action, considered structured, or slides of turn-overs or rebounds, considered unstructured. Participants were then asked to recall and reconstruct the placement of players. As with chess, expert players were better than novices

at recalling player positions, but only from the structured slides. Using a similar method, Starkes (1987) replicated these findings in field hockey. Even though the task was more complex, in basketball there are 10 players, 22 in field hockey, the recall by structure interaction remained. Additionally, Starkes (1987) employed a three-group model, with novices, skilled amateurs, and professionals, with each group out-performing the previous.

Williams, Davids, Burwitz, and Williams (1993) presented video instead of static slides to expert and novice soccer players and asked them to recall the position of specific players. As in the previous studies, structured videos were of offensive or defensive plays and unstructured were of transitions times. And, as in the previous studies, experts recalled more than novices but only from the structured videos. In addition to basketball, field hockey, and soccer, these findings have been extended across a wide variety of sports; volleyball (Borgeaud & Abernethy, 1987), rugby (Nakagawa, 1982), and snooker (Abernethy, Neal, & Koning, 1994). Taken together, these studies confirm one of the most widely replicated perceptual-cognitive aspects of expertise: experience facilitates recall and recognition by chunking individual items of analysis according to domain specific regularities.

Perception of Individuals

Researchers extended, or narrowed, these findings, from recognizing meaningful patterns among players, to recognizing meaningful patterns in an individual opponent. In the occlusion paradigm, information about an opponent's movement is removed, either temporally or spatially. Abernethy and Russell (1987) showed expert and novice badminton players video of badminton strokes and asked participants to predict where the shuttle would land. The video was stopped at either 167ms before racquet/shuttle contact, 87ms before contact, at the point of contact, or after contact when the shuttle was returned. Experts' accuracy improved in each condition, whereas

novices' accuracy did not begin to improve until the contact condition. This indicated that experts used pre-contact information to predict the eventual trajectory of the shuttle.

In order to more precisely understand what information was used for prediction during the pre-contact phases, Abernethy and Russell (1987) again showed experts and novices video of badminton strokes and asked participants to predict where the shuttle would land. In this research, the experimenters either masked the racquet, or masked the racquet and the arm holding it. Although the masking, in general, did cause a decline in performance for both groups, there was a difference between the two masking conditions. For novices, it did not matter whether the racquet alone or the racquet and the arm were occluded. Experts, though, performed significantly worse when both the arm and racquet were occluded, in comparison to their own performance when only the racquet was occluded. This finding has been replicated across a variety of sports such as tennis (Goulet, Bard & Fleury, 1989), soccer (Savelsbergh, Williams, van der Kamp, & Ward, 2002), and karate (Williams and Elliot, 1999). Taken together, these studies indicate that expert athletes use cues from opponents' bodies to make early predictions about game related events.

As the studies above indicate, the ability to quickly extract domain-specific essential information is a key perceptual-cognitive feature of expertise in many sports. Given the fast pace of many of these games, and the requirement for quick and accurate response to the actions of other players, experts develop the ability to chunk cues from the shape and movement of opponents' bodies in order to facilitate anticipation. A similar process occurs when dancers are learning new material from either a teacher or choreographer, they are presented with an abundance of complex information in the form of bodily shapes moving through three-

dimensional space with specific timing and must develop strategies in order to encode as much of that movement as possible under severe time constraints.

Expertise in the Performing Arts

Although research on the perceptual-cognitive mechanisms of expert performance in sports has flourished over the last 30 years, research on the same subject in the performing arts has been scarce. To do so requires disentangling skill alone from artistic expertise. Related to this, it is also likely due to a long history of explaining artistic expertise as a result of innate talent instead of acquirable skill (Lehman & Gruber, 2006). Although strong relationships with sport have facilitated a relatively productive research agenda on motor skills associated with dance expertise, which are shared with sport, less is understood about the expressive components that differentiate sport from dance. Researchers, though, are continuing to develop research on expertise in the performing arts. Literature on the perceptual-cognitive skills from music and theater is reviewed below.

Music

As with chess and sports, early research on perceptual-cognitive skills associated with musical expertise replicated the recall by structure interaction. Kaufman and Carlsen (1989) asked expert and novice musicians to listen to a passage of music and then wait for a period of 0, 20, 60, or 180 seconds. They then listened to another passage of music and had to judge whether this was the same as the previous passage. In this study, structured was equated to self-report assessment of familiarity with each passage. Experts exhibited better retention and recall on familiar passages, but novices' performance was not affected by familiarity with the passage. The self-report of familiarity as measure of structure, though, seems tenuous. A stronger case is made by Knecht (2003), who generated eight-note melodies that were random or contained two-

note or three-note sequences that were chosen because of their statistical frequency in western music. Expert and novice violinists were asked to listen to and then imitate the eight-note sequences. Although novices showed no difference across sequences, experts significantly improved as the condition incorporated more commonly heard note combinations. As with expertise in other domains, experience with western music allowed experts to chunk multiple notes into a single unit improving recall. Although this is in line with other research on expertise, the difficulty in precisely defining what is meant by structured, is indicative of the difficulty across the arts in developing operational definitions.

Other research has investigated perceptual-cognitive skills uniquely associated with musical expertise. Rauscher and Hinton (2011) asked expert string players, expert drummers, and novice musicians to listen to pairs of notes and judge whether the second note was higher/lower (pitch) or shorter/longer (duration) than the first note. String players had lower pitch discrimination thresholds than the other two groups, and drummers had lower duration discrimination thresholds. As music can broadly be considered configurations of specific pitches with specific durations, basic research such as this, which demonstrates superior perception of fundamental components is associated with experience, is important in clarifying definitions of expertise in the performing arts.

Theater

Theatrical expertise and acting skill is the least explored of the performing arts in terms of understanding the perceptual-cognitive aspects of expertise. This could be because expert performance in acting is based on the ability to embody the ideas, emotions, and intentions of specific characters, a skill which proves difficult to measure (Lehman & Gruber, 2006). Research on perceptual-cognitive skills in theater has focused primarily on actors' strategies for

memorizing information. For instance, Noice (1993) had expert and novice actors memorize a script either by rote (word for word) or by gist (understanding the intention of each line).

Although experts and novices performed similarly in the rote condition, in the gist condition, experts were able to recall more of the script. The authors ascribe this difference to a form of chunking, whereby intention is used as a meaningful relationship under which individual words are grouped.

Theater is not unique in its embodiment of ideas, emotions, and intentions. Music and dance (and all arts for that matter) involve purposeful expression. It could be that experimentally adding an intention or purpose to a series of musical notes or rhythmic movements would also aid in recall, but these experiments have not been run. Many arts educators already capitalize on the relationships between intentionality, memory, and expression. Supplementing this practical knowledge with the psychometric measurement of idea expression as an underlying factor in arts practices could be powerful in advocating for arts education.

Although the argument might be considered circular, it bears repeating. Holding the expression of ideas and emotions constant across disciplines, a primary characteristic of music is the sequencing of pitches with specific durations. Expertise in music is associated with the improved ability to discriminate pitch and duration. A primary characteristic of acting is the imitation or creation of states of intention. Expertise in acting is associated with the use of intentions to chunk words for improved memorization. If dance, then, is the unfolding of shapes through space and time, then it is possible that expertise in dance is associated with improved discrimination of shapes, space, and time. Further, some combination of these elements might be used in a chunking strategy to facilitate learning. Research on dance expertise has been

conducted, but a review of that literature will be saved for Chapter 4 where it can be dealt with in great depth.

Conclusion

Through this review, the current dissertation research has been positioned in relationship to current paradigms in the study of expertise. As an investigation into the perceptual-cognitive mechanisms of dance expertise, a laboratory approach is adopted in order to isolate and clarify those mechanisms. Dance is a field in which objective measures are difficult to obtain; therefore this research will compare the relative performance of experts and novices, defining experts as those who have achieved a significant, but not extraordinary level of accomplishment. And finally, although this research is limited to the domain of dance, it is less interested in the semantic knowledge of dancers and, instead, investigates skills associated with stimulus-interpretation.

Early studies on chess provide an empirically-based and oft replicated conceptual foundation for explaining an aspect of expert perception. By more quickly recognizing meaningful associations between individual items, and chunking them, experts increase the amount of information stored in STM, allowing them to sort through and evaluate options more efficiently than novices. Research from sports psychology has shown that the chunking of bodily shape and movement is possible. Research from the performing arts has shown that the fundamental aspects of an art (pitch and duration in music, intention in acting) are uniquely developed with experience and comprise the categories that allow experts to chunk information. Together these studies suggest that when expert dancers watch dance, a body moving through space and time, they use heightened domain specific discrimination skills to chunk meaningful configurations of shape, space, and time for improved recall.

CHAPTER 4: DANCE IN EXPERIMENTAL PSYCHOLOGY

Dance and psychology have always been intimately connected. From rituals on the ancient Greek threshing floor to the Ghost Dance of the American Indians, from the court of Louis XIV to the Savoy Ballroom, dance offers a unique and powerful glimpse of the human psyche. This was especially true in the United States at the beginning of the 20th century. The principles of modernity and the desire to create a uniquely American art-form led dance pioneers Martha Graham and Doris Humphrey to develop movement principles and technical training systems that facilitated the access and distillation of emotional states through movement (Thomas, 1995). At roughly the same time, Margaret H'Doubler was integrating John Dewey's ideals of progressive education into the first dance major at the University of Wisconsin, Madison.

Though H'Doubler does not directly reference Dewey, her seminal text *Dance: A Creative Art Experience* (1940) is deeply connected both by title and philosophy to Dewey's classic *Experience and Education* (1938) as well as the collected series of lectures titled *Art as Experience* (1934). In her text, H'Doubler advocates physical experience as the foundation for skills in critical thinking and knowledge construction, as well as the importance of aesthetic experience for all students. Her chapter "Technique and Expression" offers a succinct and, though seventy years old, fairly accurate account of the mechanisms of sensation, perception, and cognition in both cognitive and neuroscientific terms. H'Doubler's students, guided by her curricular ideals, went on to found many liberal arts based dance programs around the U.S. However, her interest in the psychological aspects of learning in dance did not connect with the nascent field of experimental cognitive psychology. Instead, intersections between dance and psychology through the middle of the 20th century were continued in dance therapy.

Existing in different forms in England prior to the 20th century, dance therapy in America began in the 1940s with the work of Marian Chace who performed professionally with the modern dance pioneers Ted Shawn and Ruth St. Denis. She then went on to teach dance, focusing on the power of movement to express emotions. After WWII, she was asked to work with patients at a hospital in Washington D.C, began teaching her philosophy and technique to other teachers, and eventually founded the American Dance Therapy Association in 1966 (Chaiklin, n.d.). Dance therapy is broadly interested in “furthering the emotional, cognitive, physical, and social integration of the individual” through movement practices (ADTA, n.d.) This set of goals is shared with other movement-based therapies which also developed in the mid-20th century such as Bartenieff Fundamentals, Alexander Technique, and The Feldenkrais Method, all of which use movement to promote psycho-somatic integration and healing. Although these goals seem strongly suited to investigation through empirical research, recent systematic reviews on the use of dance therapy with physical and mental illness (Kiepe, Stockigt, & Kiel, 2012), dementia (Beard, 2012), and depression (Mala, Karkou, and Meekums, 2012) indicated the inability to draw strong conclusions about effectiveness due to the low number of studies available. As with H'Doubler, though there are ideological connections between psychology and dance, the latter has not fully integrated the methodology of the former.

In the mid-20th century, psychology underwent a shift from a behaviorist stimulus-response model to a cognitive information-processing model. Sports psychology, and related fields of motor learning and motor control, flourished under this new model investigating relationships between sensory, cognitive, and motor control systems (Schmidt & Lee, 2005). In the 1970s and 1980s many dance majors were housed in physical education programs and thus psychological research in dance expanded alongside research in physical education. Research

included the use of dance in the investigation of classic motor learning paradigms such as bilateral transfer (Puretz, 1983) and mental practice (Romero & Silvestri, 1990) and sequential learning (Starkes, Deakin, & Lindley, 1987). As part of this trend Janet Starkes published two studies investigating stimulus-interpretation skills associated with expertise in dance. These will be reviewed in more detail later in the chapter.

A final shift in the field of psychology, worth mentioning here for its effects on research in dance, is the rise in the last twenty years of what is known as embodied or grounded cognition. In an embodied model, cognitive states do not exist separately from bodily states, but instead arise as a process of perceptual and motor simulation (Barsalou, 2008). The body and its movements, therefore, are considered an integral component in embodied models for cognitive and social-emotional development. Because dance is uniquely situated as both a full-bodied motor activity and an emotional expressive act, its use in both cognitive psychology and neuroscience to investigate simulation and motor representation has expanded over the past decade. Again, because of its relevance to this dissertation, this body of research will be reviewed more fully later in the chapter.

Although dance and psychology seem to be deeply intertwined, they have only briefly crossed paths in terms of experimental investigation. Fields such as dance therapy and sports psychology have had mixed success in launching research agendas. Hopefully the rise of embodied models and their repositioning of the body as central to issues of cognition will allow for a more lasting relationship between dance and experimental psychology. The following review will pick up where the previous chapter left off, looking at studies in dance from sports psychology that adopt the recall by structure interaction model. This review will then go on to consider the more recent research from dance and psychology, which is heavily influenced by

cognitive models of embodiment and simulation. In this review, particular attention will be paid to research from neuroscience and cognitive psychology that helps frame stimulus-interpretation skills associated with dance expertise.

Dance Expertise in Sports Psychology

Early research on mental representation in dance adopted methodology similar to that of sports psychology. Starkes, Deakin, and Lindley (1987) showed young expert and novice ballet dancers sequences of eight movements that had either been choreographed or were randomly ordered. They found that the experts more accurately recalled components of the ballet phrase when the phrase was choreographed. When the movements were randomized, the experts performed the same as novices. This difference however was not found in a second study using modern dancers (Starkes, Caicco, Boutilier, & Sevsek, 1990). Whether the movements were intentionally choreographed, or randomly ordered, experts were better at recalling the phrase than novices. According to the expertise literature, the stimulus-interpretation skill of chunking is dependent on the recognition of domain-specific relationships. Experience in ballet could build expectations about how ballet movements will be sequenced: for instance, it is likely that a *tombé* will be followed by a *pas de bourrée*, but it is less likely that a *tombé* will be followed by a *tendu*. By categorizing individual movements as sequentially related, experts are able to chunk sequences for efficiency of recall. It is assumed that the expert modern dancers used chunking strategies as well. However, because experts performed equally well in the choreographed and randomized conditions, expectations about sequence cannot be considered part of that strategy. Follow up studies, however, were not conducted to investigate the nature of chunking in modern dance. Thus the nature of the domain-specific relationships used by modern dance experts

remains undefined. These studies are now more than twenty years old, but current research from neuroscience and cognitive psychology might provide clues to the answer.

Dance Expertise in Neuroscience

In the past ten years the decreasing cost and increasing availability of neuroimaging methods have led to a proliferation of data from neuroscience. What has captured the attention of many researchers in cognitive neuroscience is that the neural activity associated with observing an action, found in the inferior parietal lobule (IPL), is highly correlated with activity associated with executing an action, found in ventral pre-motor (PMv) and supplementary motor areas (SMA). This indicates that both observing movement and executing movement activate similar parts of the brain. This, in monkeys, is what is known as the Mirror Neuron System (MNS) and in humans is often referred to as the Action Observation Network (AON) or simulation circuit. As neuroscientists embrace models of cognition based on simulation and embodiment, they have begun to use dance as a tool to investigate how physical experience changes neural activity. Two researchers in particular, Emily Cross and Beatriz Calvo-Merino, have investigated how experience with dance is associated with, and even causes, shifts in visual processing.

Physical Experience

In 2005, two studies were published directly addressing the effect of physical experience, or expertise in dance, on neural activity while watching dance. In both studies, it was hypothesized that participants would have greater activation in simulation regions (IPL, PMv, SMA) while watching movement with which they were physically familiar than while watching unfamiliar movement. Calvo-Merino, Glaser, Grezes, Passingham, and Haggard (2005) scanned expert ballet dancers, capoeiristas (a Brazilian dance-like martial art), and a novice control group

with functional MRI (fMRI) while watching three-second video clips of actions from ballet and capoeira that were matched for kinematic similarity but were stylistically different. FMRI is an imaging method that measures the amount of oxygen consumption in the blood in different parts of the brain (BOLD: blood oxygen level dependent response), in this case, while watching different types of movement. Differences in oxygen consumption are thought to be an index of which parts of the brain are or are not at work during a task. As predicted, ballet dancers and capoeiristas had stronger activation in the simulation circuit while watching movement from their own discipline. For the novice group, the two types of dance did not stimulate different patterns of activity. Cross, Hamilton, and Grafton (2005) used a within group design, in which each dancer was compared to his or her self across the learning process, and scanned contemporary dancers before, during, and after the process of learning a dance phrase. In the scanner, the dancers watched 36 five-second clips of a contemporary dance. In rehearsal, the dancers learned movement from 18 of those clips. By the end of the rehearsal period, then, the dancers had physical experience with half of the video clips. Just as in the previous study it was found that there was greater activation in the simulation circuit while watching movement that had been physically rehearsed.

Together, these two studies confirm that action observation involves simulation circuits in the brain, and that the strength of the neural response in the simulation circuit is mediated by physical experience. Previous research on simulation circuits involved perception of instrumental acts such as reaching for a cup or using a tool to accomplish a task. The simulation circuit could have been stimulated by perception of an object or by a representation of the goal, and not by the actual movement toward that goal. However, in dance, the simulation effect remained, even without an external object or specified goal. Movement itself was enough to

activate the simulation circuit. It could be that, because of the strong connection between the motor and parietal cortices, and the role of production and perception in mental representation, that increased activity in the simulation circuit is also associated with qualitatively different mental representations of the observed movement.

Physical Experience vs. Visual Experience

Although data from the previous studies stand as strong evidence for the primacy of motor experience in the activation of the simulation circuit, another explanation is possible. Not only do the ballet dancers and capoeiristas have more physical experience with their unique style, but they also have more observational experience. The same could be true of the contemporary dancers; in rehearsal they are not only practicing the rehearsed movements, but seeing them more frequently than the unrehearsed movements. A possibility, then, is that increased activity in the simulation circuit is not the result of motor representations gained through physical experience (what is known as “simulation theory”), but is attributable to a more general process of building representations through visual inference (what is known as “theory theory”). In order to distinguish between these two theories, Calvo-Merino, Grezes, Glaser, Passingham, and Haggard (2006) again scanned ballet dancers with fMRI while watching 3-second clips of ballet movement.

In ballet, some movements are gender specific. Men and women rehearse together, so each gender would have visual familiarity with opposite gender movements, but would only have physical experience with movements matched to their own gender. If “theory theory” were correct and simulation circuits were activated by general processes of visual inference, then it should not matter if ballet dancers were watching opposite or matched gendered movements, the activation would be the same. If simulation theory were correct, though, and motor experience

plays a unique role in the development of motor representations, then the dancers should have greater activation in the simulation circuit while watching movement that is gender matched. This is, in fact, what the researchers found. Dancers had greater activation in IPL and PMv while watching movement from their own gender.

A study conducted by Cross, Kraemer, Kelley, Grafton, and Hamilton (2008), however, seems to provide contrasting evidence. These authors hypothesize that since action observation and action execution are so closely related, neither is privileged in the development of motor representations. In their study, participants received physical training, as well as passive observational training in movement sequences from *Dance Dance Revolution* (a dance-based arcade game). During post-training scanning, participants watched movement sequences from both training conditions as well as novel sequences. It was found that watching trained sequences, either physical or observational, lead to greater activation in the simulation circuit than watching novel sequences. However, it was found that there was no difference in activation while watching sequences that had been physically trained in comparison to sequences that had been observationally trained. This, the authors claim, is evidence that it is not motor experience alone that modulates the activity of the simulation circuit, as might be claimed from the Calvo-Merino et al. (2006) study, but that observational experience plays an active role in the simulation circuit and the development of motor representations.

What these four studies from the labs of Calvo-Merino and Cross point towards is the existence of a complex, bi-directional feed forward simulation system for the development of motor representations. Observation of an action involves simulation. The more familiar one is with the movement, the stronger the response in the simulation circuit. Observational experience

is enough, but physical experience leads to greater modulation. The next section covers how increased activity in the simulation circuit affects stimulus-interpretation.

Configural vs. Local Processing

The literature thus far has investigated how action execution and action observation modulate activity in the simulation circuit and implications for the development of motor representations. The following studies clarify how a motor representation from the simulation circuit might differ from other types of visual representations. In the simulation circuit, visual processing moves from the visual cortex into the parietal cortex. There is however another pathway for visual processing that terminates in the temporal lobe. The pathway into parietal cortex is referred to as the dorsal pathway. Because of its role in spatial perception and object manipulation, it is also referred to as the *where or how* pathway. The pathway into the temporal lobe is referred to as the ventral pathway. Because it is involved in determining the identity of an object, it is often referred to as the *what* pathway (Goodale & Westwood, 2004).

Urgesi, Calvo-Merino, Haggard, and Aglioti (2007) used Transcranial Magnetic Stimulation (TMS) to study the role of these pathways in the perception of dance shapes. TMS is a method of studying brain activity by applying an electric pulse to a small area on the scalp. The pulse travels through the skull and disrupts the electrical activity in the outer layers of cortex. Any cognitive or perceptual impairment occurring during the disruption can be attributed, at least in part, to the affected region of cortex. In this study TMS was applied to right superior parietal lobule (SPL), left ventral premotor cortex (PMv) in the dorsal pathway, or to the right Extrastriate Body Area (EBA) in the ventral pathway. Participants in the study were shown a static image of a body in a dance position, the TMS pulse was applied, and then the participants were shown two images, one identical to the first and another with a slight change. They then

had to choose which image was identical to the first. Depending on where in the cortex TMS was applied, performance on the test would indicate the function of that brain region in the processing of bodily shape.

Importantly in half the trials, the body image was right side up and in the other half the body image was upside down. Previous research has shown that the human mind preferentially perceives certain stimuli, such as faces and bodies, in their upright orientation (Yin, 1969). For instance when a face is right side up, it is easier to recognize anomalies that might have been experimentally manipulated, as in the Thatcher Illusion. This is believed to happen because, in an upright position, the individual components of the face (nose, eyes, mouth) are processed as a whole unit or configuration of elements. When the face is upside down, it is no longer perceived as a configuration, and the elements are processed individually or locally. Urgesi et al. (2007) found the same to be true in the processing of bodies. When TMS was applied to PMv, accuracy in perception of upright postures was impaired, but perception of inverted postures was unaffected. When TMS was applied to EBA, accuracy in perception of inverted postures was impaired, but perception of upright postures was unaffected. Interestingly TMS applied to SPL did not significantly affect performance; however, the strong connection between SPL and PMv lead the authors to make conclusions about the role of configural processing in the simulation circuit. To be specific, the authors claim that because configural processing was impaired by disrupting the activity of PMv, the representations of observed bodies in parietal cortex (dorsal pathway) are configural, relying on representations of our own body from motor and premotor cortices. Furthermore because configural processing is dependent on the spatial orientation of the figure, representations of the body in the simulation circuit are contextualized with environmental spatial cues. Because TMS applied to EBA affected performance on inverted

postures it is assumed that temporal cortex (ventral pathway) does not rely on configural spatial cues and instead processes the placement of body parts individually.

Taken together, the neuroscientific data indicates that experience improves configural processing of human action and that motor experience provides additional resources above and beyond visual experience. In terms of motor representations in the simulation circuit, these studies support the idea of a bi-directional feed forward system modulated by action observation and action experience, but they also add a piece to the puzzle. Namely, the quality of the representation in the simulation circuit is configural; the movement is perceived not as individual relationships between separate body parts, but as a whole body moving in an environmental context. It could be, then, that the domain-specific relationship used by expert modern dancers to chunk movement phrases for efficiency of recall is the relationship of the body to external spatial cues.

Dance Expertise in Motor Cognition

The studies from neuroscience provide data on neural activity related to sensory events. It is important to recognize, though, that it is still not completely understood how neural activity maps on to cognitive activity, or, more simply, how the brain makes the mind. A more complete understanding of the relationship between perception and movement expertise should integrate data from the brain as well as cognitive measures. In cognitive models that rely on simulation, the comparison of our own movement to movement of others provides a basis for cognitive and social-emotional development. A critical issue, then, in motor cognition is to better understand how meaningful information is drawn from continuous action sequences.

Schematic and Veridical Expectation

Evidence suggests that meaning-making in action observation occurs through the parsing or discretizing of continuous movement based on the perceived goal of an observed action (Zacks, 2004). Sub-goals within an action are organized hierarchically, for instance the coarse goal of doing the dishes, might be sub-divided into the finer goals of washing and drying, which could then be reduced to even finer goals (Zacks, Braver, Sheridan, Donaldson, Synder, & Ollinger, 2001). A similar subdivision could be said to occur in dance: a *pirouette* (turn) could be divided into the sub-actions of a *tendu* (stylized extension of the leg), a preparatory *plié* (bend of the knees), a *pirouette*, and concluding *plié*. Each of these could then be divided into even finer grained actions.

Loucks and Meltzoff (2012) suggest that continuous movement sequences are organized in memory structures, not according to a veridical recording of a sequence of events, but according to a sequential organization of perceived sub-goals. This organization is referred to as a schematic. Representations of complex actions, then, include representations of sub-actions necessary to achieve the goal, but might discard extraneous actions not perceived to be integral to achieving the goal. While watching a *pirouette*, for instance, a viewer might remember the four primary actions (*tendu*, *plié*, *pirouette*, *plié*), but not remember that there was a *port-de-bras* (movement of the arms) between the *tendu* and the *plié*, because the arms were not considered the locus of intention in the action.

Schack (2010) and Blasing (2010) proposed the term Basic Action Concepts (BACs) to refer to the fundamental unit of mental representation for discretized sub-actions found in a complex movement sequence. In order to investigate the structure of BACs in dancers' representations of movement, Blasing, Tenenbaum, and Schack (2009) divided a *pirouette* into

16 BACs and questioned ballet experts and novices as to whether two BACs were functionally close or distant. Using a structural dimensional analysis, the authors found that experts' representational structure more closely resembled the functional structure of the actual movement than did the representational structure of the novices. The authors hypothesized, though, that expertise might not only be comprised of more accurate ordering, but also of finer granularity of BACs. An action sub-divided into four BACs by the novice, might be sub-divided into 12 BACs by the expert.

Using a similar method, Blasing and Schack (2012) investigated spatial parameters of expert representation. As in the previous study, movements from ballet (*pirouette, pas assemble*) were divided into discrete BACs. Instead of having to determine functional distance, novice and expert dancers were asked to assign spatial features to each of the BACs. These included direction on the two-dimensional floor (front, back, etc.) as well as vertical movement and a rating of whether the movement was close to or far from the body. It was found that novices' assignment of spatial components was not as accurate as experts'. This, the authors claim, indicates that experts' mental representations of movement included body-centered spatial parameters, whereas novices' mental representations do not. The expert dancers' mental representation of movement, then, could be considered a schematic of discretized sub-actions that are distinguishable from novices' mental representations in both their quantity and quality, namely the incorporation of spatial cues.

Schematic Expectation in Observation of Dance

Experts' incorporation of spatial cues into mental representations of movement is consistent with the findings from neuroscience on configural vs. local processing. Calvo-Merino et al. (2010) extended Urgesi et al.'s (2007) neuroscientific data to cognitive measures on

configural processing by dance experts. Expert ballet dancers were asked to determine if two consecutive 3-second video clips of Ballet movement were identical or slightly different.

Participants were shown female-specific ballet movements in which the image of the dancer's body was removed and all that remained was the movement of major joints, represented as points of light. Expert female ballet dancers were better than expert male ballet dancers and novices at recognizing differences in upright orientation, but not in inverted orientation. This indicates that the shift in neural activity associated with physical experience also manifests as improved genre specific stimulus-interpretation skills, and, further, those skills are dependent on spatial orientation (upright or inverted).

Opacic, Stevens, and Tillman (2009) tested to see if schematic expectations for dance movements could be learned through observational experience. Most dance genres and individual choreographers have unique configurations of movement that define the quality of their work. These might be considered the grammar of the dance, as the rules that guide them are analogous to the rules that guide the syntax of language. In this study, the experimenters created dance sequences that followed an artificial movement grammar. During an exposure phase, participants watched 22 grammatical dance phrases and afterwards were told that the organization of the movements followed a set of rules, but were not told what those rules were. During the testing phase the participants watched dance sequences and had to determine if they were or were not grammatically organized. Despite admitting that they had no conscious awareness of the rules that guided the organization of the movements, participants performed significantly above chance in determining which phrases were grammatical. This indicates that even in the short exposure time, it is possible to develop schematic expectation of how bodily movement through space and time should be organized.

Stevens, Winskel, and Howell (2010) used eye-tracking to determine how these schematic expectations might modify the way experts and novices watch a dance. In eye-tracking three primary measures are taken: duration and location of fixation and saccadic velocity. Human vision has the highest resolution in the center 2 degrees of the visual field, called foveal vision, because of the role of the fovea in the structure of the eye. When looking at something, we move our foveal vision from place to place in order to maintain high quality data in the visual field. The places where the fovea pauses are called fixation locations and the time spent on those locations are fixation durations. Saccades are the small movements of the eye from place to place and the speeds of those movements are saccadic velocities. In this study, novice and expert dancers watched 17 seconds of a contemporary dance phrase while the movements of their eyes were tracked. Confirming earlier research in other fields, experts had shorter fixation times and faster saccadic velocities than novices. However when the experiment was repeated with the same subjects, the novices performed significantly more like the experts than they did in the first trial. It is believed schematic expectations, developed through physical and observational experience lead to greater confidence, and therefore quicker saccades, while scanning the dance. Configural processing allowed for shorter fixations by encoding elements of movement, space, and time more quickly. Motor representations, then, guides not only how we move and what we see, but also what we expect to see.

Conclusion

Although dance and psychology have both served as a vehicle for the exploration of the human psyche, the presence of dance in experimental literature has been tenuous. Early studies on perceptual-cognitive skills associated with dance indicated that ballet dancers chunked movement information according to genre-specific rules about sequence to improve recall.

Modern dancers, however, were not affected by sequential structure, yet performed better than novices, begging the question, which genre-specific rules did they use for chunking? The answer to this might be found in more recent studies from neuroscience and motor cognition. From neuroscience, it has been shown that observational and motor experience lead to greater activation in the simulation circuit while watching dance. This activation facilitates configural processing of action in the context of space. From motor cognition, it has been shown that expertise in dance is associated with a greater number of discretized chunks, or BACs, for a given action sequence. Further it has been shown that, for experts, BACs include spatial information to a greater degree than novices. Genre specific experience leads to schematic expectations to improve recall. Based on this data, it is hypothesized that, for modern dancers, the discretized sub-actions in the observed movement sequence were chunked with spatial cues providing a richer schematic and aiding in recall.

CHAPTER 5: TERMINOLOGY

Modern and Contemporary

In the review of literature relating dance and experimental psychology, three dance genres are referenced primarily: ballet, modern, and contemporary. In dance studies, all three of these are considered *concert* dance forms. Performances usually occur with performers in a theater venue, often on a proscenium stage, and the audience seated in an auditorium. This is in contrast to *social, folk, or ritual* dance forms in which the performance space and the relationship between performer and audience are quite different. Ballet, modern, and contemporary dance most likely occur frequently in the literature on experts and novices because most colleges teach ballet and modern or contemporary dance. Therefore, when psychologists reach out to dance departments at their university, these are the forms they are most likely to find.

Ballet, though it has evolved tremendously since its origins in the courts of Europe and is currently taught and performed with a wide variety of stylistic adaptations, is still recognizable as a cohesive form. It's use of a finite and codified movement vocabulary, specific use of bodily geometry, and fairly standard progression of exercises in class unite the dance form and ensure that when researchers discuss 'ballet', a whole set of parameters are implied. The terms modern and contemporary, however, might require a bit more clarification.

Modern dance was originally developed in defiance of certain aesthetic frameworks and institutional structures associated with classical ballet. Women at the beginning of the 20th century cast-off the restrictive movements, roles, gender stereotypes, and restrictive costumes found in ballet and explored what they felt were more natural movement impulses (WNET, 1979). By the 1930s and 1940s these forms were also codified and reincorporated some of the conventions of ballet, although, with a variety of other influences as well, most notably cultural

dance forms arising from the African diaspora and African-American vernacular dance (Lacy et al., 2005). Modern dance had its heyday from roughly from the 1930s to the early 1960s. In line with other modernist pursuits, modern dancers attempted to distill movement to its essence and to cultivate the driving principles of the human spirit through movement (Thomas, 1995). Aesthetics have changed quite a bit since that time, however, the middle of the 20th century also saw a flourishing of college level dance departments which usually taught what they called modern dance, even if their training methods and aesthetics did not completely align with the work of the early pioneers.

In this way modern became a catch-all term for a concert dance form that shared some movement and presentational elements with ballet, but that incorporated a substantially different sense of weight, spinal articulation, improvisation, contact with the floor, and a variety of other characteristics. Another shift in dance aesthetics occurred during the 1960s. Dancers during this time rejected the codified dance forms of modern dance and their reliance on virtuosity, theatricality, emotion, and narrative. In line with other artistic practices of the mid-20th century, postmodern dancers explored the socially-constructed nature of performance. Although postmodern tools and aesthetics are present in current choreographic practice, postmodern dance as a style of technical training was not widely adopted by college curricula, or at least not explicitly named as such.

Recently, attempts have been made to separate current techniques from the historically situated modern techniques. It does a disservice to both the work of the dancers at the beginning of the 20th century and the work of dancers today, to continue to lump their aesthetics into a single category. For this reason, many dancers and dance scholars today employ the term contemporary. It essentially refers to a concert dance form which, like modern and ballet, is

presentational in nature, but incorporates other more contemporary movement practices such as release technique, collage, and appropriation of other movement practices such as yoga and martial arts. The switch from modern to contemporary still refers to a form that hybridizes and blends a variety of influences, but recognizes that the aesthetics of those influences have undergone a distinct shift over the last 100 years.

Therefore, although Starkes et al. (1990) use the term modern, and Cross et al. (2005, 2008) use the term contemporary, it is assumed that, for the purposes of psychological research, the authors are discussing roughly the same genre of dance. The use of different terms is more a reflection of a) the time the studies were conducted and b) the fact that Starkes et al. were working in the US, whereas Cross et al. were working in Europe where the term contemporary dance is more widely used. In this dissertation research, the author prefers the term contemporary, to align both with current dance theory as well as the current neuroscientific literature on dance. However, conclusions drawn from previous research on modern dancers are considered to be relevant to findings on contemporary dance because of historical and technical similarities between the two forms.

Movement Analysis: A Framework

While watching dance, the human body presents a two-dimensional form, or shape, on the retina. Using cues from the environment and the perception of depth, the two dimensional form is interpreted as existing in a position in three-dimensional space. Motion is perceived as the body changes its shape through the space over a given time, and as time progresses one shape transforms into the next. These changes in shape, or movements, are sequentialized to become choreography, which is then performed with the use of movement qualities. This incredibly

rough schematic for disentangling the elements of dance does not begin to uncover the incredible complexity that accompanies the analysis of movement.

In dance scholarship, the most commonly used form of movement analysis is Laban Movement Analysis (LMA). Originally developed by Rudolf von Laban and his students at the beginning of the 20th century, LMA is now used by dancers, actors, physical and occupational therapists, athletes, anthropologists, etc. as a way to visualize, interpret, and document any and all kinds of movement. Its prevalence in the dance community and its clear conceptualization of certain aspects of movement warrant a brief explanation of the framework. There are, however, certain differences in the way LMA considers movement, and the way movement will be considered in this research. Therefore adaptations of, and departures from, LMA will also be considered.

LMA divides the analysis of movement into four primary categories: Body, Shape, Effort, and Space (Salk, 2010). The category Body analyzes movement in terms of its structural or anatomical characteristics. It is concerned with identifying and describing which body parts are moving, how the movement of one body part affects the movement of another body part, and in which body part movement appeared to be initiated. For instance describing a reach as beginning with an elevation of the shoulder and abduction of the upper arm would be a description using Body. The category Shape has several sub-categories. One sub-category is Shape Form, which discretizes movement into individual static shapes that can be described in a global form. For instance within a series of movements, a dancer might adopt a posture that could be described as 'wall-like' or 'ball-like'. Another sub-category within Shape is Shape Change, which analyzes whether a movement was internally focused (Shape Flow), directed outward toward some part of the environment (Directional), or is actively interacting with all

three dimensions of space (Carving). In this second sub-category, analysis is less concerned with static shapes, and more with the action of shaping.

Swatting a fly and waving goodbye to a loved one at the train station might have similar descriptions in terms of Body and Shape. It is in the analysis of Effort qualities that meaning and intentionality in movement become clearer. Effort is divided into four sub-categories, each of which places movement qualities along a continuum. The first sub-category is Space Effort and is thought of as either direct or indirect. A focused reach might be direct, whereas the wave of a hand might be indirect. The second sub-category is Time Effort in which movement is thought of as either quick or sustained. Pulling your hand back from a burner on the stove you didn't know was on would be quick, whereas bringing an overfull cup to your mouth would be sustained. The third sub-category is Weight Effort in which movement is thought of as either strong or light. Picking up an eye-lash might use a light weight, whereas trying to open a jar might use a strong weight. The final sub-category is Flow Effort in which movement is thought of as bound or free. Painting a window-sill might be restricted or bound, whereas painting a fence might be free. Together the sub-categories in effort analyze subtle qualitative distinctions and can be used to infer the intention behind a given movement.

The final major category is Space, which is different from Space Effort. An analysis of Space considers where movement occurs in relation to one's body or in what is called the kinesphere. Space also considers how the body is related to the general space: it's facing, level, and pathway. Space can also be used analyze how multiple bodies relate to one another.

LMA is extremely useful in the analysis of movement; it is, however, the hypothesis of this research that the ability to perceive the categories of LMA is an expert ability. Novices' mental representations of movement, it is hypothesized, are constructed by discretizing

continuous action in separate BACs. Each BAC is defined as the perception of discrete two-dimensional shape forms. The expert ability to mentally represent, not just discrete shape forms, but the movement of those forms through space and time is developed with experience. Because this research hopes to situate its findings between the expert and novice perspective, it will adapt or depart from the LMA framework.

In this research the category of Shape will be more dominant than in LMA. Because movement is constantly evolving, an analysis of discrete static Shape Forms in LMA is often less appropriate than a consideration of Shape Change. However, because it is hypothesized that novices' mental representation of dance movements is more closely related to static images of postural forms, the category of Shape will be highlighted. This will allow the analysis to better capture the qualitative nature of both novice and expert representations of movement. In the experimental design, the category of Shape referred to discrete static postural forms that could be extracted from an ongoing sequence of movement.

The category of Effort and its implications on intentionality is a potentially rich avenue for research; however, it seemed that more basic research was required on the differences in mental representation of dance before this category could be included in the current hypothesis. For that reason, Effort has largely been excluded from the experimental design. One element of Effort however was included. As movement is a function of Time, this category was included in the design. Time, in this research referred to the duration of individual movements within an ongoing sequence of movement.

LMA's conceptualization of Space included several of the hypothesized qualities of expert perception and was therefore incorporated into the experimental design. It is believed that experts go beyond the perception of static postural forms and are able to contextualize shapes in

three-dimensional space and, further, are able to represent movement through space. In this experimental design, then, Shape referred to changes in the pathways for a given movement, or the body's relationship to external space as in facing or level.

CHAPTER 6: RATIONALE FOR CURRENT RESEARCH

This study sought to extend the ideas reviewed in Chapters 2-4. Prior research showed that mental representation remains integrated with bodily experience throughout the life-span (Barsalou, 2008); therefore, individuals with differing levels of physical experience in contemporary dance were expected to have differences in the mental representation of contemporary dance. Prior research showed that perception and production of action are connected through a neural substrate strengthened through experience (Calvo-Merino et al., 2006). It was expected, then, that differences in mental representation of dance would be measurable both through action execution and action observation. Research also showed that expertise is associated with the ability to chunk individual units of analysis according to domain-specific rules for efficiency of recall (Ericsson & Kintsch, 1995). Moreover, in dance, expertise is associated with greater activation in areas of the brain responsible for the configural processing of action in spatial context (Calvo-Merino et al., 2010). It is therefore expected that experts' mental representations of dance will be configural in quality, chunking spatial information with information about movement of the body. Finally, research showed that movement is mentally represented through the discretization of complex actions into hierarchies of sub-actions known as BACs. Blasing (2010) showed that expert dancers recall the order of BACs for a given movement more accurately than novices and suggests that expertise in dance is associated with the perception of a greater number of BACs than novices for a given dance movement. Blasing (2012) also showed that ballet experts' representations of ballet movements contain more spatial information than the representations of novices. This current research project continues the investigation of whether the relationship between expertise and the

structure of mental representation is only one of quantity or one of quality as well. Two pilot studies were previously conducted by the researcher, which inform the current study.

Pilot Study #1

In an initial study (Henley, 2011, unpublished), a talk-aloud procedure was employed to explore the differences in two novices' and two experts' perceptions of a short contemporary dance phrase. Experts (20+ years of professional training) and novices (<1 year professional training) were asked to watch a short sequence of contemporary choreography on video and then describe what they saw. Responses were video-taped. Based on professional experience, it was hypothesized that novices would construct an understanding of the movement primarily in terms of the shapes the dancer was making. Experts on the other hand were hypothesized to construct an understanding of the movement primarily in terms of movement qualities. Participants' responses were transcribed and coded as belonging one of four categories derived from Laban Movement Analysis: Shape, Space, Time, and Effort.

It was found that all four participants focused on the description of Shape elements, but the experts stood out for blending Shape with other categories. Novice descriptions provided a basic schematic of the gross movements that occurred in the phrase. Expert descriptions, on the other hand, began by addressing qualities of the movement. Both experts also contextualized the movement by framing it in terms of its direction through space. Although some of the same gross movements were implied in both novice and expert descriptions, the strategy the experts adopted was not to recount the sequence of movements through time, but to conceptualize all of the movement as somehow being connected or driven by a single purpose.

Although the results were not completely congruent with the hypothesis, this brief study did indicate that expert and novice perceptions were qualitatively different, and further, novices

tended to focus on sequences of Shapes. In fact, when questioned about movement qualities from the phrase, one of the novices said “I was more interested in figuring out what was happening before pulling qualities from the movement.” The experts, on the other hand, began with Shape but layered comments about Space, Time, and Effort creating a more nuanced description. It could be that novice mental representation of dance is defined by the progression of Shapes through Time. Expert mental representation contextualizes Shapes with information about Space, Time, and Effort; therefore the sequence of the movement through time was not as important as conceptualizing relationships between these broader categories. The data also suggest the novices conceptualized the phrase as a series of discrete goals that needed to be accomplished, whereas experts perceived the entire phrase as driven by a single goal.

Pilot Study #2

In a second study (Henley, 2012, unpublished), novice and expert dancers watched 30 seconds of a solo dance phrase and then completed a questionnaire assessing their ability to recall qualitative elements from the dance phrase. These elements, adapted from Laban Movement Analysis (LMA), were divided into categories of Shape, Space, Time, and Effort. It was found that experts performed better, overall, than novices, at recalling elements from the phrase. It was also found that experts performed significantly better than novices at recalling spatial elements from the phrase. It is hypothesized that the inclusion of spatial cues in the mental representation of dance movements is a qualitative, not quantitative, shift in the mental representation of movement. If this were the case, dance expertise would not only be associated with an increasing number of BACs for a given movement, but also with a richer store of information for each individual BAC.

Several limitations, however, restrict the conclusion drawn from this study. The first is, participants' abilities to recall elements of the phrase were assessed with a written questionnaire. Dance expertise is a kinesthetic expertise; the format of the assessment required participants to translate their knowledge into language, essentially removing them from their medium of expertise. The current study will drastically reduce the need to translate representations of movement into verbal descriptions. Another limitation in the previous study arose from the length of the clip: 30 seconds of movement is a large amount of information to encode, store, and recall. Differences in performance on the assessment could be attributed to any of those three cognitive processes. The current study will use shorter movement clips, reducing the memory load. Lastly, the previous study included an element from LMA called Effort. This is a complex element of movement analysis that is not immediately accessible to all experts, much less novices. For efficiency and clarity, it was removed from the current study.

Research Question and Hypothesis

Dance is a complex, continuous, ephemeral unfolding of shapes through space and time for the purpose of expressing an emotion or idea. Is expertise simply the ability to parse finer and finer packets of movement, essentially creating a higher resolution in mental representation? Or is the quality of the representation different for the novice and the expert? By analogy; is there a shift from black and white to color?

The hypothesis for the current study is that the mental representations of contemporary dance movements (BACs) are qualitatively different for experts in contemporary dance and dance novices. This is, in part, based on the evidence that the production of dance movements strengthens the perception of dance movements via the neural substrate of the AON, which is associated with an improved ability to encode spatial cues in configuration with information

about the shape of the body. It is further hypothesized that, for expert dancers, the discretized sub-actions in the observed movement sequences were chunked with spatial cues providing a richer schematic and aiding in recall. Therefore, it is predicted that there will be no difference between novices and experts in the discrimination of shape elements, but experts will perform better in the discrimination of spatial elements.

CHAPTER 7: METHODS

Methods

Participants

The primary independent variable of interest was the subject's status as either an expert or novice contemporary dancer. Experts ($n=20$) were those reporting to have had at least eight years of consistent training in contemporary or modern techniques and were recruited from Seattle dance companies. Mean age was 30 years ($SD=6.37$). Novices ($n=20$) were those reporting to have had less than one year of consistent training in any dance technique, and were recruited from graduate and undergraduate populations at the University of Washington. Mean age was 31 years ($SD=8.97$). All participants were female. All participants gave informed consent, were naïve to the hypothesis, and were compensated with a \$5 gift card.

Video

A vocabulary of 17 movements was created for this research. The vocabulary was reduced from what is potentially an infinite population of movements by selecting representative movements from theoretically important gross movement skills such as: jump, turn, lunge, walk, and balance. These were then stylized to have unique configurations of arm, leg, and torso shapes which were not immediately identifiable with a codified dance vocabulary. Each movement in the vocabulary was created to last roughly 2-3 seconds and to include a variety of movements in the legs, arms, and torso. The movements needed to be repeatable under experimental conditions; therefore, movements were created in which the timing and angles of movements could be easily controlled. Additionally because this research was interested in the mental representation of movement without the aid of verbal mediation, attempts were made to create movements that were not immediately identifiable with commonly used dance vocabulary.

Thirty-two movement phrases were then created by combining four out of the 17 movements. In creating the phrases the movement to be manipulated would be selected and then three additional movements were selected to complete the phrase. No movement was subject to the same manipulation more than once and attempts were made to ensure that all 17 movements were equally represented across the 32 phrases. The 32 phrases were placed in a 4x4 grid which crossed the four categories of interest (Shape, Time, Space, and No Difference) with temporal location of the manipulation (1st movement, 2nd movement, 3rd movement, and 4th movement) (see Table 1).

Table 1. *Grid for determining which movement (1-4) was manipulated with which quality.*

Movement	Shape	Space	Time	No Diff
1 st	A1	B1	C1	D1
2 nd	A2	B2	C2	D2
3 rd	A3	B3	C3	D3
4 th	A4	B4	C4	D4

Note: Each cell represents two paired phrases (4x4=16 cells, two items per cell=32 items)

Each of the 16 cells, then, contained two four-movement phrases and determined which manipulation would be made to which movement. For instance cell A1 would have a manipulation to the Shape of the first movement; B2 would have a manipulation to the Time of the second movement, and so forth. In this way the type and temporal location of manipulation was balanced between the 32 phrases. In creating the manipulations, all attempts were made to ensure that only one category was altered, for instance, if Time was being altered, then changes to Shape and Space were minimized.

A professional Contemporary dancer was hired to perform the movement. For each phrase, an original and a manipulated version were filmed. For the No Difference phrases, the same phrase was filmed twice. In editing, videos were cropped to begin and end 1 second before or after the movement. The videos were then placed in a timed PowerPoint presentation (PPT) such that, on a keystroke, the first video would play, the PPT would then advance automatically to a black and white geometric image for five seconds, and then automatically advance to the second video. In a pilot study, a blank screen was presented for three seconds (instead of five seconds), experts accurately recognized all manipulations to shape and time. The duration of the inter-stimulus interval was increased to five seconds to avoid ceiling affects. At the end of the second video, the PPT would automatically advance to a screen indicating which number should be answered and would remain there until advanced by a keystroke.

The 32 phrases were randomized within four blocks using an online random number generator, such that each of the four blocks of eight items contained an equal number of the four categories of interest. An optional two-minute break was inserted after the 16th item.

Sample videos:

Manipulation to Shape: <http://youtu.be/9gdTevKCNc0>

Manipulation to Time: http://youtu.be/zyfZ1jo_jMI

Manipulation to Space: <http://youtu.be/FFV1dOPqxyQ>

No Difference: <http://youtu.be/hMAU7Elb1Nk>

Static visual representations of the items are presented in the Appendix.

Procedure

All participants were assessed individually. Following an explanation of the study and procedures and signing the informed consent form, the participants sat in front of a 14 inch laptop computer and were given a paper packet that included instructions and an answer sheet (see Figure 1). After participants read the instructions, the investigator practiced to example items with the participants to make sure the participants understood the instructions before beginning the experiment. Participants were allowed to keep the instruction sheet, with definitions for each category, available for reference throughout the experiment.

The participants viewed a series of 32 pairs of dance video clips, each about 10-seconds long. After viewing each pair, the participants selected one of four options on the answer sheet they felt best reflected the change in movement quality between the first and second video: (a) Shape, (b) Time, (c) Space, or (d) No difference. In addition, the participants rated their confidence to be used in separate analyses. At completion of 32 items, each participant responded to a short answer reflecting on the processes she used in making the judgments, and answered three demographic questions.

Instructions, Sample Response Option, and Short Answer Question

For this research project, you will be asked to watch a series of 10-20 second videos of a solo dancer performing dance movements. The videos you will see are paired. You will watch one video of dance movement, there will be a brief pause, and then you will watch a second video that is either the same movement, but from an alternate take, or mostly the same movement with a slight difference. After each pair of videos, you will be asked to make a choice. If you think the movement in both videos was the same, then you will mark **No Diff** (no difference). If you noticed a difference between the videos, then you will mark the appropriate quality that was changed: **Shape**, **Space**, or **Time**.

Shape: If a change has been made to Shape, then a relatively stable position of the dancer's body will have been altered. For instance, if, in the first video the dancer's leg is curved, and in the second video the dancer's leg is straight, then there was a change in Shape.

Time: If a change has been made to Time, then the duration of movements will have been altered. For instance, if, in the first video the dancer takes a length of time to curve her spine, and in the second video the dancer takes twice as long, or half the time, to curve her spine, then there was a change in time.

Space: If a change has been made to Space, then the dancer's movement through the environment will have been altered. For instance, if, in the first video the dancer's arm moves upward and in the second video the dancer's arm moves downward, or if there was a change in level or facing, then there was a change in Space.

No Diff.: The videos will never be exactly the same, and there might be slight differences in the way the dancer performs the movement in each clip. However if it looks as if the dancer is performing the same choreography, then there was no difference. (Note: **No Diff** is not an infrequent answer, if you don't see a change, that's ok. Don't overthink it.)

After each pair you will also be asked to rate how confident you are with your decision (1-5, with 5 being very confident)

1. Shape Time Space No Diff.

1	2	3	4	5
Not confident		Very Confident		

One final question. Since this projects seeks to better understand how people learn dance movements, it would be useful for me to read, in your own words, what process or proecesses you used to reach an answer.

Did you have a strategy to determine if a change had been made and, if you saw a change, which quality had been changed? (Please provide a short written answer below.)

Figure 1. Instructions, sample response option, and short answer question

Dependent Measures. The primary dependent measure of interest was participant's categorization of perceived manipulations on each of the 32 items. There were 8 items for each category (Shape, Time, Space, and No Diff). Participant responses were coded as either correct or incorrect for each item and a score that reflected the number of correct answers, out of 8, was calculated for each participant in each category. Additional dependent measures included participants' confidence rating for each item on a scale of 1-5 (1= not confident, 5= very confident), as well as participants' short answers, which were analyzed for trends in learning strategies and coded according to a grounded theory perspective.

Validity. Before finalizing the videos, the researcher reviewed the manipulations separately with a Certified Movement Analyst and Associate Professor of Dance to verify that the assignment of a manipulation to an individual category was accurate. Manipulations that were inaccurate were reassigned to the appropriate category. Manipulations that were unclear or could be considered a manipulation to more than one category were re-choreographed and re-filmed.

Reliability. Cronbach's α was used to estimate the internal consistency among items within each category. Low α levels ($<.7$) indicate that the items within each category are not consistently measuring the same construct (see Table 2).

Table 2. *Reliability analysis*

Category	Cronbach's α		
	Combined	Novice	Expert
Shape	.02	.13	0
Time	.19	.32	.32
Space	.49	0	.20
No Diff	.53	.32	.55

Note: Combined $N=40$, novice $n=20$, expert $n=20$. $\alpha > 0.7$ preferred.

Mean confidence ratings by group were also calculated for each category as an estimate of category difficulty. Experts were more confident than novices that they had recognized a manipulation to Shape (novices, $M=2.99$, $SD=0.69$, experts $M=3.50$, $SD=0.64$), $t(38)=2.43$, $p<.05$. However, there were no differences between experts' and novices' ratings of confidence in the other three categories (see Table 3).

Table 3: *Mean confidence ratings by group and category.*

Category	Novice		Expert	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Shape*	2.99	0.69	3.50	0.64
Time	3.23	0.80	3.57	0.76
Space	2.90	0.74	3.25	0.85
No Diff	2.81	0.76	3.14	0.76

Note. Novice $n=20$, expert $n=20$, mean confidence ratings (1-5, 5 being very confident). $*p<.05$.

A one-way repeated measures ANOVA was also conducted to determine if performance among blocks of 8 items (items 1-8, 9-16, 17-24, 25-32) differed from each other (to evaluate whether fatigue was playing a role in differences between groups. Although there was a significant main effect of block (i.e. differences between sets), $F(1,39)=8.58$, $p<.01$, follow-up pairwise comparisons revealed that only block 2 (items 9-16) has significantly lower scores than each of the other three blocks (unadjusted p -values $<.05$). Any differences we find comparing

experts and novices therefore are likely not going to be due to fatigue, but rather to the presence of particularly difficult items within block 2 (see Table 4).

Table 4. *Comparison of performance by block*

Block	M	SD
1 (Items 1-8)	3.83	0.25
2 (Items 9-16)	2.75	0.24
3 (Items 17-24)	4.20	0.19
4 (Items 25-32)	4.18	0.23

Note. $N= 40$. Individuals performance by block (items 1-8, 9-16, 17-24, 25-32) was summed (max. of 8).

CHAPTER 8: RESULTS

Results from Comparison of Means

Means and standard deviations are presented in Table 5, and intercorrelations among outcomes in Table 6.

Table 5. *Mean correct answers by group and category.*

Category	Novice		Expert	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Shape	3.10	1.41	3.65	1.18
Time**	3.70	1.46	5.65	1.42
Space*	1.80	1.11	2.75	1.45
No Diff*	3.95	1.67	5.30	1.78

Note. Participants' responses were summed across categories (maximum of 8) and groups' ($n=20$ novice, $n=20$ expert) means were compared with four t tests. * $p<.05$, ** $p<.001$. p -values unadjusted for multiple comparisons.

Table 6. *Correlation matrix.*

Measures	1.	2.	3.	4.
1. Shape		-0.00	0.13	0.35
2. Time	-0.24		0.16	0.21
3. Space	-0.02	-0.20		-0.01
4. No Diff	-0.24	0.34	0.08	

Note. Expert ($n=20$) correlations reported on upper diagonal, novice ($n=20$) correlations reported on lower diagonal. No significant correlations were found.

The number of correct answers in each category was summed for each participant and the means between expert and novice groups were compared. There were significant differences between the novice and expert groups on three of the four categories (see Figure 2).

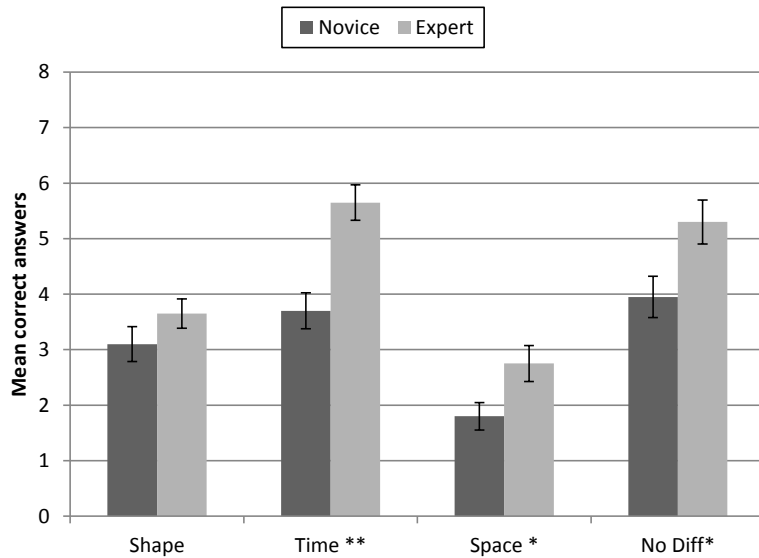


Figure 2. Results from comparison of means. Participants' responses were summed across categories (maximum of 8) and groups' ($n=20$ novice, $n=20$ expert) means were compared with four t tests. * $p<.05$, ** $p<.001$. p -values unadjusted for multiple comparisons.

No significant differences were found between novices' scores ($M=3.10$, $SD=1.41$) and experts' scores ($M=3.65$, $SD=1.18$) for the perception of manipulations to Shape, $t(38)= 1.34$, $p>.05$. There were, however, significant differences between novices' and experts' scores in the perception of manipulations to Time (novices, $M=3.70$, $SD=1.46$, experts $M=5.65$, $SD=1.42$), $t(38)= 4.28$, $p<.001$, $d= 0.96$, and Space (novices, $M=1.80$, $SD=1.11$, experts $M=2.75$, $SD=1.45$), $t(38)= 2.33$, $p<.05$, $d= 0.52$. Experts were better than novices at identifying manipulations to spatial and temporal elements. There were also significant differences in scores for the perception of No Difference (novices, $M=3.95$, $SD=1.67$, experts $M=5.30$, $SD=1.78$), $t(38)= 2.47$, $p<.05$, $d= 0.55$. Experts were better than novices at determining if no manipulation had been made to the movement. There were no differences between groups in the perception of manipulations to Shape, but there were differences between groups in the perception of

manipulations to Time and Space. It is possible that experts' mental representations of the movements they viewed included more information about pathways, orientation, and durations of the movement than the mental representations of novices. These more complex representations allowed experts to recognize differences between videos better than novices.

Results from Error Analysis

For each incorrect answer, the number of times each of the other options was chosen by a participant was summed within each category (e.g., the number of times a participant chose No Diff when the correct answer was Shape) and the *means* were compared between expert and novice groups (see Figure 3).

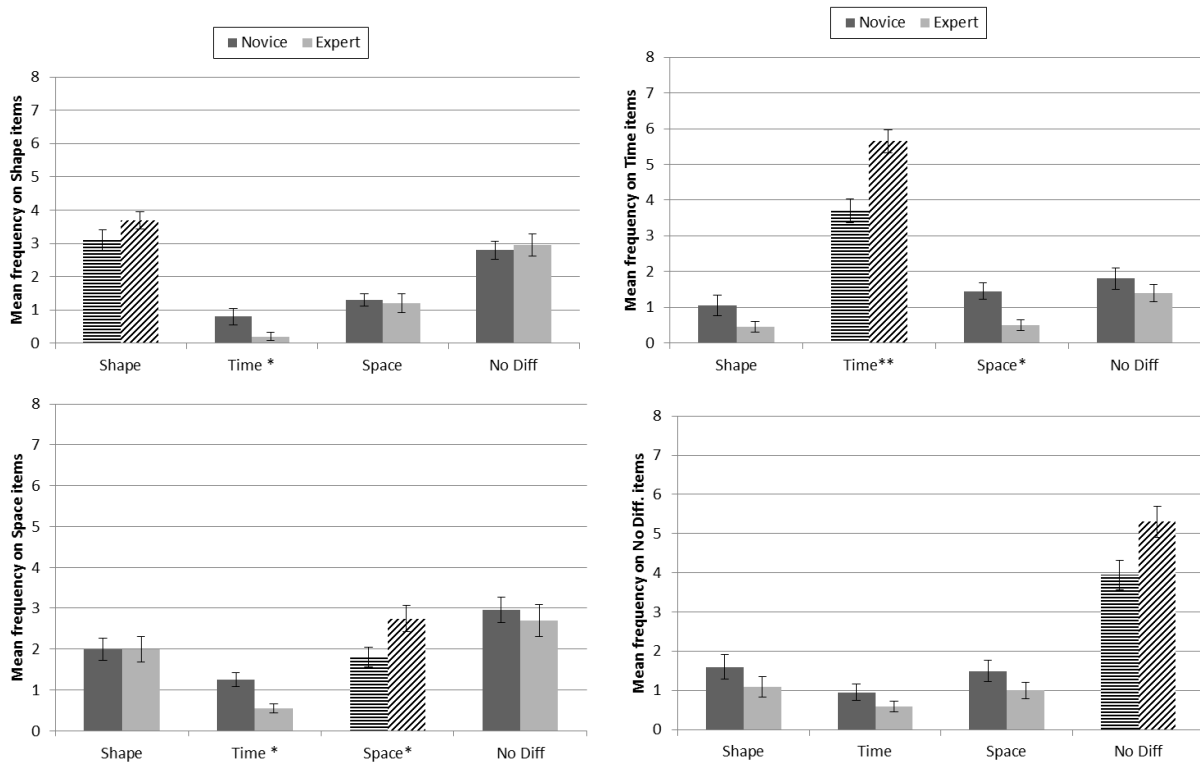


Figure 3. Error analysis. Patterned bars are correct answers, included for ease of comparison purposes. * $p < .05$, ** $p < .001$. p -values unadjusted for multiple comparisons.

From the twelve possible comparisons of means, three significant differences were found. Novices were more likely than experts to misappropriate manipulations to Time to the category of Space (novices, $M=1.45$, $SD=0.23$, experts $M=0.50$, $SD=0.15$), $t(38)= 3.50$, $p<.05$, $d= 0.78$). Novices were also more likely to misappropriate manipulations to Space to the category of Time (novices, $M=1.25$, $SD=0.18$, experts $M=0.55$, $SD=0.12$), $t(38)= 3.34$, $p<.05$, $d= 0.75$). Finally, novices were more likely than experts to misappropriate manipulations to Shape to the category of Time (novices, $M=0.80$, $SD=0.25$, experts $M=0.20$, $SD=0.12$), $t(38)= 2.20$, $p<.05$, $d= 0.49$). Novices, overall made more mistakes and these mistakes were more evenly distributed across categories. Experts were less likely to confuse Space and Time, or to assign manipulations to Shape to the category of Time.

Results from Qualitative Analysis

Participants' responses to a short answer question were transcribed into a separate document that contained no information about group membership. Participant responses were reviewed and two major themes emerged as potential strategies for determining if there was a manipulation to the movement. These themes were: verbal labeling, and simulation. Simulation was further broken down into kinesthetic and aural simulation.

Verbal labeling referred to a response in which the participant explicitly mentioned assigning names to individual movements and using the words to help discern manipulations in the second video. *Kinesthetic simulation* referred to a response in which the participant explicitly mentioned following along bodily or imitating the movement from the first video, and then comparing the kinesthetic memory from the first video to the second video. *Aural simulation* referred to a response in which the participant explicitly mentioned recording an

internal rhythm or melody during the first video and then comparing the aural memory to the second video.

Responses were reviewed again, and if a response matched one of the three strategies it was coded as such. Six participants' responses reflected more than one theme, twenty-four participants' responses reflected only one theme, and ten participants' responses reflected none of the selected themes. Responses that contained no themes had vague responses which were mostly a reiteration of the instructions: "I tried to remember the dance moves and see if the dancer was doing the same on the second video." The presence of each of the four strategies was summed for each group. The frequency of reported strategies by group was compared with a series of 2-group chi-square tests of differences. There were no differences between groups in the use of verbal labeling ($\chi^2(1)=0.92, p>.05$). However, there were differences between the groups in the use of kinesthetic simulation ($\chi^2(1)=5.63, p<.05$) and in aural simulation ($\chi^2(1)=4.44, p>.05$) (see Table 7).

Table 7. *Frequency of strategies reported in short-answer question by group.*

Strategy type	Expert	Novice
Verbal labeling	10	7
Kinesthetic simulation*	1	7
Aural simulation*	0	4

Note. * $p<.05$.

CHAPTER 9: DISCUSSION

This research sought to investigate the differences in the perception of qualitative aspects of contemporary dance between novice and expert contemporary dancers. Participants watched 32 pairs of videos of short contemporary dance phrases and had to determine if a manipulation had been made between the videos, and further, if that manipulation was to the Shape, Time, or Space of the movement. Participants' responses were coded as either correct or incorrect, and the mean number of correct scores for each group was compared in each of the categories (Shape, Time, Space, and No Difference). Overall, experts were better than novices at recognizing if a manipulation had been made to the movement. This finding could indicate there is general ability to perceive changes to dance movements associated with experience. However, an analysis of group differences by category indicates that performance varied depending on the category of manipulation.

Although there were no differences between experts and novices in the ability to recognize manipulations to Shape, experts did perform significantly better than novices at recognizing manipulations to Space and Time. It is possible that experts' and novices' mental representations of the dance phrases were comprised of similar amounts of information about discrete postural forms found in the movement. Experts' mental representations, though, included additional information about the pathways, orientations, and durations of the movement.

An analysis of self-reported strategies for determining if and what changes had been made indicated that while both novices and experts named individual movements in order to remember them, only experts attempted to simulate the movement, either kinesthetically or aurally. It could be that naming the movements aided in recognition by discretizing the

continuous action into a sequence of discrete shapes while simulation of the movement supplemented the experts' mental representations with spatial and temporal information allowing the experts to perceive the movement as continuous action.

Implications for Instrument Development

A large portion of this research was dedicated to the development of an instrument that could assess perceptual-cognitive differences between novice and expert dancers. All conclusions drawn from the data are dependent on the reliability and validity of the tool. Therefore a reliability analysis was conducted on items for each category (see Table 2, pg. 66).

If each category tested a distinct aspect of movement perception then performance across items within a category should be consistent. The low alpha levels (≥ 0.7 is preferred) indicate that the items are unreliable. The subsequent results, therefore, could be an artifact of the instrument and the hypothesized underlying differences might not exist. It is also possible that underlying differences do exist, but further instrument development is required to more reliably assess those differences.

Further analysis of participants' responses supports the latter option: the potential existence of underlying differences between expert and novice perceptions. An analysis of which option participants chose when they made an incorrect selection showed that novices were more likely than experts to choose Time when the manipulation was to Space. Novices were also more likely than experts to choose Space when the manipulation was to Time. This could indicate that novices implicitly recognized the existence of manipulations to Time and Space, but lacked the sophistication found in the experts to explicitly categorize that manipulation. Novices, however, were also more likely than experts to choose Time when the manipulation was to Space. It could, therefore, also be that novices tend to default to choosing Time when

they are unsure of how to correctly categorize the manipulation. Compared to experts, though, novices were more likely to confuse Space and Time, which could indicate that the ability to distinguish between the two categories was uniquely associated with expertise.

The qualitative data also suggest that there might be underlying differences in novice and expert perception. Although both experts and novices reported using verbal labels to attempt to remember the movement, it was a strategy reported more frequently by novices than experts (see Table 7, pg. 72). Additionally, the use of verbal labels might have been different between the two groups. For instance a novice stated, “I had to give names to the different moves, labeling the sequence, but could not also link directionality to those labels.” Another novice stated, “I found that the words I assigned focused on a certain aspect, like shape or time, but not all together.” An expert, however, who also reported using verbal labels stated, “I also tried to give each movement a name and tried to memorize the order. As I got to know the vocabulary, I was able to add details – i.e. Spoke, later became Spoke to Down Stage Left.” For the novices, it seemed that assigning verbal labels restricted their perception to the qualities implied by the label. For the expert, however, the label provided a schematic onto which more detailed information could be layered, in this case, its stage direction (a spatial component of the movement).

Experts also reported using either kinesthetic or aural simulation more than novices. For instance, one expert who reported using a kinesthetic strategy stated, “I felt a bit more of a physical compass, so to speak, attempting to dance with the phrase, with the dancer, in order to find more specificity.” Another expert stated, “I used my own body to kinesthetically adapt movement on the screen – ‘get it in my body’.” An expert who used an aural simulation strategy stated, “I talked to myself in rhythm as she’s moving the first time, and record overall pathways

and shape snapshots with my eyes. The second time I would sing those descriptive words with her.” The strategy of simulation is consistent with neuroscientific evidence that indicates that experience in dance leads to greater activation in neural pathways for simulation while watching familiar movement (Calvo-Merino et al., 2005). Both the novice and expert groups used verbal labeling as a strategy to recognize manipulations in the movement. Experts, though, were able to create more complex mental representations of the movement by layering qualitatively different information from simulation strategies.

The reliability analysis indicates that the significant findings from the group comparisons on responses within categories might be an artifact of the tool and not a function of underlying differences between groups. The data from the error analysis and the examination of the qualitative data indicate that although this tool might not be reliable, the comparison of groups’ performance on the categorization task is not unique in distinguishing experts from novices. The implications of the existence of underlying differences in mental representation between groups will be explored with the caveat that definitive conclusions should not be drawn until a more reliable instrument can be developed.

Implications from Group Comparison

For Production-Perception Relationships

Research from embodied cognition suggests that some aspects of mental representation remain functionally connected to sensation and perception through embodied states, situated action, and simulation (Barsalou, 2008). The findings from this dissertation are consistent with theories from embodied cognition that suggest the ability to produce an action is associated with shifts in the ability to perceive the same action. It is hypothesized that this is due to covert simulation of perceived actions in the Action Observation Network (AON), which acts as a

neural substrate for the comparison of perception and production (Gallese, & Goldman, 1998). This hypothesis is supported by the qualitative data in which experts reported using simulation strategies, both kinesthetic and aural. In this research, experts recognized manipulations to Space and Time more accurately than novices, but the two groups did not differ in recognizing manipulations to Shape. Expertise in contemporary dance, then, was associated with an improved ability to recognize spatial and temporal qualities of movement. Because expertise is also associated with simulation, this data suggests that the process of simulation is also associated with superior encoding of certain movement qualities (spatial and temporal), but not others (shape).

For Expertise in Dance

Research on the perceptual-cognitive structures of expertise suggest that, by more quickly recognizing meaningful associations between individual items, and chunking them, experts increase the amount of information stored in STM. This allows experts to sort through and evaluate options more efficiently than novices (Ericsson & Kintsch, 1995). A study by Starkes et al. (1987) suggested that expert ballet dancers used domain-specific rules about the sequence of movements in order to chunk dance phrases. In a second study (Starkes et. al, 1990), expert modern dancers recalled dance phrases more accurately than novices. Because the process of chunking has been validated as a perceptual-cognitive skill across domains of expertise, it was assumed the modern dancers were chunking elements of the movement, however, unlike ballet, sequence was not a factor and it was unclear what domain-specific relationships facilitated their ability to chunk.

The findings from this research on contemporary dance (considered the current equivalent of modern dance, see Chapter 5 for clarification) suggests that experts do not simply

recall more discrete movement, that is, have increased STM for Shape, but that their ability to retain more information from the first phrase is potentially due to information about the Shape of the movement being contextualized with information about Space and Time. This suggests that in the absence of domain-specific rules about the sequence of movements, contemporary dancers chunk the movements of the body with spatial and temporal cues to aid in the encoding and storage of dance movements. This is not to say that ballet dancers do not also chunk spatial and temporal information, simply that in the absence of genre-specific regularities about movement sequence, contemporary dancers rely more heavily on cues from Space and Time.

For Dance and Neuroscience and Motor Cognition

Investigations of dance in the field of neuroscience indicated that neural activity was modulated by experience (Calvo-Merino et al., 2005). While watching dance movement, novice dancers tended to have more activity in what is known as the ‘what’ pathway for visual perception and experts tended to have more activity in what is known as the ‘how’ pathway for visual perception (Calvo-Merino et al., 2010). The primary question arising from these findings was whether or not differences in neural processing were related to differences in mental representations of movement.

Research in motor cognition suggested mental representations of continuous action sequences are broken into discrete segments based on perceived goals. These segments are referred to as Basic Action Concepts (Schack, 2010). Research using BAC theory to investigate mental representation in dance suggested that expertise is associated with discretization of dance movements into a greater number of BACs as well as a more accurate ordering of BACs (Blasing, 2010). Taken together, the data from neuroscience and motor cognition would suggest that modulation from the ‘what’ pathway to the ‘how’ pathway is associated with a greater

number of discrete segments for the representation of movement. It seemed unlikely, however, that shifts in neural processing were associated exclusively with a greater number of BACs, but rather, that the quality of information encoded in each BAC was modulated as well.

The data from this dissertation indicate that mental representation of movement is different for novices and experts and, further, that the mental representations are qualitatively different. Although novices and experts performed similarly in the recognition of manipulations to Shape, experts performed significantly better than novices in the perception of manipulations to Time and Space. This could mean that both novices and experts mental representations of movement include information about discrete postural forms, or shapes that the body was making, but experts representations also included information about the duration of movement as well as pathways and relationships to the general space. It could be that a unique role of the ‘how’ pathway for visual perception is to incorporate spatial and temporal information above and beyond what is needed for recognition. This seems logical, in order to recognize an object, its spatial and temporal properties are less important than when intending to interact with the object. Expertise in contemporary dance, then, which is associated with shifts in visual processing from the ‘what’ to the ‘how’ pathway, is also associated with differences in the qualitative nature of mental representations for contemporary dance.

For Dance Education

The data of the current study preliminarily indicate that, for dance experts, spatial elements (such as the pathway of the movement, the direction the dancer was facing, and the direction she moved) and temporal elements (such as the duration of movements) were meaningfully connected, or chunked, to other elements for efficiency of recall. It could be that, when asked to remember a movement phrase, novices encoded the shapes of the body without

spatial reference (i.e., the dancer made a circle with her ribs). Experts, however, could have chunked information about Shape with Space (i.e., starting upstage, the dancer circled her ribs clockwise). Given the high demand on Short Term Memory, experts' chunking of Shape with Space and Time allowed more, or a different quality of, information to be encoded and available for recall.

This is, most likely, not a surprising finding for most dance educators. Laban's movement scales, for instance, help develop a dancer's spatial awareness. Texts on dance education often begin by drawing the learner's attention to the use of personal and general space (Green-Gilbert, 1992; Minton, 2003). Authors have even suggested that dance, used as a tool, in the physical education classroom, can improve spatial awareness skills in the general classroom (Smith-Stevens, 2004). This study sought to support this approach by contributing to the empirical research base. Although the role of spatial awareness is well conceptualized in dance education, validation from psychometric testing could be strengthened. If perceptual-cognitive mechanisms, such as spatial awareness, are uniquely associated with contemporary dance, further research is needed to more clearly define their structure and acquisition.

Research on the acquisition of expertise suggests that optimal practice occurs when participants are given appropriately difficult tasks, informative feedback, and the opportunity for repetition and correction. When these components are present, participants are engaged in what is called deliberate practice (Ericsson, Krampe, & Tesch-Romer, 1993). Deliberate practice in the technique classroom (as opposed to the creative dance classroom) often focuses, for good reason, on improving dancers' ability to execute movement. The dancer, though, is executing movement based on an internal mental representation. The fidelity of that representation to the original model (usually the teacher's or choreographer's demonstration) is dependent on the

student's ability to interpret and recall movement. Individual variation in performance could be due to an inability to physically execute the movement, but it could also be due to an inability to perceive and interpret critical aspects of the choreography. Within a dance technique class, for instance, it is common to see a novice dancer execute a *tendu á la seconde* (an extension of the leg with a pointed foot) directly to the side, instead of following the angle of rotation from the hip, which is the anatomically safer way to execute the motion. This is more likely due to an 'incorrect' mental representation (i.e. remaining faithful to the dimensional cross and truly moving front, SIDE, back) than to an inability to physically execute the 'correct' movement. Further it suggests that the mental representation of the novice is defined by the final shape of the *tendu* and not the pathway of the leg.

If there are systematic perceptual-cognitive differences between novices and experts, then, principles of deliberate practice could be applied to stimulus-interpretation training in dance. To accomplish this, an exercise could keep the technical demands of execution low, but increase demands on perception, for example, repeating a phrase with subtle manipulations to directional pathways. Assuming the ability to execute is held constant across dancers, the focus of feedback and correction would be on improving skills in perceiving shifts in pathways. The focus of deliberate practice in the dance classroom could shift between developing skill in movement interpretation and movement execution, bolstering both the internal and external components of performance.

Limitations

Several considerations limit the current findings. The first is the low reliability of the instrument, which was discussed as part of Implications for Instrument Development. Until

participants' responses are consistent within the individual categories significant differences between groups cannot be attributed to underlying perceptual-cognitive differences.

Second, the entire procedure is observational; participants are viewing and responding while seated in a chair. Dance expertise is kinesthetic expertise, in attempting to better understand the role of production and simulation in mental representation; it would be worthwhile to develop measurement techniques that allow dancers to express their expertise in a kinesthetic modality.

Third, this research used a modified same/different task in order to remove the need to verbalize what was observed. Although the author feels this was an improvement on previous research designs, it also presents its own difficulties. The primary concern, here, is the ambiguity of the response. The participants are watching between 6 and 12 seconds of dance, each phrase divided into 4 movements. When they provide a response of Shape, Time, Space, or No Diff, their perceptions are reduced to a single data point. Even if a participant answered an item correctly, there is no way to verify that she is responding to the intended manipulation. She might have perceived a manipulation that was unintentional or not present, but with the current data there is no way to verify which portion of the movement inspired the participant's response.

Fourth, in the development of the video, a compromise was made on the amount of vocabulary created. If the same four movements had been repeated in each video, participants would have quickly learned the movement between items aiding the perception of differences within items. Creating 4 unique movements for each of the 32 items totaling 128 movements, though, was a daunting and potentially unnecessary task. The qualitative data, however, indicates that a number of participants adopted a strategy whereby they named familiar movement to aid in recall and recognize differences. Because the data was self-reported and did

not specifically inquire about verbal labeling and simulation, it is unclear how many others were using one of these two strategies. It could be that strategy accounts for differences better than group membership. Further research could explore learning strategies with more depth.

Fifth, in both creating the video and explaining the instructions to the participants, the distinction between Shape and Space was problematic. It was decided that if, for instance, the movement of an arm passed through the same general space but was straight, curved, or angled, then the Shape had been changed. If however the movement of the arm took a different pathway through space but maintained its straight, curved, or angled structure, then the Space had been changed. In this example, though, even if the Shape of the arm is held constant, when a new pathway is adopted, then the Shape at the shoulder necessarily changes. Although the instructions and examples helped to clarify this difference, Shape and Space (and Time) are still deeply connected and categorization of manipulations was highly dependent on perspective. Future research could capitalize on this by explicitly showing the participants the manipulations and then, without definitions from the researcher, ask the participants to categorize the change.

Future Directions

Reliability and Validity

If this instrument is to be used again, further development is required to improve the reliability and validity of the items. A small sample of experts and novices could talk-aloud while viewing a sub-set of the items. This could be done for items with both a high and low rate of successful categorization. Better understanding precisely what elements of the phrase inspired participants choices could then be used to create new video pairs, which hopefully more reliably measure performance in each of the categories.

Understanding the Role of Production

As was mentioned in the limitations, the study design limited the kinesthetic response of the participants. Normally while dancers are learning movement they have the ability to follow along with what they are watching or create a kinesthetic schematic of certain movements (a process called marking). In order to better understand the role of kinesthetic response in the creation of mental representations of dance movement, several modifications to the current design are possible. One possibility is to retain the current format of the paired videos with a paper and pencil response, but place the participants in a more ecologically valid context. The experiment could be run in a dance studio. Participants could be asked to dress as they would for a dance class, warm-up if necessary, and be standing while viewing the video. They could be instructed to move as much as they would like while watching the videos. If means scores were higher, the role of production and simulation in mental representation would be further strengthened.

A second possibility would alter the study design considerably but would again move closer to achieving ecological validity. As in the previous modification, the experiment could take place in a dance studio with participants dressed appropriately and warmed up. They could be asked to view a short video of movement, similar to one in this design, and then, instead of watching a second video and being asked to make a cognitive distinction, the participants could be asked to physically repeat the movement they had just seen. Participants' danced responses could be video-taped and then coded for their fidelity to the original video in the categories of Shape, Time, and Space. It should also be noted that learning dance from video, might be a different skill than learning dance from a live model, which should also be addressed in future

research designs. A third possibility for the incorporation of kinesthetic experience is suggested in the next section on the role of language.

Understanding the Role of Language

The qualitative data indicated that many of the participants adopted a strategy of naming individual movements to aid in recall and recognition of manipulations. A modification of the study could provide further information on how critical the use of naming is in the mental representation of movements. Instead of beginning to watch the videos with no prior knowledge of the dance vocabulary, participants could be taught the vocabulary, through either physical or observational experience. Additionally, participants could be either exposed to the movements without names or explicitly taught names for each movement. There would then be 4 groups (Physical/No Name, Physical/Name, Observational/No Name, Observational/Name) which could be compared to each other and a fifth control group which would complete the experiment as it was designed for this dissertation. It would be expected that any exposure to the vocabulary would improve performance, with physical experience improving performance above and beyond observational experience. It would also be expected that being given names for the vocabulary would improve performance. Of primary interest would be the interaction between type of experience and naming. Would physical experience without explicitly naming the movements lead to better performance than observational experience in which the movements were explicitly named?

Including Additional Qualitative Elements of Dance

In creating the video it was essential that, in the second clip, the movement be repeated as close to the original as possible, unless there was a manipulation. This led to a very measured movement style; one that LMA might refer to as Vision Drive. In Vision Drive the

mover is using three elements of Effort (Space, Time, and Flow) but the fourth element of Effort is latent (Weight). Tai Chi would be an example of a movement practice that is primarily in Vision Drive, a child throwing a temper tantrum is not. It was felt that the addition of Weight Effort, understood as variations between strong or light, would increase the difficulty in accurately repeating the movement. It would also add another category level into the design and since there was no strong hypothesis about the perception of Effort, and Weight Effort in particular, it was decided that this quality would be held constant.

Future research, however, could incorporate all four Effort elements into the design. As was discussed in Chapter 4, an analysis of Effort is an analysis of the structures of movement that suggest intentionality. The design of this dissertation could be modified to better understand what elements of movement participants use to infer intentionality. Does a strong (Weight), quick (Time), direct (Space) movement of the arm imply something different than a strong, quick, indirect movement of the arm? Isolation and manipulation of these individual elements could help reveal how meaning is extracted from a variety of non-verbal behaviors.

Tools of Cognitive Science and Neuroscience

Although the findings from this research begin to shed light on how expert dancers' mentally represent dance movements, further research utilizing the tools of cognitive science and neuroscience would be useful in creating a more complete picture of the structure of dancers' mental representations. In this design, response times were not measured. The addition of response latencies could support the hypothesis that mental representation is supported by simulation. Previous research has shown that the time course for covert mental representation is positively correlated with the time course of the event being simulated (Decety, & Jeannerod, 1996), indicating that the representation likely involves a real-time simulation. If an analysis of

participant response times shows that experts take longer to respond than novices, or if response times vary as a function of the duration of the video, this could provide additional evidence that experts are using experience from production to simulate the movement.

Research using eye-tracking technology could also be beneficial in furthering the understanding of how dancers represent movement. A potential limitation of this study was the ambiguity inherent in reducing perception of manipulations to a single data point. The addition of eye-tracking data could disambiguate the results. If, for instance, the eye fixates on the location of the manipulation during the time the manipulation occurs, it could be said with more confidence that the participant's response is reflective of the intended manipulation. Other research using eye-tracking has indicated that dancers with more experience tend to fixate on background spaces while watching dance (Stevens et al., 2010). It is hypothesized that para-foveal and peripheral vision are better at tracking movement than foveal vision. In addition to replicating this data, it would be interesting to determine if successful categorization of Shape manipulations were associated with items in which the fovea was fixated on the location of the manipulation during the time the manipulation occurred, whereas successful categorization of Space manipulations occurred on items in which the manipulation occurred in para-foveal or peripheral vision.

For purposes of data analysis, this study was limited to contemporary dance, a female model, and female participants. Future research could increase its scope and test expert and novice differences, not only in other concert dance forms, such as ballet and jazz, but in social and ritual dance forms as well. Ballet has a finite vocabulary and all movements have French names by which they are commonly known and taught. Oftentimes the names define or imply duration or spatial orientation. Perception of elements of Space and Time, therefore, might be

subsumed by verbal representations. Dance forms like hula and bharatanatyam, are highly narrative and each movement is symbolic. Perception of Space and Time, in these forms, might be more deeply connected with the semantic content of the movement. Swing dance and other social dance forms emphasize the use of interpersonal space over general space. An exploration of different dance forms could reveal both similarities and differences in movement perception across genres. Results could also be replicated with male participants and a male model. Interactions between the gender of the participant and the gender of the model could shed light on the importance of identification in simulation.

Although research from Cross and Calvo-Merino, reviewed in Chapter 4, has provided neuroscientific evidence for the role of physical experience in modulating neural pathways for perception of dance, the suggestion, from this dissertation research, of distinct qualitative components in perception of dance, opens additional avenues for inquiry utilizing tools from neuroscience. The temporal resolution offered by EEG could provide evidence on activity in the dorsal and ventral pathways. Matched videos could be shortened to display a single movement that contains a manipulation to Shape, Time, or Space between the first and second viewing. The timing of the manipulation in the video could be compared to the timing and location of neural responses in the dorsal and ventral pathways. The spatial resolution of fMRI could also be capitalized upon. Participants could watch paired videos with manipulations while being scanned with fMRI and analyzed in a Region of Interest analysis. If recognition of manipulations to Shape are more strongly associated with activity in the ventral pathway, and recognition of manipulations to Space and Time are more strongly associated with activity in the dorsal pathway, conclusions about the relationship between expertise, neural processing, and movement quality would be strengthened.

Conclusion

It is the long-term goal of this research to contribute to the quantitative research base in support of arts education. It is believed that experience in the arts is a vital component of development, and that dance education can support the understanding of human movement as an important source of meaning. However, psychometric measurement in the arts, which would help substantiate this claim, is not widely practiced. This research, contributes to the quantitative research foundation in dance education by investigating perceptual-cognitive differences associated with expertise in dance. In this dissertation, novice and expert contemporary dancers watched pairs of videos that were either the same choreography or contained a single manipulation to an element of the choreographic phrase associated with Shape, Time, or Space. After watching each pair, participants were asked to select from one of four options they felt best reflected the quality that had been changed between the videos: Shape, Time, Space, and No Difference. Participants' responses were summed within categories and group means were compared. No differences were found between novices and experts in the discrimination of manipulations to Shape, however, significant differences were found between novices and experts in the discrimination of manipulations to Space and Time.

Although reliability analyses indicate that further instrument development is required before strong conclusions can be drawn, the data initially supports the idea that contemporary dancers are able to discern spatial and temporal elements of contemporary dance better than novices. This is consistent with research from neuroscience that suggests experience modulates neural processing in areas of the brain responsible for the comparison of production and perception through simulation. Further, this data suggests that processes of simulation provide unique access to spatial and temporal information. It is the hope of this researcher that once the

perceptual-cognitive skills associated with experience in dance are better defined, they can be used to support the framing of dance education, not just as peripheral, but integral to the cognitive and social-emotional development of all students.

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APPENDIX

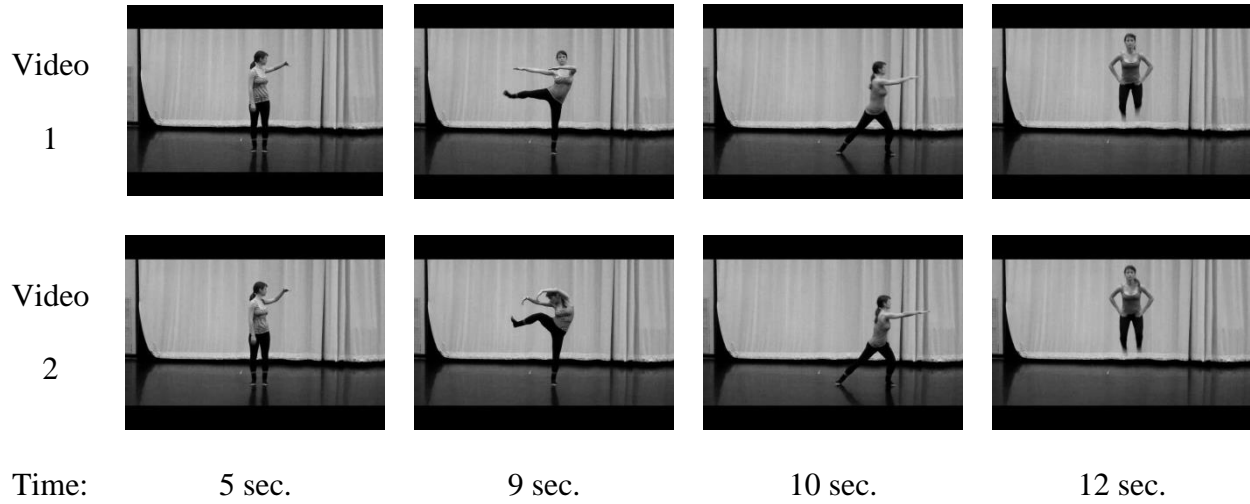


Figure 4. Manipulation to Shape. The shape of the arms changes from straight/angled in Video 1 to curved/curved in Video 2 on the second movement of the phrase.

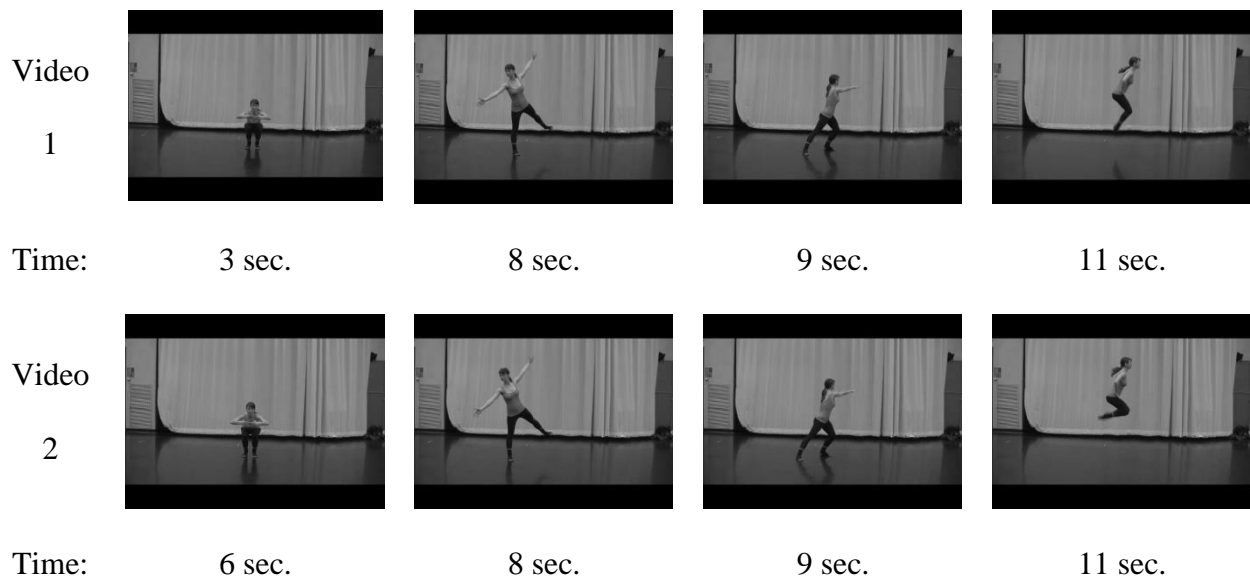


Figure 5. Manipulation to Time. The timing of the first movement involved a quick descent (3 sec.) and slow ascent in Video 1. The same movement was performed with a slow descent (6 sec.) and quick ascent in Video 2.

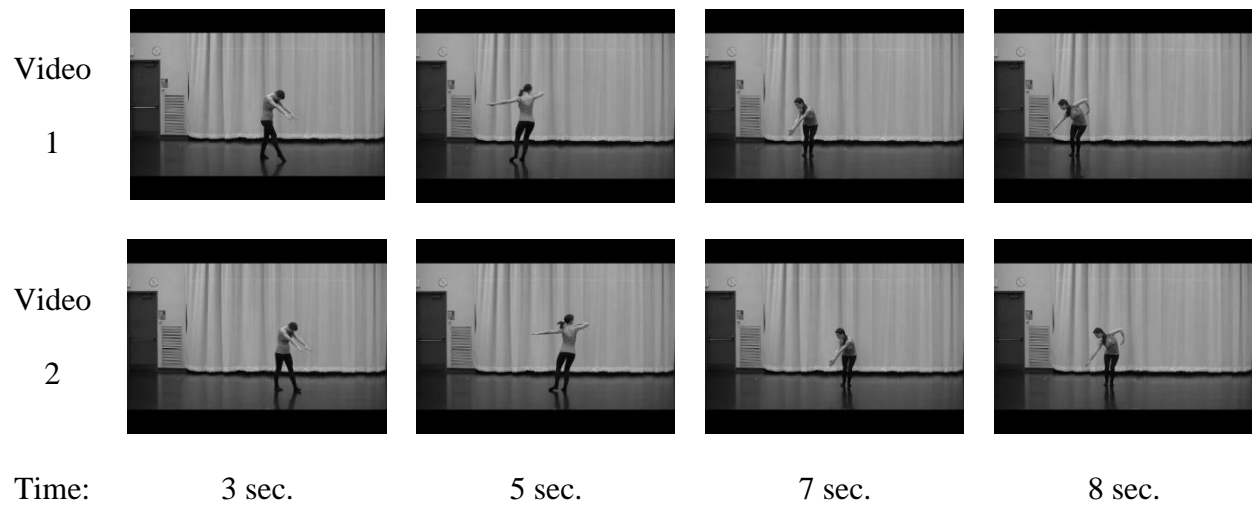


Figure 6. Manipulation to Space. The direction of the dancer's steps changes from backward in Video 1 to forward in Video 2 on the first movement of the phrase.

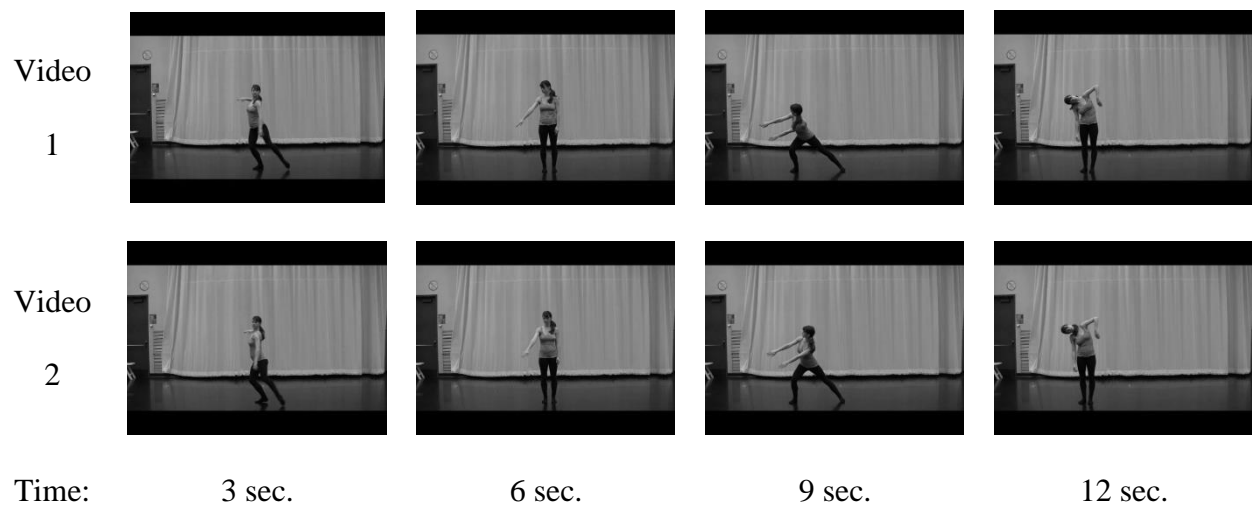


Figure 7. No Difference. Although there might be slight differences between the execution in Video 1 and Video 2, the shapes, timing, and use of space are not explicitly manipulated.