BODY of KNOWLEDGE

Untying the Knot of Dance Movement Expertise: An Enactive Approach

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Introduction

Many cognitive scientists are turning to dance experts to explore the relationship between bodily knowledge and perception. Dancers have a unique skill set that integrates physical and expressive abilities, making them intriguing participants in studies that examine how the action observation network, action prediction, learning, memory, cognitive abilities, and aesthetic preferences are related to one's physical experiences. Findings from these studies suggest that dance experts perceive and think about movement differently than novices, but the definitions of what constitutes a "dance expert" are far ranging, making it challenging to compare results across studies.

We discuss the variety of dance experts that are recruited for scientific studies, and draw upon research in dance education and sports studies to form a richer definition of dance expertise. One possible way to parameterize expertise in dance is by role (e.g. performer, teacher) and style (e.g. ballet, hip-hop). We illustrate that there is a challenge in differentiating expertise by style or role since many dancers have trained in multiple styles of dance and commonly have overlapping roles–thus creating a knot of expertise.

To untie this knot, we propose an enactive approach. Rather than label dancers as experts or novices based on an arbitrary requirement of the number of years a dancer has trained in a style or role, we suggest that broader categories of expertise will emerge from the data that go beyond both style and role. We predict four main types of expertise: Virtuosic, Expressive, Kinematic and Expressive. Through combining quantitative and qualitative methodologies such as psychometric measurement, eye tracking, brain imaging, phenomenological, and analytical accounts of movement we can develop a more complete understanding of how expertise relates

to ways in which dance experts observe, learn, and articulate movement. This research can both inform the study of movement perception and help define gaps in dance education.

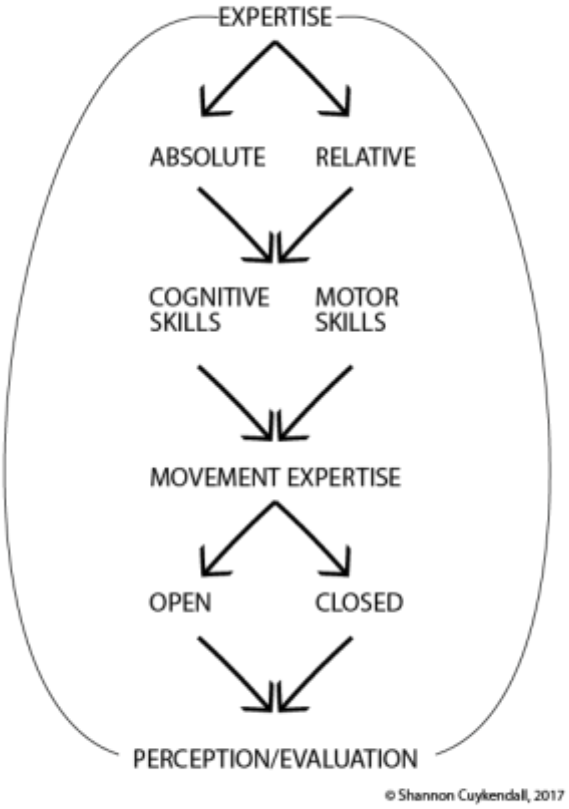

Figure 1: We illustrate the multiple routes researchers have taken in the general study of expertise.

Background

Expertise has been examined across a broad range of activities including chess, typing, music, medical procedures, painting, sports, and dance [1, 2]. An expert in any domain is generally referred to as "someone [who] has gained special skills or knowledge representing mastery of a particular subject through experience and instruction" [3]. Much of the research that

has evaluated expert skill and perception has developed out of a cognitivist approach that reduces the complex, dynamic relationship of the body, mind, brain, and environment into symbolic systems that describe information processing. In Figure 1 we illustrate paths that researchers have traditionally taken in expertise research. Through our literature review, we demonstrate the need to create new paths that acknowledge the integration of physical, expressive, and intellectual ways of knowing in dance.

Chi [4] distinguishes between *relative* and *absolute* expertise. Absolute expertise refers to "exceptional" individuals that are recognized as having innate talent and skills, while relative expertise explores differences between groups with varying skill levels. Traditionally, researchers have classified expert skills into two categories: *perceptual-cognitive* and *perceptual-motor*. Perceptual-cognitive skills refer to intellectual capabilities (e.g. strategy, decision making, and memorization), and perceptual-motor skills describe physical capabilities [5, 6]. This separation, between cognitive and motor skills, reflects a cognitivist tradition rather than an embodied perspective.

Generally, the study of *movement expertise* requires attention to both cognitive and motor skills and often these skills are entwined and domain specific. The examination of movement expertise is far ranging and can include the evaluation of motor and cognitive skills in surgeons, musicians, typists, athletes, and dancers. Allard and Starkes [7] distinguished between two types of movement skills: *open* and *closed*. Open skills are, "A skill performed in a dynamic environment, often including an opponent and having the production of a particular environmental event as its goal" [7]. While closed skills are, "A skill performed in an invariant environment and having the production of a particular motor pattern as its goal" [7]. Allard and

Starkes suggest that domains with closed movement skills include dance technique, diving, gymnastics, and figure skating and open movement skills are used in team sports such as, basketball and soccer [7]. The open and closed categories attempt to distinguish between the movement expertise required of a basketball player and a dancer. Yet, in practice dance performance demands both open and closed skills. Even in a choreographed dance production, the environment of a performance is never invariant, and one performs in relation to the audience, fellow performers, the body's sensations, and the conditions of the performance space. Many dance performances may also include environmental goals, especially in interactive works, where a dancer's movement triggers specific environmental changes in sound or visual projections.

Based on our literature review, we define two main directions of research in dance movement expertise: the study of *perception* and the *evaluation* of skills (See Table 1). Perceptual studies include research in embodied simulation [8], attention [9], and movement appreciation [10]. In these studies, researchers are more concerned with understanding *how* experts perceive, attend to, and sense movement rather than testing how well they perform a task. In evaluation studies researchers investigate skills such as recall [11], motor control [12], performance quality [13], recognition [14], empathy [15], and mental representation [16]. Findings from these studies inform the way in which researchers define and continue to study dance movement expertise, leading to a recursive process of expertise research. It is also important to note that many of the skills examined in these studies are not chosen based on insight from dance education, but rather previous scientific research that has been largely informed and conducted through a cognitivist lens.

Findings in Dance Movement Expertise Research

Researchers have explored three main assumptions in relation to dance movement expertise: 1) The way in which an expert dancer encodes movement (e.g. mental simulation, marking, verbal description) will impact dance-related abilities. 2) Dance training impacts how one perceives movement. 3) Expert dancers can execute, mentally represent, and recognize changes or patterns in movement better than novices.

Movement Perception	Evaluation of Skills
Embodied Simulation	Recall
Attention	Motor Control
Movement Appreciation	Performance Quality
	Recognition
	Mental Representation / Imagery
	Kinesthetic Empathy

Table 1: Research in dance movement expertise has gone in two main directions: studies in movement perception and evaluation of skills.

Many discrepancies have emerged when exploring these three assumptions. Considering the first assumption, Foley et al [17] and Kirsh et al. [18] came to different conclusions in how encoding methods influence memory in dance. Kirsh et al. [18] and Warburton et al. [13] reported different results of how dance marking, or encoding movement in a reduced form, influence a dancer's performance of dynamic qualities. In contrast to these studies, Bläsing et al.

[19] did not find differences in performance quality when dancers encoded movement through visual compared to verbal procedures.

Researchers have also reported mixed findings in regards to the second assumption. Stevens et al [9] and Petrakis [20] did not find comparable results of how eye movement patterns relate to expertise. Glass [21] and Reason and Reynolds [22] reached different conclusions on how a spectator's familiarity with movement impacted his or her enjoyment of the performance.

Lastly, researchers have reported contradictory findings in how dance experts perform various skills. Henley [14] found that expert dancers could see changes in timing better than novices; however, Sgouramani and Vatakis [23] did not find expertise related differences in how observers estimated the duration of slow and fast ballet steps. Contrary to previous studies, Jola and Mast [24] found that dance experts performed slower than novices in a mental object rotation task, and found no expertise effect in a mental body rotation task. However, Bläsing and Schack [16] found notable differences in mental representation between amateur and expert dancers. These discrepancies suggest that many factors play a role in determining an expert's abilities and perceptions, including the conditions of the experiment, the task performed, and the participants that are recruited.

The inconsistent findings in dance movement expertise research make it challenging to develop a rigorous definition of dance expertise. From an embodied perspective, many questions remain untouched such as: 1) Does a dance movement expert need to be an expert mover? 2) How does one's physical and intellectual abilities relate to our dance expertise? 3) How does the decline of one's physical abilities or intellectual abilities affect one's dance movement expertise?

We propose that the first steps in answering these questions are evaluating what types of dance experts most commonly participate in scientific studies and unpacking how the nature of their expertise relates to our current understanding of dance knowledge.

Defining Dance Movement Expertise

Many researchers have suggested types of skills and knowledge that dance experts acquire. Bläsing et al [25] define dance expertise as: "Dance expertise can be acquired to different degrees of professionalism, often judged according to the performers' physical virtuosity in terms of limb coordination, flexibility, and strength, as well as other performative and esthetic elements that are more subjectively determined." Dancer and cognitive neuroscientist Corrine Jola suggests three main skills in dancers besides muscular strength and flexibility including spatial awareness, body representation, and perception of time [26]. Matthew Henley, a dance education researcher suggests that dance expertise is "…associated with improved discrimination of shapes, space, and time" [27].

Experts have typically been identified based on social reputation, education, and having over ten-years of experience in the domain. Support for the ten-year rule has been identified in activities such as chess; however, it has not been found in all domains [28]. Ericsson [29] argues that expertise is not based on years of experience, but hours of "deliberate practice," or concentrated, focused practice. These ideas have since morphed into the "10,000-hours-of-practice rule," made popular by science writer Malcolm Gladwell in his book, *Outliers* [30].

In addition to hours of deliberate practice, Ericsson and Lehman [1] suggest that age plays a factor in expertise and depending on the domain, experts reach their peak performance at

different stages. For example, sports expertise peaks in one's twenties, fine motor skills peak in one's thirties, and creative achievements tend to peak in one's thirties and forties.

Dance experts train for a wide variety of skills and their expertise crosses skills required for sports, fine motor performance, and creative skills. Dancers are not only training to be proficient movers that can memorize a long series of movement, but must also be expressive artists, creative thinkers, and attuned observers. Often dance experts have many overlapping types of skill sets, and many performers are also teachers, choreographers, and avid dance audience members. Additionally, dance experts frequently participate in other types of movement practices such as somatics, sports, and martial arts. We refer to these overlapping skill sets as the knot of dance movement expertise.

In the following sections, we describe criteria that is regularly taken into consideration when recruiting dance experts for scientific studies. We use literature in dance education and findings from movement expertise research across multiple disciplines to analyze the types of experts that are commonly examined in dance expertise studies. Through our analysis, we demonstrate the need to not only better define expertise, but to also develop new research methods that can aid in untying the knot of dance movement expertise.

Style

Dance experts commonly have experience in more than one style of dance, and dancers are often recruited based on the dance form they are currently practicing. Researchers have examined a variety of different dance styles such as, ballet, modern, contemporary, capoeira, tango, breakdancing, and salsa (See Table 2). Researchers limit their recruitment criteria to either

focus on one style of dance [11] or compare different styles [15]. A few studies have found that perception and skills vary across different styles of dance. Using quantitative methodologies, Starkes and Deakin [11] and Starkes et al. [31] suggest that the ability to recall unstructured dance sequences may vary between ballet and modern dancers. Koehne et al. [15] found that tango and capoeira artists scored higher than salsa and breakdance artists on tests measuring their ability for kinesthetic empathy. In qualitative studies, Bull [32] describes differences in how dancers use primary senses such as touch, hearing and sight, when practicing ballet, Ghanaian dance, and contact improvisation. In a phenomenological study, Ravn [33] found differences in how butoh, ballet, and contemporary dance practitioners sensed the weight of their bodies.

Despite these findings, some researchers recruit a group of expert dancers that have varied experiences with multiple styles of dance. Jola and Mast [24] recruited dance artists in ballet, modern, contemporary, or jazz. They found that experts performed worse on mental object rotation tasks than non-experts. One explanation for this finding may be that the experts' techniques for mental rotation did not transfer to the general stimuli that was used in the experimental task. They state: "…some dancers indicate that they are able to vividly imagine a pirouette or a battement, but not any other types of movement which are not specific to their field of expertise. Several studies have shown that the effects of expertise acquired in dance or related sports activities do not transfer to other types of movement" [24].

Bläsing and Schack [16] recruited expert participants from both modern and classical companies. Using ballet steps as their stimuli, they found that experts were better at performing mental representation tasks than novices. The ballet stimuli did not appear to adversely affect dancers that had been primarily practicing modern dance. However, it is difficult to know if style

may have had an effect in this study, since often modern dancers have had some training in ballet. In summary, researchers often report on style in scientific studies, but it is challenging to draw conclusions about how training in various styles of dance influence expertise and how skills transfer across varying types of stimuli.

Role

Most studies in dance expertise have examined current dance performers, and there is little information regarding how much the participants perform or if they have participated in other roles within dance (See Table 2). Jola and Mast [24] is one of the few studies that included experts in various roles such as, performers, teachers, choreographers, and managers; yet, there was no investigation into how these various roles may influence the experts' ability to execute the experimental task. In contrast, findings from sports studies indicate that abilities vary between judges, referees, and coaches as well as between various positions, such as a goalkeeper or forward in soccer [5]. Judith Lynne Hanna, a dance education researcher, also describes differences between choreographic and performing skills in dance:

> The choreographer and the dancer use knowledge differently. The creativity of making set dances and improvising within a style requires declarative and procedural knowledge (usually tacit) or relational rules for matching movements with appropriate meanings...In contrast to dance making, dance imitation (or dancing someone else's choreography) depends on learning a set pattern that involves analogical and spatial abilities [34].

Based on evidence in sports expertise and insights from dance education, it seems likely that one's role in dance may impact how an expert perceives and executes experimental tasks; however, so far there have not been many scientific investigations that examine these relationships.

Level and Training

Researchers report a dancer's training and experience differently across studies (See Table 2). Most studies examine either students or professionals, but some, such as Jola and Mast [24] include both students and professionals in their expert pool. Stevens et al. [9] report the average years of training and performance experience of expert participants. Jola and Mast [24] report the average minutes the dancers have trained per day and the percentage that held college degrees. Bachrach et al. [35] report not only the experts' average years of experience, but also their average hours of deliberate practice. Bläsing and Schack [16] report that their expert participants had a range of 7-35 years of experience.

In addition to reporting the hours, minutes, and years of experience, many researchers report additional criteria taken into consideration for recruitment of expert dancers (See Table 2). Orgs et al. [36] recruited student dancers that had started their training before the age of ten and had taken daily dance classes for the past four years. Jola and Mast [24] required that experts had at least one hour of dance training per day for the past five years. Bachrach et al. [35] recruited experts that had at least four years of dance training.

An expert's amount of experience is one of the most commonly reported criteria across studies; however, some studies indicate that this may not be the best metric to determine expertise. Bläsing and Schack [16] found differences between professional and student dancers in mental representation tasks, even when the two groups had overlapping years of experience. Starkes and Deakin [11] compared between expert and non-expert dancers that had an average of

5 or 4.7 years of training respectively. In this case, the main difference between the experts and non-experts was not their years of experience, but the prestige of the places they had trained.

As mentioned earlier, Ericsson [29] has suggested that hours of "deliberate practice" may be a more reliable indicator of expertise than years of experience, but how should researchers determine what counts as "deliberate practice" in dance? Bachrach et al. [35] examined dance observation and calculated deliberate practice based on the hours the participants had spent in dance or somatic movement classes. Many studies have found that both visual and physical familiarity with dance influence perception [8, 37, 38]; yet, a dancer's observational experience is rarely reported.

Age

The ages of experts across studies range from children to adults (See Table 2). Although previous research suggests that age may influence expertise [1], Bruyneel et al. [12] is one of the few studies that have examined age-related differences in dance expertise. In a qualitative study we previously conducted [39], we found differences in how performers describe their movement depending on whether they had started ballet training in their youth or adulthood. Research in neuroscience also suggests that childhood learning is important to musical expertise [40]. Therefore, we suggest that gathering information on the age an expert began training is equally important to reporting the ages of the experts.

Source	Style	Role	Level	Experience	Additional Criteria	Age
Bachrach et al [35]	Contemporary	Performer	Professional	M= 20, 416 hrs. of deliberate practice SD = 16,531 M= 17.85 yrs. SD = 5.82	At least 4 yrs. training	M=27.65 SD = 6.07
Bläsing and Schack [16]	Classical and Modern Dance	Performer	Professional (experts) Student (amateur)	7-35 yrs. training, M=16.75, SD=6.86 1-20 yrs. training M=8.22, SD=7.22		18-40 yrs. M=26.44, SD=6.76 16-45 yrs. M=29.44, SD=6.89
Jola and Mast [24]	Ballet Modern, Contemporary Jazz	Performer Teacher Choreographer Manager	Professional or Student	M=213 min/day SD=120.2	One hour of training per day over the last 5 years	M = 30.5, SD = 6.81
Koehne et al. [15]	Tango Salsa Capoeira Breakdance	Not reported	Not reported	Not reported	At least 18 yrs. old German, mother tongue	Not reported
Orgs et al. [36]	Contemporary and Classical	Performer	Student	Began dancing by 10 yrs. of age	Daily classes for past 4 years Folkwang University Germany	M=25
Stevens et al. [9]	Contemporary	Performer	Not reported	M=19.5 yrs. training SD= 3.87 M= 13.5 yrs. perform SD=5.20		M=28.63 SD=6.12
Starkes and Deakin [11]	Ballet	Performer	Student	Experts: M=5 yrs. Novices: M= 4.7 yrs.	National Ballet School of Canada Two local ballet schools	M=11.3 yrs. M=10.9 yrs.

Table 2: Recruitment criteria in scientific studies that examine dance movement expertise.

Future Directions

The varying reporting styles and far ranging criteria in dance expertise research make it difficult to compare results among studies. Most studies focus on evaluating differences between experts and novices rather than comparing between different types of experts. Based on prior research in dance education and expertise, we propose there are many different types of dance knowledge. Experts acquire skills for performing, observing, articulating or creating dance through various movement practices and roles in which they participate (e.g. teacher, coach, audience, performer). To effectively examine dance expertise, we need to form a richer definition of movement expertise and consider how overlapping movement training backgrounds and experiences contribute to dance knowledge.

Dance Enaction: A Theoretical Framework to Study Dance Expertise

Warburton [41] coins the term *dance enaction* as a theoretical framework in which to study "dance thought in action." Dance enaction is derived from Varela, Thompson and Rosch's theory of enactive cognition [42] that attempts to bridge the gap between human experience and traditional scientific methods. According to Evan Thompson, "The basic idea of the enactive approach is that the living body is a self-producing and self-maintaining system that enacts or brings forth relevance, and that cognitive processes belong to the relational domain of the living body coupled to its environment" [42]. In contrast to other embodied approaches that have been used to examine expertise, such as the ecological approach, the enactive framework provides a way to differentiate between "online (time pressured)" and "offline (mental simulation)"' components of cognition [41]. Additionally, Eleanor Rosch compares enaction to other

embodiment theories stating, “Whereas most embodiment research focuses on the interaction between body and mind, body and environment, or environment and mind, enaction sees the lived body as a single system that encompasses all three” [42].

Warburton [41] defines three ways in which humans empathize and experience dance: *somatic empathy*, *kinesthetic empathy*, and *mimetic empathy*. Somatic empathy is foundational to all dance experiences and refers to a dancer’s sensitivity towards another’s intentions in movement. Dance practitioners use mimetic empathy to embody the movement of another. Warburton describes that mimetic empathy goes beyond “outward mimicry” and “aping,” and is “…the ability to put oneself imaginatively in place of another, reproducing in one’s own imagination and physicality the emotional tenor and movement form of another” [41]. Kinesthetic empathy describes the spectator’s experience of movement simulation when watching dance. Warburton suggests these three types of experiences in dance overlap with three main bodily actions discussed in the theory of enactive cognition 1) *self-regulation* (somatic) 2) *sensorimotor coupling* (kinesthetic) and 3) *intersubjective interaction* (mimetic) [41].

The theory of enaction suggests that our perceptions and experiences are entwined and continuously inform one another. Through a dance enaction framework, we seek to understand how dance-related experiences shape the body, mind, and brain rather than reduce an experience to a single cause. We propose a mixed-methods approach that compares physiological data, task performance, and subjective accounts of experiences. In addition to collecting each participant’s subjective account of the experimental task, we also collect data on the participant’s related experiences in movement practice and observation. Our emphasis on accounting for related

experiences allows for new modes of analysis which were not available in previous studies [43, 44].

Dance Enaction in Action: Designing an Experiment

We designed an experiment that includes eye tracking data, quantifiable accounts of task performance, and subjective accounts of the experimental task and other related experiences. Our main experimental task is based on a previous study in dance expertise conducted by Henley [14]. In this study, Henley asked expert and non-expert dancers to view pairs of dance videos and decide if the movement changed in shape, space, time, or remained the same between the two videos. Henley designed the movement stimuli to include varying types of gross motor skills such as jumping, balancing, turning, lunging, and walking [14]. We used many of Henley's custom-designed movements in the video stimuli for our study and similarly to Henley [27], we ask each participant to reflect on her experience of completing the task in a short interview session. Henley's experimental design provides a way to obtain quantifiable data on qualitative observations in dance. This structure can aid in finding relationships between quantitative and qualitative data and help overcome challenges discussed in mixed-methods approaches related to "over-interpreting" [43] results.

In contrast to Henley [14, 27], we supplement the main experimental task with eye tracking data and an extensive survey that asks participants to describe their past and current experiences in multiple types of movement activities. More specifically, the survey includes both quantitative and qualitative questions that inquire about the participants' experiences in performing, practicing, studying, competing, observing, creating, and teaching in the fields of

dance, somatics, athletics, martial arts, and kinesiology.[1] We intend to test several hypotheses that relate task performance, eye movement patterns, and subjective accounts of experiences.

In our study, we require expert participants to be female, 19 years or older, and professional, pre-professional, or college-level dance practitioners. We chose to include a wide range of dance experts so that we can test hypotheses of how style, role, level, training and age impact an expert's abilities and perceptions of dance movement. The expert participants we have recruited thus far have experience in multiple styles of dance including ballet, hip-hop, tap, jazz, contemporary, modern, bangra, improvisation, and gaga. Many of them have also participated in various roles (e.g. choreographer, teacher, and performer), and some have experience in somatic practices and athletics. Many of the novices we have recruited have some experience in dance in addition to experience in other movement forms such as somatic practices and athletics. We predict that some novices may complete the experimental task similarly to experts if they have similar movement experiences described on the survey. Our analysis of the data will not only evaluate differences between our pre-defined groups of experts and novices, but also examine alternative ways to classify the data that can inform future studies in dance movement expertise.

Towards a New Definition of Dance Expertise

We predict four main categories of dance movement expertise: *virtuosic*, *somatic*, *kinematic*, and *expressive* (See Figure 2). Virtuosic expertise refers to the ability to execute complex movement phrases. Somatic expertise is the ability to expand attention and describes

1 We are still refining the survey; however, a listing of the questions in the most current version can be found here: https://github.com/scuykendall/movement-expertise-survey

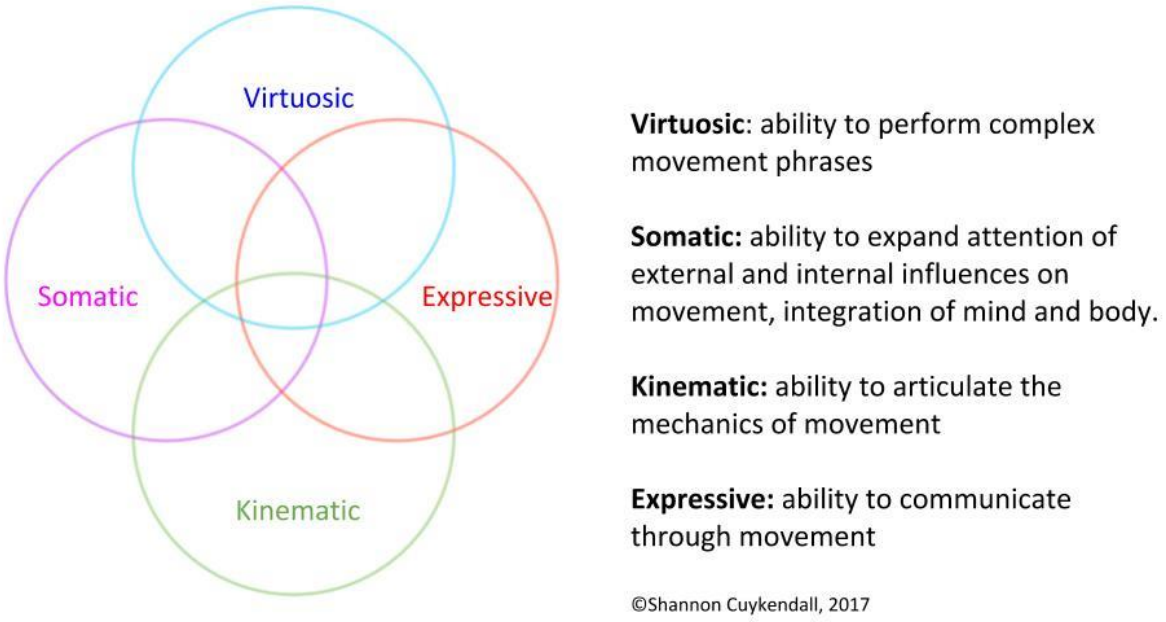

Figure 2: Categories of movement expertise

one's overall awareness of internal and external influences on movement. Kinematic expertise is the ability to articulate movement to others, and expressive expertise is the ability to effectively communicate through movement. These categories of expertise attempt to classify dance knowledge and skills across multiple movement practices, dance styles, and roles. For example, young dance performers may have a high virtuosic expertise, but low kinematic, somatic, and expressive expertise. Experienced dance teachers may have high kinematic expertise and low virtuosic skills if they are not actively training in dance. Knowledge within these categories may be further divided by the dance-style or genre of movement, but it is also possible that some skills may transfer across multiple styles and roles in dance. This model of dance expertise provides a starting point for researchers to further examine this complexity. Further, it suggests that dance knowledge is not just about recognizing patterns of movement or being able to

technically perform movement well, but also about the ability to effectively communicate, articulate, and attend to the multiple influences, intentions, and motivations of movement.

Conclusion

The study of dance movement expertise is still in its infancy. Although many types of movement expertise have been studied in relation to dancers, athletes, surgeons, musicians, and typists, a precise definition that distinguishes between these types of expertise is lacking from the literature. Most of the research in movement expertise has been heavily influenced by theories and assumptions put forth by a cognitivist approach that attempts to separate cognitive and motor skills. We suggest that new models of expertise need to be developed that emphasize the body's role in cognition.

We propose a dance enaction approach to the study of dance movement expertise and describe a mixed-methods approach to data collection and analysis that considers the relation between physiological data, task performance, and subjective accounts of experience. In contrast to previous studies, we emphasize the importance of the participant's related experiences and have constructed an extensive survey to use in dance expertise studies. We propose a new model of dance expertise that describes virtuosic, somatic, kinematic and expressive knowledge that provide a way to examine relationships of movement expertise both across movement domains and within specific dance styles or roles. Through comparing types of dance movement experts, we can better understand the role of the body in cognition and better define gaps within dance education and training practices.

References

[1] K. A. Ericsson and A. C. Lehmann, "Expert and Exceptional Performance: Evidence of Maximal Adaptation to Task Constraints," *Annual Review of Psychology,* vol. 47, no. 1, pp. 273-305, 1996.

[2] K. A. Ericsson and A. M. Williams, "Capturing Naturally Occurring Superior Performance in the Laboratory: Translational Research on Expert Performance," *Journal of Experimental Psychology: Applied,* vol. 13, no. 3, pp. 115-123, 2007.

[3] K. A. Ericsson, "Expertise," *Current Biology,* vol. 24, no. 11, p. 508, 2014.

[4] M. T. Chi, "Two Approaches to the Study of Experts' Characteristics," in *The Cambridge Handbook of Expertise and Expert Performance*, K. A. Ericsson, N. Charness, P. J. Feltovich, and R. R. Hoffman, Eds.: Cambridge University Press, pp. 21-30, 2006.

[5] N. J. Hodges, J. L. Starkes, and C. MacMahon, "Expert Performance in Sport: A Cognitive Perspective," in *The Cambridge Handbook of Expertise and Expert Performance,* K. A. Ericsson, N. Charness, P. J. Feltovich, and R. R. Hoffman, Eds.: Cambridge University Press, pp. 471-487, 2006.

[6] D. A. Rosenbaum, J. S. Augustyn, R. G. Cohen, and S. A. Jax, "Perceptual-Motor Expertise," in *The Cambridge Handbook of Expertise and Expert Performance*, K. A. Ericsson, N. Charness, P. J. Feltovich, and R. R. Hoffman, Eds.: Cambridge University Press, pp. 505-520, 2006.

[7] F. Allard and J. L. Starkes, "Motor-Skill Experts in Sports, Dance, and Other Domains," in *Toward a General Theory of Expertise: Prospects and Limits*, K. A. Ericsson and J. Smith, Eds.: Cambridge University Press, pp. 126-152, 1991.

[8] B. Calvo-Merino, J. Grèzes, D. E. Glaser, R. E. Passingham, and P. Haggard, "Seeing or Doing?: Influence of Visual and Motor Familiarity in Action Observation," *Current Biology,* vol. 16, no. 19, pp. 1905-1910, 2006.

[9] C. Stevens, H. Winskel, C. Howell, L.-M. Vidal, C. Latimer, and J. Milne-Home, "Perceiving Dance: Schematic Expectations Guide Experts? Scanning of a Contemporary Dance Film," *Journal of Dance Medicine & Science,* vol. 14, no. 1, pp. 19-25, 2010.

[10] L. P. Kirsch, K. Dawson, and E. S. Cross, "Dance Experience Sculpts Aesthetic Perception and Related Brain Circuits," *Annals of the New York Academy of Sciences,* vol. 1337, no. 1, pp. 130-139, 2015.

[11] J. L. Starkes, J. M. Deakin, and S. Lindley, "Motor Versus Verbal Recall of Ballet Sequences by Young Expert Dancers," *Journal of Sport Psychology,* vol. 9, pp. 222-230, 1987.

[12] A. V. Bruyneel, S. Mesure, J. C. Paré, and M. Bertrand, "Organization of Postural Equilibrium in Several Planes in Ballet Dancers," *Neuroscience Letters,* vol. 485, no. 3, pp. 228-232, 2010.

[13] E. C. Warburton, M. Wilson, M. Lynch, and S. Cuykendall, "The Cognitive Benefits of Movement Reduction: Evidence from Dance Marking," *Psychological Science,* vol. 24, no. 9, pp. 1732-9, 2013.

[14] M. K. Henley, "Comparison of Shape, Space, and Time Judgments in Expert Dancers and Novices: Evidence that Production Enhances Perception," *Journal of Dance Medicine & Science,* vol. 19, no. 3, pp. 103-109, 2015.

[15] S. Koehne, M. J. Schmidt, and I. Dziobek, "The Role of Interpersonal Movement Synchronisation in Empathic Functions: Insights from Tango Argentino and Capoeira," *International Journal of Psychology,* vol. 51, no. 4, pp. 318-322, 2016.

[16] B. Bläsing and T. Schack, "Mental Representation of Spatial Movement Parameters in Dance," (in en), *Spatial Cognition & Computation,* vol. 12, no. 2-3, pp. 111-132, 2012.

[17] M. A. Foley, V. Bouffard, T. Raag, and M. DiSanto-Rose, "The Effects of Enactive Encoding, Type of Movement, and Imagined Perspective on Memory of Dance," *Psychological Research,* vol. 53, no. 3, pp. 251-259, 1991.

[18] D. Kirsh, R. Caballero, and S. Cuykendall, "When Doing the Wrong Thing is Right," in *Proceedings of the 34th Annual Conference of the Cognitive Science Society*, pp. 1786-1791, 2012.

[19] B. Bläsing, J. Coogan, J. Biondi, L. Simmel, and T. Schack, "Motor Learning in Dance Using Different Modalities: Visual vs. Verbal Models," vol. 15, ed: Springer-Verlag, 2014.

[20] E. Petrakis, "Analysis of Visual Search Patterns of Dance Teachers," *Journal of Teaching in Physical Education,* vol. 6, no. 2, pp. 149-156, 1987.

[21] R. Glass, "Observer Response to Contemporary Dance," in *Thinking in Four Dimensions: Creativity and Cognition in Contemporary Dance*, R. Grove, C. Stevens, and S. McKechnie, Eds. Carlton, Vic: Melbourne University Press, pp. 107-121, 2005.

[22] M. Reason and D. Reynolds, "Kinesthesia, Empathy, and Related Pleasures: An Inquiry into Audience Experiences of Watching Dance," (in en), *Dance Research Journal,* vol. 42, no. 02, pp. 49-75, 2010.

[23] H. Sgouramani and A. Vatakis, "“Flash” Dance: How Speed Modulates Perceived Duration in Dancers and Non-Dancers," *Acta Psychologica,* vol. 147, pp. 17-24, 2014.

[24] C. Jola and F. W. Mast, "Mental Object Rotation and Egocentric Body Transformation: Two Dissociable Processes?," *Spatial Cognition & Computation,* vol. 5, no. 2-3, pp. 217-237, 2005.

[25] B. Bläsing, B. Calvo-Merino, E. S. Cross, C. Jola, J. Honisch, and C. J. Stevens, "Neurocognitive Control in Dance Perception and Performance," *Acta Psychologica,* vol. 139, no. 2, pp. 300-308, 2012.

[26] C. Jola, "Research and Choreography: Merging Dance and Cognitive Neuroscience," in *The Neurocognition of Dance* B. Bläsing, M. Puttke, and T. Schack, Eds. Hove and New York: Psychology Press, pp. 203-234, 2010.

[27] M. Henley, "Perception of Movement Qualities Associated with Expertise in Dance," PhD Dissertation, University of Washington, 2013.

[28] K. A. Ericsson, "The Influence of Experience and Deliberate Practice on the Development of Superior Expert Performance," in *The Cambridge Handbook of Expertise and Expert Performance*, K. A. Ericsson, N. Charness, P. J. Feltovich, and R. R. Hoffman, Eds.: Cambridge University Press, pp. 683-703, 2006.

[29] K. A. Ericsson, R. T. Krampe, and C. Tesch-Römer, "The Role of Deliberate Practice in the Acquisition of Expert Performance," *Psychological Review,* vol. 100, no. 3, pp. 363-406, 1993.

[30] M. Gladwell, *Outliers: The Story of Success*. New York, NY: Little, Brown and Company, 2008.

[31] J. L. Starkes, M. Caicco, C. Boutilier, and B. Sevsek, "Motor Recall of Experts for Structured and Unstructured Sequences in Creative Modern Dance," *Journal of Sport & Exercise Psychology,* vol. 12, no. 3, pp. 317-321, 1990.

[32] C. J. C. Bull, "Sense, Meaning, and Perception in Three Dance Cultures," in *Meaning in Motion: New Cultural Studies of Dance*, J. Desmond, Ed.: Duke University Press, pp. 269-288, 1997.

[33] S. Ravn, "Sensing Weight in Movement," *Journal of Dance & Somatic Practices,* vol. 2, no. 1, pp. 21-34, 2010.

[34] J. L. Hanna, "A Nonverbal Language for Imagining and Learning: Dance Education in K-12 Curriculum," *Educational Researcher,* vol. 37, no. 8, pp. 491-506, 2008.

[35] A. Bachrach, C. Jola, and C. Pallier, "Neuronal Bases of Structural Coherence in Contemporary Dance Observation," *NeuroImage,* vol. 124, Part A, pp. 464-472, 2016.

[36] G. Orgs, J.-H. Dombrowski, M. Heil, and P. Jansen-Osmann, "Expertise in Dance Modulates Alphabeta Event-Related Desynchronization During Action Observation," *European Journal of Neuroscience,* vol. 27, no. 12, pp. 3380-3384, 2008.

[37] C. Jola, A. Abedian-Amiri, A. Kuppuswamy, F. E. Pollick, and M.-H. Grosbras, "Motor Simulation without Motor Expertise: Enhanced Corticospinal Excitability in Visually Experienced Dance Spectators," *PLoS ONE,* vol. 7, no. 3, p. e33343, 2012.

[38] E. S. Cross, D. J. M. Kraemer, A. F. d. C. Hamilton, W. M. Kelley, and S. T. Grafton, "Sensitivity of the Action Observation Network to Physical and Observational Learning," *Cerebral Cortex,* vol. 19, no. 2, pp. 315-326, 2009.

[39] S. Cuykendall and T. Schiphorst, "Transmitting and Distributing Bodily Knowledge in the Digital Age," *Congress on Research in Dance Conference Proceedings,* vol. 2016, pp. 94-105, 2016.

[40] Y. Chang, "Reorganization and Plastic Changes of the Human Brain Associated with Skill Learning and Expertise," *Frontiers in Human Neuroscience,* Mini Review vol. 8, no. 35, 2014.

[41] E. C. Warburton, "Of Meanings and Movements: Re-Languaging Embodiment in Dance Phenomenology and Cognition," *Dance Research Journal,* vol. 43, no. 02, pp. 65-84, 2011.

[42] F. J. Varela, E. Thompson, and E. Rosch, *The Embodied Mind*. The MIT Press, 2017.

[43] C. Jola, S. Ehrenberg, and D. Reynolds, "The Experience of Watching Dance: Phenomenological-Neuroscience Duets," *Phenomenology and the Cognitive Sciences,* vol. 11, no. 1, pp. 17-37, 2012.

[44] A. Bachrach, Y. Fontbonne, C. Joufflineau, and J. L. Ulloa, "Audience Entrainment During Live Contemporary Dance Performance: Physiological and Cognitive Measures," *Frontiers in Human Neuroscience,* vol. 9, p. 179, 2015.