Interactive Tango Milonga

An Interactive Dance System for Argentine Tango Social Dance

by

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ABSTRACT

"Warning: tango contains highly addictive ingredients, such as pain, pleasure, passion, excitement, connection, freedom, torment, and bliss. In seven out of ten cases it takes over a person's life." --Naomi Hotta

When dancers are granted agency over music, as in interactive dance systems, the actors are most often concerned with the problem of creating a staged performance for an audience. However, as is reflected by the above quote, the practice of Argentine tango social dance is most concerned with participants internal experience and their relationship to the broader tango community. In this dissertation I explore creative approaches to enrich the sense of connection, that is, the experience of oneness with a partner and complete immersion in music and dance for Argentine tango dancers by providing agency over musical activities through the use of interactive technology. Specifically, I create an interactive dance system that allows tango dancers to affect and create music via their movements in the context of social dance. The motivations for this work are multifold: 1) to intensify embodied experience of the interplay between dance and music, individual and partner, couple and community, 2) to create shared experience of the conventions of tango dance, and 3) to innovate Argentine tango social dance practice for the purposes of education and increasing musicality in dancers.

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DEDICATION

For my parents Martha and Brent Brown, my twin sister, Heather Brown, and my partner in tango and in life, Brent Brimhall.

I acknowledge and thank Brent Brimhall for being my tango partner as well as unpaid artist assistant and providing unwavering support throughout my doctoral studies. For spending so many nights in rehearsal while holding a sometimes grueling dayjob, for running errands and saving me in a thousand small ways that add up to so much more than their sum, for providing valuable feedback, especially in terms of movement and embodied expertise, for believing in me in moments when I did not believe in myself – thank you.

I also want to thank my parents, Martha and Brent Brown, for their support and guidance. From them, I have learned that the most important part is the trying, not the outcome – life is a process. I thank my sister, who has come so unbelievably far after a tragic car accident and brain injury to lead a normal life in ways that the doctors claimed was impossible – she has been an ongoing inspiration. Without this mindset of perseverance, it is certain that I would never have reached this point. My family has also taught me the essential responsibility of each individual for giving back to the community and helping others in the ways that they are most capable and able. This work has been a reflection of my attempts to live up to that ideal.

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INTRODUCTION

Figure 1. Dancers Using the Interactive Dance System.

This chapter introduces Argentine tango and its social dance forms followed

by an outline of how these considerations form the framework for this research.

1.1 Introduction to Argentine tango, Connection, and Musical Interactivity

Argentine tango dance is grounded in the relation between two moving bodies,

leader and follower. Like other social dances, its focus is inward, emphasizing internal

experience over presentation (Olszewski, 2008). In every moment, improvised interplay

and nonverbal conversation determine movement quality, character and trajectory.

Lacking a basic step set to a specified rhythm, the tango couple is free to improvise and

determine the rhythmic phrasing and framing of their bodies in relation to the

accompanying music.

The tango concept of connection[1] refers to this interaction between dance partners and music, signifying both its mechanical and kinetic aspects, as well as the experience of feeling at one with one's partner, the music, and the rest of the dance floor (Olszewski, 2008; Cara, 2009; Seyler, 2009). Aspects of this connection, such as complete absorption in an activity, resemble Csikszentmihalyi's concept of flow (Csikszentmihalyi, 1990), as well as Judith Becker's description of trance (Becker, 2004). However, while the feeling of being at one with a partner is integral to connection, being in a flow state does not necessarily require another person.

Musicians may also experience a similar quality of connection when performing within ensembles. In the moment, they may lose their sense of being individual to a larger, transcendent whole. Like tango dancers, musicians, particularly when they are improvising, must engage in nonverbal interchanges that result in precisely timed movements and responses. For musicians, the main conduit of these conversations is sound rather than touch.

For instance, Thomas Turino describes flow experiences in participatory music[2], or in the context of "music as a social act," in which participants feel an intense "social connectedness" (Turino, 2008, p. 29). He stipulates that in order to be deeply participatory and facilitate these experiences, event attendants must make meaningful and substantial contributions to a shared musical outcome (ibid). Moreover, he includes social dancing as part of his definition of participatory music (ibid).

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[1] This internal experience is discussed in detail in Chapter 4.

[2] The term 'participatory music' is discussed in detail in section 1.3.5.

Music and dance have long been associated with one another, with some cultures not distinguishing between them (Small, 1998). Moreover, anthropological, musicological, and emerging technology-based research indicates that the movement of Western partnered social dancers is closely and intrinsically tied to the accompanying musical tradition. For instance, Nevada and Leman have revealed shared structures and patterns between music and dance in Samba and the Charleston[3] via motion capture and analysis (Naveda & Leman, 2009, 2010; Leman & Naveda, 2010). Performance analysis of Lindy Hop dancers has shown instances of how they use movement phrases delimiting rhythmic macrostructures in the music (Wells, 2014).

Interactive dance systems[4] further blur the distinction between musician and dancer, sonifying movements previously unsounded within dance traditions. In the context of Argentine tango, musical creation in real-time through an interactive system allows dancers an additional avenue for communication and improvisation: sound and musical structure. *Interactive Tango Milonga* gives dancers agency over music and investigates how this new relation through sound can amplify and add further dimensions to the internal experience of dancing Argentine tango.

Additionally, with this new musical agency comes a new responsibility, as dancer movement choices assume musical consequences affecting the entire dance floor, heard by onlookers and resting dancers. Thus, the creation of such an interactive dance system necessitates the development of new tango practices, sensitive to sonorous movement and

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[3] A style of jazz dancing.

[4] The term 'interactive dance systems' is discussed in detail in section 1.3.4.

ensemble sound. The stimulation of such exploration is another motivating factor for *Interactive Tango Milonga.*

1.2 Approach

The design of *Interactive Tango Milonga* flows from the aim of facilitating and deepening connection experiences. Musical agency is the tool that the system employs to achieve this goal, as it allows participants a way 1) to provide an integral contribution to musical outcomes 2) an additional, sounding conduit for connection to other dancers. Some aspects of system design are of particular importance to this goal including 1) timing of musical response 2) the ability to make musical mistakes while using the system 3) consideration for the consequences of dancers taking the role of a musician. 4) designing the system for the Argentine dance social context.

Timing is crucial to this sense of musical agency. Some movements, such as high-energy moves like a rebounding kick or a footstep are experienced as instantaneous, and thus, suggest immediate response. Similarly, certain musical properties, such as volume envelope, or the attack, give a visceral sense of agency when tightly coupled to these types of movements. Conversely, some movement properties are not experienced immediately, but emerge gradually from the dance, in varying time intervals. For instance, moving heavily, dramatically during the dance does not happen in an instant. Ideally, musical response accumulates along with dancer experience, arising as the dancer becomes aware of these movement qualities. The timing of the response should match the timing of the awareness of the action or movement quality.

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Moreover, musical responses may take the form of an event or a continuous response. For instance, while the accumulation and sustain of high-energy movement happens over a time window, thickening the orchestration by adding an instrumental line in response occurs as an event. An example of continuous/continuous translation is the quality of smoothness in the movement affecting how legato or staccato the resulting music is played. In addition, if system response is relatively stable, dancers should be able to create larger musical forms and phrases via self-similar movement. Thus, even at a macro level, time relationships are integral to developing musical intentionality.

The ability to make mistakes, that is, create undesired sounds that may be monotonous, off the beat, out of key is also another fundamental component to the feeling of musical agency in relation to a musical instrument or system. A system that creates beautiful music to every move of every dancer is not acknowledging stumbles, missteps, off-rhythm moves, or idiosyncratic explorations. When the system does not acknowledge these mistakes or explorations, cognitive dissonance builds between embodied understanding of an action and musical response in such a system. The dancer begins to perceive the locus of control to be outside of her body. Therefore, when the dancer errs, the music should reflect that inconsistency.

Interactive Tango Milonga invites the tango dancer to take on the role of both dancer and musician. However, dancer movement has purposes other than sound creation, such as visual impact or the somatic connection to a partner (Siegel & Jacobsen, 1998). Playing an instrument, even a virtual one, requires very specific movements; thus, it is possible that the more control a dancer has over the music, the less freedom the dancer has in choosing her movements for other reasons (Siegel & Jacobsen, 1998;

Jürgens, 2006; Toenjes, 2007). By design, almost all tango movement within *Interactive Tango Milonga* has musical consequences. Less freedom is lost, however, than in the case of the post-modern-contemporary/modern dancer. First, tango dancers are already dancing to structured, tonal music, ideally creating rhythmic phrases, acknowledging musical cadences, incorporating dynamic variation in response to musical characteristics such as tempo, timbre, and smoothness. Second, social dancers seldom move primarily for visual effect, as they are not dancing for an audience. Third, tango movement is highly stylized and further, limited by the embrace, even if that embrace is flexible to some degree.[5] The interactive system is designed for this movement vocabulary, responding to tango dancer movement in a reversal of the how they may have responded while synchronizing their movements to fixed music.[6]

Finally, the interactive tango social dance system must give consideration to the various cultural and social contexts of Argentine tango. If the system disrupts the essential activities of tango social dance, it will also rupture connection, an experience intimately associated with the tradition. In addition, such a system would be unlikely to be embraced by social dancers who value and respect that tradition. For instance, the majority of dancers at milongas (i.e., Argentine tango social dance events) switch partners every set of three to five songs (tandas), and frequently move on and off the dance floor. Social dancers are not likely to adopt an interactive system with motion tracking technology impeding these activities. Further, tango dancers dance to music that

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[5] The flexibility of the tango embrace varies widely by style. More discussion on this topic can be found Chapter 4.

[6] More types of music-movement relations, beyond only synchrony, are discussed in the Chapter 6.

falls within the Argentine tango tradition, along with their steps, embrace, and movements. It follows that an interactive tango system must engage with both traditional musical and movement structures, and the cultural and social milieu of Argentine tango.

This work is informed by my involvement as a social dancer in the global Argentine tango community, primarily in the United States. In order to develop this project, I conducted research in Buenos Aires via the contribution of the 2013–14 Fulbright Award. These experiences within the Argentine tango community informed system design and influenced my tango music composition, and place the work within the cultural context of contemporary Argentine tango dance and music practice.

1.3 Overview of Terminology

This section provides definitions of key terms used throughout this document. They are provided here because they also outline a conceptual framework as a semantic space reflecting the driving ontology of this research.

1.3.1 Argentine tango

Argentine tango refers to the music and dance tradition that developed in the Río del Plata region of Argentina and Uruguay during the mid to late 1880s. In this text, the term 'tango' refers to this tradition unless otherwise noted. Other dances named tangos include American Ballroom Tango and European Ballroom Tango, and it is these tangos that heavily dominate popular media and film portrayals of tango. These ballroom dances are out of the scope for this dissertation, as they employ a significantly different movement vocabulary and embrace, within cultural practices removed from those of

Argentine tango. For context, a brief discussion regarding these tangos and their place within larger tango history is presented in Section 3.2.2.

1.3.2 Connection

In Argentine tango, connection refers not just to the transcendent experience, but also to the physical relationship between partners and technique allowing nonverbal communication and improvisation (Olszewski, 2008). Chapter 4 covers various aspects of connection in detail, including its role as movement technique in section 4.5.

1.3.3 Agency and Intentionality

Agency is the capacity to act and produce an effect, while intentionality refers to mental state representing a commitment to carrying out an action. A feeling of agency is generally required for an actor to enter the mental state of having intentions or intentionality. However, an inanimate object may have agency, and a human who does not have intentionality may also have agency. Musical agency is the capacity to affect change in a musical outcome, while musical intentionality is having the goal to change musical outcomes.

1.3.4 Interactive Dance System

An interactive dance system refers to technology which tracks dancer movement, sends the data to a computer for analysis, which is then used to drive sound/music synthesis parameters, responding to dancer movement in real-time. Multimedia systems interactive with respect to video or other media are largely outside the scope of this dissertation.

1.3.5 Participatory Music

Participatory music refers to music as a social act, in which the roles of spectator and performer are fluid. Due to the strong performer/audience divide, performance works of all types generally would be considered presentational rather than participatory. Most interactive installations would not be considered participatory music, as participating in such a work is generally not part of an on-going social community or tradition.

1.4 Overview of Structure and Methodology

This section describes my dissertation's outcomes and structure.

1.4.1 Outcomes

This dissertation has two components, a written thesis and the development of an interactive system for Argentine tango dance. The interactive dance system consists of motion tracking, music and analysis technology as well as musical works, including both original compositions and arrangements of traditional tango music, arranged for use in the system[7]. *Interactive Tango Milonga* employed an iterative design process, assessing each prototype with user studies. These studies utilized Video-Cued Recall as a tool for assessing user experience, a technique in which subjects are directed to recount past experiences while watching video of themselves in the moment that they are describing. These studies examined the impact of dancer agency over music on their internal experience of connection.

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[7] Video documentation of the interactive tango system in use is here: http://vimeo.com/courtneydbrown/interactive-tango-milonga-performance-demonstration. This demonstration was recorded in Jan. 2016 and the version of this system is Prototype #1 as described in Chapter 7.

The interactive dance system has been primarily developed for use within the social dance context. Social dance refers to dances and events where participants dance, individually, in pairs or larger groups, on a common dance floor. The separation between performer and observer is fluid; the majority of the participants are skilled amateurs. Novices, intermediate and expert dancers all share the floor. By dancing, individuals are actively participating and engaging with social, music, and movement traditions and communities. By interactive social dance, I refer to one or more tango dancers using the system at the same time, creating tango music in real-time through their movement during milongas, practicas (informal social tango events), and other tango social dance occasions. Every couple on the dance floor may not be actively using the system; however, they are responding to the music generating by dancers using the system. *Interactive Tango Milonga* currently accommodates a maximum of two couples at a time. The system has also been successfully deployed unaltered, in the context of wheelchair tango[8], a style of Argentine tango adapted for participants using wheelchairs. Other outcomes for this system include interactive tango dance performance and use as a pedagogical tool teaching dancer musicality.[9]

The work described in this dissertation is the beginning of a longer cultural intervention. The tango interactive system has been designed not for a singular art installation or musical work, but to begin the process of developing new interactive tango practices. These practices are in no way a replacement; rather, they add to the richness of

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[8] The system was deployed at Tango for All, a local practica at the Ability360, Phoenix, AZ.

[9] In this dissertation, musicality will refer to how dancers move with or respond to the music.

existing practices. Additionally, to be effective in this task, eventually this project must move beyond my own idiosyncratic artistic practice into the community, where it can be used and adapted according to a diverse range of viewpoints and functions.

As a social dance system, *Interactive Tango Milonga* debuted at the weekly local practica El Abrazo in Scottsdale, Arizona, and has been used at ASU dance classes and other local practicas in the Phoenix, AZ area. As a performance, the work has been staged for the 2015 SSOO Festival in Flagstaff, AZ, and has also been performed locally in Tempe, AZ as well as the International Live Interfaces Conference (ICLI) 2016 in Brighton, UK.

1.4.2 Structure of Dissertation Text

This text examines Argentine tango dancer experience within the interactive tango system, analyzing issues of agency and embodiment as expressed and perceived within the specific cultural context. Additionally, this work presents the design, technological, social, and musical issues arising from the creation of this system, and documents the process of addressing them.

Chapter 2 addresses major issues and concepts emerging from interactive dance, placing this work within that context.

Chapter 3 explicates the historical, political and cultural background of Argentine tango, presenting the specific cultural setting for this work, speaking to its history of globalization, appropriation, and misunderstanding, and situating *Interactive Tango Milonga* within Argentine tango history and community.

Chapter 4 analyzes the Argentine tango concept of connection, giving an overview of related work on agency, embodiment, and internal experience. This chapter also examines the specific role of connection in tango dance including kinetic, musical, social, and timing aspects. Argentine tango movement practices and steps are also introduced, elucidating these concepts in relation to the interactive tango system.

Chapter 5 delves into the implementation of the system, presenting the development of motion tracking, motion analysis, and interactive music technology in accordance with tango cultural and social design specifications.

Chapter 6 describes the assessment of the interactive system and discusses user study results and feedback. The technique and utilization of video-cued recall within this project is detailed and discussed.

Finally, Chapter 7 presents a conclusion, returning to the topic of designing interactive musical systems for internal experience, focusing on connection, embodiment, and cultural and social design constraints. The chapter also discusses possibilities for future work, illuminating new avenues in interactive social dance and internal experience design and research.

CHAPTER 2

INTERACTIVE DANCE SYSTEMS AND PERFORMANCE

2.1 Introduction

Just as a blank sheet of manuscript paper tends to inspire what Trevor Wishart called "lattice-based music"—referring to the grid implied by the musical staff (Wishart, 1996), interactive dance systems elicit certain kinds of dancer movement, sounds, and participant experience. The motivations of their makers shape these outcomes via their design, which are often invested in the aesthetics of a singular work. The aspects of design which shape an interactive dance work include its motion tracking technology, its coupling of movement to musical outcomes, and to what extent movement is set or improvised. Moreover, the majority of interactive dance systems tend to fall into roughly two categories. First, there are systems intended for use by highly skilled dancers in performance. John Cage and Merce Cunningham's *Variations V* (1965), an early interactive dance work, is an example of such a paradigm. Secondly, there are systems used in art installations and collaborative musical settings intended for the untrained general public. An example of the latter type of system is the pioneering installation *VNS (Very Nervous System)* (1986-1990) created by David Rokeby (Rokeby, 2010).

Interactive Tango Milonga engages with social dance and thus, does not easily fit into the above categories. In some respects, *Interactive Tango Milonga* engages with dancers in a similar manner as performance systems via its interaction with trained dancers. Dancers in these systems draw from a specific movement vocabulary that both arises from a cultural tradition and emerges from their own practice. In other respects, the

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interactive tango system is more like an installation: the resulting work is not staged and there is a greater focus on participant experience. Social dancers do not perform for an audience, yet their skills set them apart from the general public participants of an art installation. Moreover, the aims of this system are not tied to the artistic expression of a specific work, but to the alteration of participant experience and their ongoing tango practice.

In order to situate *Interactive Tango Milonga* within the larger context of interactive dance and installation work, the following text investigates how the various aims and cultural contexts of interactive dance systems impact dancer experience and artistic outcomes through use of motion tracking, movement-music translation, and choreographical fixedness. This analysis illuminates the relationships between 1) artistic intentions and interactive dance system design 2) system design and resulting dancer experience 3) system design and cultural context. However, a comprehensive survey of interactive dance systems is not within the scope of this text. The systems and artists presented are chosen based on a combination of factors: 1) relevance to issues pertinent to this analysis as described above, 2) representation of a diversity of aims and views, 3) impact on the field of interactive art. This chapter addresses the concepts of interactivity and musical intentionality, and examines how they are expressed in the various interactive dance systems discussed.

2.2 Interactive Dance Performance Systems

This section discusses interactive dance systems intended for presentation on stage for an audience where the dancers have a professional level of skill.

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2.2.1 Early systems

This section introduces three early interactive dance systems and works, focusing on sensor design, dancer agency, and dancer internal experience.

2.2.1.1 John Cage's *Variations V*

Cage's *Variations V* (1965) exists as an outlier among the interactive dance works that followed as the dancers were given little agency over the music they created. While dancers trigger sound onsets by occluding beams of light and activating photoelectric sensors and by their proximity to Theremin-like poles, live sound artists choose the sounds played in response (Cage, 1965; Miller, 2001). Unlike most modern systems, the motion tracking system was based on absolute position in relation to fixed objects and locations in space (ibid). The system reacted to an encounter with a location, rather than internally directed movement. The dancers affected only onset, not duration or volume envelope (Cunningham, 1968, 1992). The system reacted only to immediately perceived action with a singular type of event, lacking continuous control and was not translated, subsequently, into the resulting sound. In accordance with Cage's aesthetic, dancer-choreographer Cunningham reported a limited sense of musical agency[10], despite system responsiveness (ibid). He remarked, "[The light beams were] like the doors automatically opening when you enter a supermarket (Cunningham, 1992, p. 145)." In the original performances, the dancers were also performing Cunningham's fixed

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[10] These responses are regarding interactions with the sensors on the stage. In the case of the dancers who used props that had contact microphones placed on or inside of them, the relationship between movement and music would have been very clear.

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choreography, which was performed to an internal rhythm unaffected by the musical response[11]. However, in this choreography, Cunningham designed many moments to bring out and play with system responsiveness, such as using dancer fingers to move in and out of the range of a sensor, continually setting off musical onsets (Miller, 2001).

2.2.1.2 Troika Ranch

Mark Coniglio's MidiDancer is a motion tracking system used in interactive dance performance in the context of his and Dawn Stoppiello's Troika Ranch collaborations (Stoppiello & Coniglio 2003; Broadhurst, 2008). It used flex sensors placed on dancer joints. During their first experiments with the system, they assigned control of a specific sound to each joint of the body, in order to create the stability of response of physical instruments (Stoppiello & Coniglio 2003). However, Stoppiello recalls how "stifling this relationship was" during the design of a related work *In Plane* (1994), a duet between Stoppiello and a projected dancer double. Additionally, in this work, the sensors were much smaller and did not encumber her movement. She controlled sound, video playback, and lighting with her movements (ibid). In the newer work, her aims were to have her movement serve the chorographic and aesthetic purposes in the work, instead of functioning to control the system (ibid, p. 449). Thus, they abandoned stability, and changed the mapping of each joint with each section of the piece. This new paradigm allowed her to experience the media as an extension of herself:

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[11] Some later performances by other sound artists and choreographers incorporated more improvisatory movement (Miller, 2009).

As a dancer I inherently understand the realm of the body. I had no idea that technology would enter into that understanding until I chose to entwine myself with the machine. I was altered, and so was my body as it expanded to include sound, light and image. The slashes in my art are inserted between my flesh, the media that moves with it, and the machine that locks the two together. And this puts me at the intersection of flesh and silicon, blood and television, body and computer that our culture is in the midst of splicing together. (ibid, p. 449–50)

This experience came as a surprise to Stoppiello, as their intention was to allow greater artistic expression rather than to facilitate feeling at one with media and technology (Stoppiello & Coniglio 2003). As it is described, this phenomenon bears some resemblance to the tango connection experience. However, the aesthetic intentions of *In Plane* lie in the staged juxtaposition of the flesh and blood body capable of failure and injury next to the unchanging perfection of projected image. Altered perception and experience is an interesting and welcomed side effect.

2.2.1.3 DIEM Digital Dance System

Wayne Siegel & Jens Jacobson's work with DIEM's Digital Dance System, including the works *Movement Study* (1997) and *Sisters* (1998), allows dancers to shape musical processes in order to make clear musical and movement relationships to the viewers (Siegel & Jacobson, 1998; Siegel, 1998). An additional motive was to inspire dancers within a work, although the works allowed for little improvisation once they were composed (ibid). In *Movement Study*, the work starts with a musical compositional idea, to which a dance work is choreographed with the interactive dance elements, and in

Sisters, the work starts with the choreography (Siegel, 1998). Instead of capturing locational information, DIEM Digital Dance system employs flex sensors measuring the angles of dancer joints such as knees, elbows, and ankles. Thus, the motion tracking method is based on the relationships within the dancer's own body, a more intimate space than that of *Variations V*.

Event-based triggers are eschewed for continuous control of processes such as filter parameters and the density of notes in a passage. These sound-movement relationships, or mappings, allow for agency over musical content, which Cage was actively trying to circumvent. The movement-music relationship comes through much more strongly than in Cage's work. However, Siegal & Jacobson abandoned such triggers so that dancers could both have control over sound without becoming musicians, thus retaining the ability to move for visual effect without having to consider musical significance at all times (Siegel & Jacobson, 1998).

While they were interested in investigating the new possibilities arising from interactive dance, including new dancer roles and responsibilities, dancer experience was not a central concern. Instead, they aimed to create performances for audiences using interactivity as a tool in their compositional processes and in the live synchronization of movement and music. How dancer, choreographer and composer[12] share roles in the creation of musical and movement outcomes and how structure is created and maintained are critical challenges in interactive performance, addressed in more detail in Chapter 2.2.3.

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[12] Note that one or more individuals may inhabit all roles, including that of the system designer.

2.2.1.4 A Concluding note on Early Systems

DIEM's Digital Dance system was inspired by the flex sensors of Coniglio's MIDIDancer, and the works presented here have much in common. They both seek to couple dancer movement with musical processes while preserving the abilities of the dancer to make visually and somatically expressive movement. Additionally, like *Variations V*, they employ experimental and electroacoustic sounds. After workshopping, these choreographies are, for the most part, fixed, and they spring, generally, from the same movement tradition of Western modern and post-modern dance.

2.2.2 Performative Interactive Dance and Non-Western Art Traditions

A number of works address interactive dance systems influenced by or utilizing non-Western Art traditions and movement vocabularies including Japanese traditional dance, belly dance, flamenco, and tango. As *Interactive Tango Milonga* also with a non-Western art music and dance tradition, these systems are of particular relevance to this research.

2.2.2.1 Hahn & Bahn

Streams (2001) and *Pikapika* (2001) break this pattern, as the dancer and choreographer in both works, Tomie Hahn, has a background in Japanese traditional dance (Birringer, 2004, 2008; Hahn & Bahn, 2002). In particular, *Pikapika* utilizes movement inspired by bunraku (Japanese puppet theater) and anime traditions. Additionally, both works rely heavily on improvisation. However, the resulting sound remains in the electroacoustic realm, rather than utilizing traditional Japanese music. *Streams* is a collaboration between Hahn, composer Curtis Bahn, and violinist Dan

Trueman, while *Pikapika* is the work of only Hahn and Bahn (ibid). In both works, the motion of hands is tracked via a wireless MIDI device consisting of an accelerometer and buttons in each palm, enabling both continuous control and triggered events (ibid). These buttons could additionally distinguish between long and short holds as well as double-clicks (Hahn & Bahn, 2002). Furthermore, arrayed speakers, i.e., the SspeaPer [13] interface, was mounted on Hahn, allowing spatialization of sounds at specific locations (ibid).

The decision to use hand movement also affects the focal aspect of the choreography by placing attention on that part of the body (ibid). It also frees the dancer to use the rest of her body for untracked choreographic expression, addressing one of the challenges faced by the DIEM research. Further, since each part of the body is unique in movement abilities, limitations, and capacity to apply force, this choice to track the motion of a particular part of the body affects both the bodily and musical gestures arising out of the system (Winkler 2004). In *Streams*, detailed hand movements are mapped to a physically-based model of the human voice (Birringer, 2004), while in *Pikapika* the sounds are based on machine noises, metaphorically corresponding to the sounds of moving puppets (Birringer, 2004, 2008; Hahn & Bahn, 2002). During the process of making *Pikapika*, Hahn vocalized the sounds she imagined her moves making during rehearsals, and sounds were created in order to match and expand her vocalizations (Hahn & Bahn, 2002). Hahn sees these systems as affecting the processes of collaboration between music and movement (Birringer, 2004, 2008). Rather than structuring, the work "composes the body" (ibid), but this process is not instantaneous:

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[13] 'sensor-speaker performer'.

Pikapika[14] has matured over time. In hindsight we understand that her early phase was a pre-pubescent iteration. When watching early footage (from the first six months) we noticed qualities that displayed her immaturity. Pikapika appeared stiff, still struggling with her identity, expression, and the interface. She seemed removed and introverted, almost too cautious and self-conscious within the new environment. The interface was not her domain yet. Hahn finds that these qualities reveal not only her personal struggle to connect with the interactive structure, but also her challenge to clarify Pikapika's identity. Both arise from the essentiality of embodiment. Over time the interface became second nature. Once accustomed to it, Bahn would add another parameter, continuously augmenting it with new physical challenges. Gradually and organically Pikapika developed – in complexity and persona. Because Pikapika matured over time it is now difficult to separate the development of the movement from the sound. As we have stated in previous papers, 'Is the music ''moving'' the dance, or are the movements ''playing'' the music?' (Bahn, Hahn & Trueman 2001). (Hahn & Bahn, 2002, p. 234).

While both *Streams* and *Pikapika* deal with movement vocabulary from Japanese traditional dance, as well as motifs and visual elements deriving from different Japanese traditions, the works are in the context of Western staged performance and the sounds are derived from Western experimental music tradition.

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[14] Pikapika in this context refers to the character that Hahn is embodying within the work *Pikapika.*

2.2.2.2 RAKS Performance System

A similar mix of movement from a non-Western tradition paired with electroacoustic sound for the stage can be found in Aurie Hsu's and Steve Kemper's RAKS performance system, which utilizes belly dance movements for an embodied musical composition process they call 'kinesonic' (Hsu & Kemper, 2015). They track movement via flex sensors and accelerometers placed variously on the dancer's torso. Like Hahn and Bahn's work, the movement is divorced from its sounding tradition, but does not reference any other cultural motifs, except in the dancer's clothing, which is suggestive of belly dance tradition. For instance, in the work *Teka-Mori* (2013), the music has a "dystopian, 'broken-machine' aesthetic" (ibid, p. 46).

Far more than any other work mentioned thus far, the music is tightly coupled to the dance. In this work, the dancer composes music with her movements (ibid). This aspect arises from the explicit goal of using the system as a musical compositional tool, and thus, non-musically expressive movement is not a priority. This system emphasizes the translation of gesture, from movement to music, and through this focus, allows a high-degree of musical agency. In *Teka-Mori*, the mapped movements with respect to timing are immediate and continuous. The system does not explicitly analyze perceptual movement qualities that emerge more gradually, such as smoothness or heaviness of movement. Instead, some of these qualities arise in sound through the close linkage between movement and music.

2.2.2.3 Evangelos Lympouridis' *Duende*

Another recent system for interactive dance, Evangelos Lympouridis' *Duende* (2010), engages with the flamenco tradition, in both the movement vocabulary and resulting music (Lympouridis, 2012). It is intended for performance as well for educational outcomes. The creator states:

> The aim of explorations of interactivity in the traditional dance context, is not to create a digital system that could replace musicians but only mimic to a degree, their virtuosity and playfulness when performing within a traditional framework. Moreover, [it] is an attempt to link the emerging technologies with the direct transfer of tacit skills of traditional performers and create a bridge between technology and the playfulness of traditional dance (ibid, p. 129).

By 'traditional dance', he appears to refer to dance outside of the Western post-modern contemporary and modern dance tradition.

The motion tracking is achieved via ten Xsens[15] inertial sensors placed on the body, surrounding joints (Arvind & Valtazanos, 2009). Xsens are inertial sensors consisting of two accelerometers and two gyroscopes placed orthogonal to each other (Lympouridis, 2012). A movement analysis system, Orient, then generates a 3D rigid-body representation of the body from this data (ibid). Lympouridis utilizes this representation of movement very literally in his movement to music translations. He maps hand movement to clapping sounds, while dancer legs control the lower-pitched sounds of the cajón, a box used for flamenco percussion. His assignation of castanets to

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[15] http://www.Xsens.com accessed March 2017.

hip and chest movement is less transparent. This mapping of instrument to body part is similar to early Troika Ranch collaborations featuring the MidiDancer.

His sound choices are curious, as flamenco dancers already create the majority of these sounds as they dance (i.e., castanets, palmas). Additionally, he does not utilize the traditional modes of communication, i.e. llamadas (calls), between flamenco dancer and musician (Guedes, 2007). Instead, each section of the body (e.g. hands) affects both volume and onset density of its assigned sounds (Lympouridis, 2012). When the dancer is still, there is no sound, and with more movement, the sound becomes denser (ibid). These choices suggest that the relationship between the dancer and the system is intended to be more akin to that of the musician and her instrument rather than that of a duet.

This design reflects the creator's concern that the dancer feel agency over the music (ibid). As the aim of system is partially to further flamenco education, this sense of agency is important. He notes that system responsiveness with respect to dancer action must be perceived as immediate, that is, within a few milliseconds (ibid). However, he does not address other granularities of timing responsiveness in relation to experience, such as phrase length or the sense of tension and release.

2.2.2.4 Laura Sinnott's *Augmented Tango Shoes*

Another notable interactive work engaging with a dance tradition outside post-modern contemporary is another tango system. Laura Sinnott's *Augmented Tango Shoes* (2008) allows one dancer to create and affect electrotango music via tango-like movements (Sinnott, 2007; 2008). Electrotango is a style combining electronic dance music with tango music elements, such as use of the bandoneón. As per the title, the

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motion tracking is achieved via sensors placed on a pair of women's stiletto tango shoes, including accelerometers and pressure sensors. MIT Media Lab's *Expressive Footwear* pioneered this form of motion tracking for interactive dance using sneakers instead of stillettos (Paradiso, et al., 1999; Paradiso, 2002). Like *Expressive Footwear*, Sinnott's system appears to be primarily oriented towards performance rather than social dance, as it is implemented for one dancer and intended for at most, one couple. However, dancer intentionality is one of the central goals of the system. For instance, this is the reason she states for triggering sounds in response to kicks. Sinnott remarks that this element made her feel as though she had more agency (ibid). Additionally, she measures a movement quality she calls "sharpness", which is related to the musical quality of staccato and she chooses sound files to play based on this quality (ibid). The system measures this quality by counting the number of steps and kicks within a time window (ibid), thus providing a second layer of timing response in addition to the immediate.

The *Augmented Tango Shoes* performance borrowed elements of tango and was compelling, but was not in the Argentine tango tradition.[16] The performance mainly featured solo dancing, as well as two dancers dancing the same choreography, side by side not in an embrace (Sinnott, 2007). As Argentine tango dance exists in the relation between two dancers, even in its performative manifestations, this performance borrows from certain aspects of tango vocabulary but does not engage with the tradition. However, there was one moment in the dance where the two dancers danced in an open, practice embrace, and one dancer performed a tango move, ochos, but as it appeared in

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[16] More discussion about what constitutes Argentine tango tradition is presented in Chapter 3 and Argentine technique and movement vocabulary is discussed in Chapter 4.4.

the video of the performance, this move did not seem to be led (ibid). The dance is choreographed[17] and the two dancers move side by side instead of in an embrace (Sinnott, 2007). Additionally, the second dancer moves on and off the stage at very specific times. The interactive system was not created specifically for this performance work and it would be relatively trivial to adapt to another performance (ibid; 2008).

2.2.3 Agency, Interactivity and Structure in Performative Interactive Dance Systems

This section presents interactive systems and a discussion addressing structural concerns such as choreographic fixedness and interactivity of an interactive dance work and how they shape experience of dancer agency.

2.2.3.1 Palindrome Intermedia Performance Group

All the systems discussed so far, except for *Variations V*, use wearable motion sensors: accelerometers, gyroscopes, flex sensors placed on joints, and momentary contact buttons. However, many other interactive dance systems use cameras, including video capturing both visible and infrared light, to track motion. One such system is Palindrome Intermedia Performance Group's EyeCon, which uses frame-differencing and other rudimentary computer vision techniques to measure the amount and trajectory of changes in light intensity each camera frame, also allowing users to set boundaries, zones of action, and masks within the frame for triggering events when a motion crosses them (Wechsler, et. al, 2004). The system also can be used to determine a rough approximation of shape, size, and object proximity in relation to another (ibid).

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[17] The page for the vimeo video includes choreographer credit (Sinnott, 2007).

Palindrome's work *A Human Conversation* (2007) employs this system in a compelling way. While sound material is relatively independent of dancer motion, onset and volume are very tightly coupled. In this work, the mappings do not remain stable, but shift within the context of the dance (Wechsler & Hosken, 2007). At the start, facial movements, such as opening mouths and eye movements generate electroacoustic sounds. While later in the piece, sound only occurs when the two dancers touch one another (ibid). The action of touching is captured via electrodes attached to the dancers, rather than the video input. In this work, the movement-music interaction serves the aesthetics of the work, expressed in the title. At times, dancers have precise control over sound, and at other moments, their movements evoke no response (e.g., later in the work, when the dancers are not touching, their movements are not sonified).

While many of the previous systems split focus between dancer and audience experience, Palindrome makes strong aesthetic choices in order to make the dancer-music relationship visible to the spectator. When and how the interactivity occurs is often integral to the aesthetic, and in the final outcome, carefully controlled and choreographed. The majority, but not all, of Palindrome's choreography is fixed: Wechsler puts the percentage at about 80% (Wechsler, 2006). The result is generally a tightly constructed interplay of musical and movement elements.

2.2.3.2 Garth Paine and Hellen Sky's *The Darker Edge of Night*

If structures are open, the dancer may choose how to navigate through a musical work. Garth Paine and Hellen Sky's work, *Darker Edge of Night* (2009) explores this notion of interactivity and dynamic form. In this work, they set out to make use of dancer

embodied knowledge for traversing 'pools of potentials', which are sets of interrelated sound and visual (for projected video and stage lighting) possibilities (Paine, 2009, p. 1-2). For example, the initial pool had qualities which were "quiet," "whisper-like," "otherworldly" and "far away," and the associated sounds were described as "air – climate-like," "spacious," and "looking backwards in time." Among the gestures associated with this potential were "very still" and "eyes closed." These potentials were then organized into "pools," a collection of potentials with a defined set of interrelationships (ibid, p. 2). As the dancer moves, the system also moves into another potential, performing the associated sounds and visuals. The system utilizes both immediate excitation and longer windowed analysis to generate musical outcomes. The dancer can also weight behaviors such that the system interpolates from the current pool of potentials to a new pool, providing new possibilities not previously available.

In order to capture this movement, they use EMG (Electromyography) to track facial muscle movements as well as shoulder and hand movement. Additionally, they use EOG (Electrooculography) to track eye movement and EEG (Electroencephalogram) to measure brain waves (Paine, 2009). The system tracks movements much more intimate than the previous systems. While Palindrome regularly uses eye movement to trigger sounds, recording the muscle movement allows much more fine-grained readings. The use of brain waves is both more intimate and involves a more abstract conception of dance movement and performance than the motion tracking systems that have been previously discussed. In addition, while dancers have the ability to indirectly change their heart rate and EEG frequencies, they are not always subject to conscious control. Thus, the interactive system may respond to both intentional and non-intentional stimuli from

the dancer. This approach circumvents the direct relationship between spatial movement and musical outcomes, leaving spatial choreography to the domain of the dancer.

In this system, an immediate sense of interactivity is not the overriding goal of the system. Dancer agency is central to this work, but not in the sense of becoming a musician and having precise control of sound envelope and onset at all times. Rather, interactivity is a tool to explore different potentials of the work, allowing the dancer to explore aesthetic expressions and moods in different ways each time it is performed.

2.2.3.3 Open and Fixed Structures in Performative Interactive Dance Systems

Performative interactive systems differ greatly with respect to the fixedness of their choreography and musical outcomes. For instance, while Palindrome's choreography is relatively unchanging from performance to performance (Wechsler, 2006), the *Darker Edge of Night* utilizes interactivity as a means to explore the open form (Paine, 2009). However, Wechsler points out that there is a looseness in even completely structured choreography that an absolutely fixed medium such as television does not contain (Wechsler, 2006). Thus, a sense of musical intentionality may still exist in a completely fixed work.

In the context of interactive dance, it may be easier for performers to become immersed in a fixed work with less rehearsal and training, since the decision-space has been restricted, lowering cognitive load and allowing dancers to concentrate on details. At any moment, cognitive resources, such as attention and working memory, are finite (Baddeley, 2003; Franconeri, et. al, 2013), and flow theory implies that lessening the cognitive resources needed for a task via training allows individuals to become

completely absorbed (Csikszentmihalyi, 1990). Then, performers also using cognitive resources to generate improvisational movement may require more familiarity with novel interactive systems before being able to reach the same levels of immersion or focus on specifics.

On the other hand, much of the response has been scripted, so while the performer may change details, she does not have the freedom of an improviser to disrupt, explore seams in the system, to fully transform mistakes into productive, artistic decisions, as she may have done during the development of the work. Yet, she may have a sense of musical agency during performance, but its bounds during the staged performance may be untested and unexplored.

If movement is entirely and rigidly scripted, interactivity may not add to a performance work. Live sound performers may very well sync with dancer movements, and composers and choreographers may achieve greater control over performative outcomes. In a sense, this would still be an interactive system, but the conduit is human rather than mechanical. Would the dancer experience musical agency? It is unlikely that a human musician would achieve the kind of immediacy and fine granularity in response that would be required for any significant time length. Additionally, if a dancer made a mistake, the responding musician may not realize in time to compensate, revealing her own (the musician's) agency and the dancer's lack of such within the feedback loop. In terms of a performance, this may be a desired effect because the music has not been thrown off-course. However, it ruptures dancer musical intentionality.

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2.2.5 Dancer Experience in Performative Interactive Dance Systems

Performative interactive dance systems assume an audience and as such, the primary motivation is generally presentational work for stage or another venue, rather than dancer experience, per se. The facilitation of novel or particular dancer experience and means of expression, however, may be seen as vital pathway to the outcome.

A few of the systems above are not solely intended for performance, such as *Duende* and RAKS, and these systems tend to focus more strongly on dancer experience than performative systems, such as those of Palindrome. Performative interactive dance systems also differ on whether or not the audience can understand and perceive the movement to music relationship, themselves. For Palindrome, clarity about this aspect is crucial, but for other systems, such as *Variations V*, *Darker Edge of Night*, RAKS and DIEM Digital Dance System, it is either secondary or approaching the irrelevant.

However, when spectators easily perceive the music-movement relationships within an interactive system, it does not always imply a deeper experience of agency on the part of the dancer. During user studies of an interactive dance system, Akerly discovered a disconnect between dancer experience of musical agency and the perception of an outside observer (Akerly, 2014). When the dancer experienced the greatest sense of musical intentionality, it did not necessarily appear so from the outside. Meanwhile, interactions that produced a clear relationship between movement and music to the outside observer did not always translate into the dancer having that perception herself (ibid).

2.3 Interactive Art Installations

Unlike interactive dance performance, installations are created for participants who are generally assumed to have no specialized movement skills. Additionally, most installations take place in a space widely accessible to the public, rather than an elevated platform. The setting of the work often has profound influence on how participants engage with the work. Moreover, participating within an interactive installation can sometimes be a type of performance, in which gallery visitors unable or unwilling to participate at that moment become spectators of the active participant(s). Still, installations, as a whole, tend to be more focused on user experience as an outcome, which may or may not include a sense of musical intentionality.

2.3.1 *Very Nervous System*

"I am an interactive artist; I construct experiences," said David Rokeby (1998, p. 27). His work, *VNS (Very Nervous System)* (1986–) plays with this idea of intentionality, as he remarks that when he is not trying, it feels as though he has control, but once he (or another user) tries to intentionally direct musical outcomes, this feeling of control dissipates (Rokeby, 2009, 2010). He stresses the idea of interaction as an interchange between two entities. If one entity can control the other, then for him, it ceases to be interaction (Rokeby, 1998, 2009, 2010). Thus, the tight coupling between dancer and resulting sound would not truly be interactive by his definition. In this work, the system's musical response sometimes delayed rather than co-articulated with participant gesture; however, movement input is required for sound. Gestures from the participants play out over longer periods of time, continuing to excite the system long after the initial impulse

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(Rokeby, 2009). Thus, sound becomes more and more removed from the user's intentional action. However, the user is able to add more input into the system with more movement in response to music from the system (Rokeby, 2010), so that the excitation of the system eventually can become clear to the user. In this way, the system becomes resonant, creating feedback loops of movement-music reactions, in a sense, like an ecosystem (ibid).

As this work has been developing for over a decade, it has had many iterations, presentations, and his intentions and its technological implementation have shifted. However, the use of optical motion capture is integral to the work, which also functions as metaphor for seeing (Rokeby, 1998; Jones & Muller, 2010). The first version was achieved mainly via hardware, but the later motion analysis software developed for the installation, *SoftVNS*, was in widespread use by many in the interactive community into the mid-2000s. He remarks that the initial impulse for the work came from an idea to fight against what the computer represented to him. For instance, since computers took people away from their bodies, he desired to engage the body with the computer. Additionally, since the computer was "disinterested and objective", he sought to create an experience that was intimate (Rokeby, 1998).

Ten years after writing the above text, he explains one of his motivations as changing the relation between body and mind[18] (Rokeby, 2009). For instance, when a gallery visitor participates in the installation for an extended length of time, for at least fifteen minutes, Rokeby describes an experience of the body moving as if it knows what

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[18] Expressed in terms of Rokeby's framing, as he uses the rhetorical device of separating body and mind in his language within his texts and interviews.

to do, without conscious control of the mind (ibid). Additionally, he describes a "residue" felt afterwards, in which the user becomes very aware and attached to environmental sounds. Not surprisingly, some aspects of his description seem related to literature describing the experience of a skilled musician performing a musical instrument. For instance, in *Ways of the Hand* (1976), David Sudnow describes how, as he learns to play jazz piano, he stops directing movement, and his hands take over (Sudnow, 1976).

Rokeby also remarks that the vast majority of participants do not spend enough time in the installation to have these kinds of experiences (ibid). This points to another feature of art installations in galleries and museums. They often allow participants to move freely in and out of them, and gallery visitors often walk inside with little or no context. Additionally, while visitors may have to spend a certain amount of time in order to get an effect from an installation, very few may do so. Even if visitors would like to spend more time, popular exhibits often have visitors waiting to use them. Monopolizing such an exhibit could be perceived as rude. Research has generally shown that gallery visitors typically spend less than half a minute engaging with an individual fixed artwork (Smith & Smith, 2001). While research examining interactive art engagement time across exhibits is rare, science museum studies can offer insight. This research has found that visitors spend a similar amount of time on fixed objects as in galleries, i.e. half a minute. (Sandifer, 2003). On average, interactivity can increase that engagement time to around 1.5 minutes, although this depends on the nature of the exhibit: its novelty and its open-endedness (ibid).[19] In one study, the most engaged exhibit held attention for an average of

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[19] In this context, openness refers to specifically how much the exhibit let visitors determine their own goals and modes during interaction.

5.6 minutes (ibid). Thus, while becoming a skillful user is an important aspect to *VNS's* evolving experiential design, within the gallery setting, few users will spend that time. The experience is largely available to the few in the general public with motivation and access to use the system for longer periods of time or through multiple exposures.

2.3.2 Interactive Installations for Electronic Dance Music

Art installations, however, do not have to take place in a gallery context. Several interactive installations or interventions have taken place within the context of a dance club, in the context of EDM (Electronic Dance Music), including a recent concert by the German EDM band, Booka Shade, in which audience members play music and visuals through a custom phone application and enhanced phone speakers that they distribute as part of their performance (Price, 2014; Vodafone, 2014). These works are of particular relevance to this research because they engage with a form of social dance. Unlike in gallery settings, people in dance clubs expect a long, seamless experience of music and participatory dance. They may expect to reach a trance-like state via their actions, but also by taking illicit drugs (Shenton, 2015). Additionally, dance clubs are the scene for various other social activities less common in galleries, such as meeting other people and socializing.

2.3.2.1 Interactive Dance Club

An early example of such interactive work is MIT's *Interactive Dance Club* presented at SIGGRAPH 98[20] (Ulyate & Bianciardi, 2002). Users could interact in

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[20] The 1998 International Conference and Exhibition on Computer Graphics & Interactive Techniques.

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specific ways to create electronic dance music (EDM) (ibid). While a worthwhile exploration of interactive music in a social context, this work does not utilize EDM movement traditions or many of its social conventions. It engages with the idea of a DJ, assigning available context to users at any given time to an EJ ("experience jockey") (ibid).

The intention of the installation was to create something novel to act as a draw to the conference, as well as to explore interactions with large-scale crowds while maintaining a coherent musical outcome (ibid). Rather than a consistent user interface, the *Interactive Dance Club* consisted of many smaller installations, the output of which was synchronized in order to create a singular musical experience (ibid). Many of these interactive zones consisted of interfaces that engaged with instrumental ideas rather than dance ideas, such as those with drum pads that people could hit (ibid). Indeed, engagement with the work is more about addressing the technological interfaces than the social act of dancing. Users interacting with this work are not necessarily participating in a wider EDM culture and community. Instead, this system served mainly the technology community at SIGGRAPH. Additionally, although it inspired a few similar events, *Interactive Dance Club* was a one-off event (ibid).

2.3.2.2 Feldmeier & Paradiso's EDM Interactive Dance Systems

Mark Feldmeier & Joseph Paradiso's work in creating interactive dance systems for large crowds continued to exploit the free-form nature of EDM dance culture (Feldmeier & Paradiso, 2007). However, their approach is very different from those taken from the *Interactive Dance Club*. Instead of a modular approach, they developed a

cohesive interactive paradigm for the system. Their aim was to create a system for EDM dance that could accommodate large crowds while still finding a way to give the individual a certain amount of agency (ibid). Additionally, they were interested in creating a system that could be used within multiple events.

Thus, they developed an inexpensive motion sensor that each person in the crowd is given to keep. This sensor uses RF (radio-frequency) technology and sends pulses to the main analysis machine when it detects acceleration above a threshold (ibid). Thus, by moving the sensor, dancers could send 'hits' to the system. How the system handled the hits depended on how many the system received. If there were not very many hits, then the system responded immediately. Otherwise, it took the moving average of the hits in a time window and responded accordingly (ibid). During these stages, individual dancers could make decisions by either going with or against the rest of the crowd, contributing to a group dynamic. Additionally, the system has five energy levels, which are determined by the hit rate. At each level, the music becomes busier and more complex until the last level, where it is as chaotic as it can be (ibid). This chaos is used as a device, in a sense, to calm down the crowd movement, so that the music would not continue to rise in energy, but also drop, creating more variation.

Feldmeier & Paradiso made an effort to reach out to the EDM community, and attached their sensors to glowsticks in order to make the system appealing and attract an audience (ibid). They distributed questionnaires after each interactive show querying about dancer agency. After the last show, Talbot3, the average response to agreement with the statement, "I felt in control of the experience" was 3.4/6, where '6' indicated complete agreement with the statement and '1' the converse (ibid). Since there were only

about 25 dancers in the system, this is a modest result (ibid). This paradigm of large group interaction does not lend itself easily to individual agency, particularly since while there may be 25 dancers, 25 voices playing at once would be an exceptionally thick orchestration. If those voices are completely independent from each other, this may tend towards cacophony, especially in the context of structured music such as EDM.

2.3.2.3 Experio

A more recent system, *Experio* (2014), developed the idea of an interactive EDM dance club further (van Hout, et al., 2014). The system is specifically for use within the EDM community, designed to be portable and for multiple use, perhaps something adopted within the community. Their motion system tracks feet movement via laser beams and sends the signals to Ableton Live, where a live DJ decides how the moves affect the music (ibid). Thus, it is akin to the *Beam Breaker* interaction zone of the *Interactive Dance Club*, which tracked hands instead of feet (Ulyate & Bianciardi, 2002). Also like *Interactive Dance Club*, this system relates to EDM traditions by utilizing a live DJ, but in contrast, this system always allows dancers to freely move while interacting. However, EDM dance also involves upper body movement, which is not tracked or analyzed within the interactive process. Thus, it only responds to a subset of EDM movement. Like *Interactive Dance Club*, the interactive system does not engage with any specific movement traditions of EDM dance, instead exploiting its free-form aspects.

One of the goals of this system was to facilitate more of a sense of individual agency than the systems coming before it (van Hout, et al., 2014). Thus, they provide immediate audio feedback in response to foot movement. The creators also designed the

system to be easily accessible, to learn, and to use. During deployment, they noted that the system was very successful in this regard and facilitated more social interaction than usual, helping to connect strangers (ibid). The style of interaction is solely event-based, i.e., triggers over which, like in *Variations V*, users have no other control. However, in this system, sounding responses are designed to promote dancer agency. While this seems to be a fun interaction, this system does not elicit complex reactions and feedback loops like Rokeby's *VNS*. Additionally, *Experio* privileges satisfactory musical outcomes over dancer agency. This system gives the option of overriding participant input to the moderator in the interest of serving musical coherency and results. Thus, it may be difficult to make a mistake within this system, creating undesirable sound as a result. Moreover, while this design eases the first encounter with the system, it does not leave much room for dancers to develop virtuosity or individualism in their use.

2.3.3 Proyecto Biopus' *Tango Virus*

The intention of Proyecto Biopus' *Tango Virus* (2005) was to have the movement 'infect' the tango music, thereby, inviting the public to participate, via tango dancing, in the creation of art through destruction. The authors of the work, a subset of the group, were Emiliano Causa, Tarcisio Lucas Pirotta and Matías Romero Costas. They write: "If, they say, the tango is in our blood, 'we will now infect the body of the tango'" (Causa, et. al, 2005a, n.p.). [21] When a couple dances within the installation, the system translates their movement into viruses displayed visually behind them. In a biological simulation, these viruses then 'attack' a representation of the playing tango song. As a result, the

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[21] Originally: "Si, como se dice, al tango lo llevamos en nuestra sangre, entonces ahora 'nosotros infectaremos el cuerpo del tango'."

song becomes more and more filtered and distorted the longer the couple dances within the system (ibid).

The motion tracking is achieved via blob-tracking with a video input signal[22], allowing couples to easily move in and out of the installation space. Thus, the couple is tracked as one entity within the system. While leaders may have had a sense of musical intentionality or agency within the system, it is likely followers did not[23]. Moreover, while Proyecto Biopus is interested in reversing the paradigm of tango music and dance by having the dance affect the music instead of vice versa, they are less invested in an individual's or couple's experience of musical agency.

Tango Virus was installed in the Espacio Fundación Telefónica in Buenos Aires (ibid), where tango dancers from the public visiting the exhibition were invited to dance within (ibid). In another city, there might be the possibility that no or very few dancers would emerge from the audience of this gallery space to participate[24]. Indeed, just a few decades before, due to political and social tensions[25], this perhaps would have been true of Buenos Aires, as well. However, the artists point out that they chose to engage with tango not because of its local relevance, but because of its improvisatory structure (ibid). They see tango having a kind of concatenative grammar, in which no two dances would produce the same patterns, although they make up similar shapes (ibid).

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[22] A motion tracking technique which detects image regions which have similar properties.

[23] Leaders, not followers, determine the gross trajectory of couple movement. The mechanics of Argentine tango movement are discussed further in Chapter 4.4.

[24] Barring targeted advertising within a local tango community.

[25] These tensions are discussed further in Chapter 2.

Causa (2005b) states that members of the public were surprised to find themselves the "protagonists" within the exhibit and seemed to be timid about stepping into the center of attention. He attributes this to their lack of experience with interactive art, and suggests that the few that actively participated had intense experiences (ibid). It is worth noting that ten years have passed since this work was displayed, and perhaps now, this work would elicit different reactions. However, this installation, in effect, does ask tango dancers from the public to give impromptu performances. Argentine tango, particularly in relation to other Western partnered social dances, is not an easy dance to master. While most social dancers may feel comfortable dancing in public in the context of a milonga, practica, or class, they may not feel comfortable in this setting, which is much more like a performance and may seem to ask for a certain level of virtuosity and skill.

2.3.4 Urban Musical Games

Rather than asking the public to perform, IRCAM's[26] *Urban Musical Games* (2011) asks them to take part in multiplayer games. IRCAM researchers' aim is to create a new musical interface which could potentially be adopted by a wider public (Rasamimanana, et. al., 2012). They put inertial sensors (i.e. accelerometers and gyroscopes) inside of a foam ball, and then analyzed the ball's behavior during game play (ibid). From this analysis, they determined different "playing techniques" as well as movement qualities via a gesture recognition system (ibid). Thus, each player in the game only has musical agency as long as she is in control of the ball. Not incidentally, this paradigm is similar to many team sports involving balls.

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[26] Institut de Recherche et Coordination Acoustique/Musique.

They developed a series of musical games involving a ball, so that the resulting sound depends upon the rules and outcome of the game play. The series of games involve keeping the beat with the ball (*UMG-Volleyball*), and playing with three balls to create a musical performance (*UMG-Band*) (ibid). One of these games, *UMG-Basketball,* facilitates sonification of a basketball game. Each team is associated with a musical style and material, and the winning team hears their music more of the time. Additionally, the different actions of the ball continue to elicit different musical responses based on their character (ibid). This particular game could be seen as an intervention into an existing cultural practice. The other games require users to learn completely new rules, even if the social context of the game is a familiar one. However, the setting of this work is an installation in a festival, rather than a neighborhood basketball court or gym. While amateur basketball players may have attended the event and participated, they came into the art festival context to attend. The system has not yet traveled in their spaces.

While no formal assessment was performed, informal interviewing revealed the installation was compelling. Indeed, visitors used the system for an average of around 20 minutes, and came back for repeated games (ibid). Like EDM dance clubs, this context is an inherently social one, and within game play, these social interactions are even more structured by their context within a game.

2.3.5 InfoMus International Research Centre's *Mappe per Affetti Erranti*

InfoMus International Research Centre's *Mappe per Affetti Erranti* ("Maps for Wandering Effects") (2008) is an installation dealing with social interaction within the more traditional art gallery space (Camurri, et. al., 2008; Volpe & Camurri, 2011). The

musical system developed for this installation was also utilized in a related performance, *The Bow Is bent and Drawn* (2008) in collaboration with the composer Nicola Ferrari. The interactive artwork uses Antonio Camurri's *EyesWeb*, an influential camera-based system, which in its early version, used software 'agents' that react differently based on the emotional state that the dancer's movements convey (Camurri, et. al., 2000). These agents learn how to interact with the performer during the course of the piece, changing the way they respond in accordance with dancer movement throughout the work (Camurri, et. al., 2000). The version of Eyesweb used for *Mappe per Affertti Erranti* does not appear to make use of such agents, but the focus on the translation of gesture into emotion remains.

Mappe per Affertti Erranti is an example of what Camurri and his collaborators call 'active listening', a practice in which listeners are enabled to modify musical content in real-time without any particular musical or movement skill (Camurri, et. al., 2008; Volpe & Camurri, 2011). This practice can be seen as a response to the transition of musical experience from the past, when musical listening always involved a live musician playing in real-time to the present, when the majority of human-produced music is in the form of the recorded sound artifact (Mancini, et. al., 2010). This concept is implemented via a multi-track recording of different expressive variations of the same work of music; the variation chosen to be played is based on gallery visitor gestural and movement (Camurri, et. al., 2008; Volpe & Camurri, 2011).

The space is conceptually divided into different sections that are mapped to a particular instrument. In order to hear the full orchestration of the work, participants must be distributed among sections (ibid). Participant movement is analyzed for emotional

content and classified into four possibilities: "Happy/Joyful," "Solemn," "Intimate/Shy," "Angry/Aggressive." For instance, they take a movement measure such as the Directness Index, related to Laban's theory of effort, which is the ratio of the length movement trajectory in relation to the sum of the component trajectories, over a window (Volpe & Camurri, 2011). A high value for this movement measure corresponds to a "Solemn" emotion, a medium value to "Happy/Joyful," and both "Intimate/Shy" and " "Angry/Aggressive" correspond to low values. The system uses eleven other movement measures to help to determine whether particular participant movement is indicative of one of the four specified emotional states. The installation then selects expressive variation corresponding to that emotion to play (ibid). The musical work requires social interaction and cooperation to be played as a coherent whole, since participants must have emotional synchrony between their movements to each voice with the same expressivity (ibid). Individual participant gestures are also mapped onto digital effects, such as filters and track volume.

Like Rokeby's *Very Nervous System*, this work is aimed at the general public, allowing for naïve user participation. However, where Rokeby is concerned with altering perception and bodily experience, especially in relation to human-computer interaction, the 'active listening' paradigm implies a restoration of a previous mode of listening. Camurri, et. al. are generally not concerned with creating possibilities for expert use of installation and do not touch on the topic of immersive experience. Rather, the focus is on momentary social interaction, emotional response, and synchronization between participants. The engagement need not induce transcendent experience.

2.4 New Musical Interfaces for Collaborative Music

Generally speaking, new musical interfaces enabling collaboration and audience participation have been growing. The interactive tango system, as well as a number of systems discussed in the above section, including *Mappe per Affetti Erranti* and *Urban Musical Games* fall into this category. While an extensive review of musical collaborative systems and structures is outside the scope of this dissertation, in this section I will discuss how these musical systems and structures engage with cultural context, modes of participation, and design aims in order to place *Interactive Tango Milonga* within this wider contexts.

One rapidly spreading form of musical collaboration in computer music is the laptop ensemble, such as plork (Princeton Laptop Orchestra) and lorkas[27] (Laptop Orchestra of Arizona State) (Trueman, 2007; Wang, et. al., 2008; Bukvic, 2010). Laptop ensembles are often composed of members with diverse musical skill sets, including novices. Unlike art installations, however, laptop ensembles hold regular rehearsals and in some cases, their activities may been seen as a community practice, such as those of a church choir. However, generally the musical interface is not consistent between each work nor is mode of musical collaboration. By participating, members are taking part in a larger community, but their specific movements and musical actions are not necessarily part of a larger tradition or movement vocabulary. Their movements are tied to specific, idiosyncratic works.

Tina Blaine & Tim Perkis' *Jam-O-Drum*, however, draws on percussion music and movement vocabulary for an interactive musical instrument intended for public

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[27] See http://lorkas.org accessed March, 17, 2017.

exhibition (Blaine & Perkis, 2000; Blaine & Forlines, 2002). The work uses the metaphor of a drum circle and as such, it aims to stimulate musical social interaction and engagement. The work consists of both audio and visual elements and accommodates up to six players. The visual elements are projected on a large wheel display and the musical interface consists of seven drum pads that users strike with their hands to create sound (Blaine & Perkis, 2000). Unlike in a traditional drum circle, users generally employ the exhibited system for one or perhaps two sessions. *Jam-O-Drum* has several modes of play, including one mode allowing free improvisation. Blaine & Perkis found that musical novices often did not pay attention to sound-making due to the dominance of visual elements in this mode (Blaine & Perkis, 2000; Blaine & Forlines, 2002). However, another mode, Call and Response, was very successful in the their goal of facilitating social interaction across participants with musical skill levels. The system would play a rhythm and ask for a musical response from the user, indicating whether this was a solo, selected small group or full ensemble. In an advanced mode, it allowed for improvisation during response (ibid). The creators describe this mode as similar to the children's game 'Simon Says' and the video game Dance Dance Revolution[28], without the element of competition (Blaine & Perkis, 2000; Blaine & Forlines, 2002). The clear game-like structures of this mode, its incorporation of an almost universal time-based organizing structure and its orientation towards training and learning likely allowed the increase of participation of the musically-naïve.

The collaborative musical instrument Tooka, designed by Sid Fels, is of particular relevance to this dissertation because it requires, like tango, two individuals to be played

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[28] See http://www.ddrgame.com/ accessed April 2017.

(Fels, et. al., 2004). Two musicians blow into a hollow tube at each end and their coordinated button pressing selects the pitch of the resulting sound. Pressure sensors allow each player's breath to modulate the volume and in a later version the bend of the tube also bent the pitch of the sound (ibid). Unlike the above examples, the Tooka is intended for expert play, and like the interactive tango system, uses interactive sound as a conduit for increased communication and intimacy. While this instrument was developed for expert use ultimately leading to performance, the designers emphasized aspects of user experience as a motivating factor, ultimately relating it to expressivity rather than social participatory aims (ibid).

For many of the collaborative musical projects, including laptop orchestras the focus is on breaking barriers between established Western musical roles of audience, performer, and composer as well as musician and non-musician. This goal is similar to many of the interactive dance systems, which break barriers between dancer and musician. For laptop ensembles, this focus often serves pedagogical aims (Trueman, 2007; Wang, et. al., 2008; Bukvic, 2010). Tanaka discusses how this process often explicitly or implicitly challenges authority and hierarchical structures, such as in do-it-yourself (DIY) music and electronic workshops and ensembles such as (Tanaka, 2011). Outcomes, like participation in tango social dance and other forms of participatory music, are not primarily for established art outlets such as museums and stages but for personal enjoyment, making friends, and other social and personal functions (ibid).

These DIY ensembles often deal with experimental forms of musical expression such as noise, which may be compelling to smaller portions of the public. In contrast, use of more conventional music content, such as *Jam-O-Drum*'s use of a drum circle

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metaphor may have more popular appeal and therefore, a broader reach. However, art exhibitions such as *Jam-O-Drum* take place in an exhibition context, and the centralized location and momentary nature limit impact. Tooka, on the other hand, does not challenge the Western traditional performance-audience divide, but still opens up musical performance to the examination and expression of a social experience.

2.5 Concluding Notes on Interactive Dance Systems and Performance

Interactive dance works and installations are shaped not just by their designer's intentions but also through their social and cultural setting. How these systems constrain, influence, or dictate dancer movement through their movement-to-music relationships is a critical challenge.

Creators of interactive dance works for the stage must contemplate how their interactivity affects spectator experience, as well as that of the dancer(s). Works for the stage often involve a highly developed movement vocabulary, which both influences and is influenced by the interactive system. A tension exists between the views of the dancer who becomes a musician, in that her movement is tightly tied to musical outcomes, and that of the dancer who remains a dancer, whose movement is sonified yet not significantly constrained by musical concerns. Systems leaning towards the former paradigm necessarily prioritize dancer musical experience, although in performance works experiential outcomes are often secondary to the goal of allowing artistic expression.

On the other hand, interactive installations prioritize participant experience, as the separation of audience and performer roles is either meaningless or constantly shifting.

Additionally, interactive installations tend to take place in a greater variety of settings, having a profound effect on the types of interactions that arise from them. Unlike performative works, all the interactive installations surveyed in this analysis expect no specialized movement skills from their public, with the possible exception of the *UMG-Basketball* game. Many of the systems place particular design emphasis on their ease of use by the naïve user without instruction or additional training.

CHAPTER 3

ARGENTINE TANGO: HISTORICAL AND SOCIAL CONTEXTS

Interactive Tango Milonga engages with the specific movement, music, and

cultural tradition of Argentine tango. As all globally popular representations and practices

named as 'tango' do not refer to the Argentine tango tradition and its adherents in tango

communities abroad, the following historical and anthropological discussion is presented

to clarify this tradition and culture. *Interactive Tango Milonga* has been conceived within

the context of these communities in Buenos Aires as well as in the United States and in

collaboration with individuals from these communities via their feedback, advice, and

participation in user studies. Moreover, Argentine tango has a long history of

appropriation by colonizing and controlling cultural forces that use it as signifier of

exotic otherness and passion (Savigliano, 1995). Thus, this chapter addresses the

transformations in tango dance, music, and culture in order to explain the ways that this

project addresses the questions of cultural imperialism, expectations, and unrest in

evolving tango practice.

3.1 The History of Argentine Tango

This section presents the history of Argentine tango until the early 1980s,

addressing the inception of tango, the first global craze along with the imitation practices

that were created as a result, the Golden Age of Tango, and ends with Argentina's Dirty

War.

3.1.1 Birth of Argentine Tango

Argentine tango arose as a mix of several traditions, including the habanera, the Andalusian tango, and the milonga, in this case referring to an Afro-Argentine dance related to candombe, an Uruguayan African slave dance (Collier, 1992). It began as a form of vernacular music and dance of the lower classes in the Río de la Plata near the borders of Argentina and Uruguay in the 1880s.

The Argentine government had opened up migration laws with the hope of attracting elite, educated Northern Europeans. However, while European, the immigrants that came were mostly impoverished men from the Mediterranean who were relegated to living in the outskirts of the city, or the arrabales. (Tabares, 2014). Also living in these suburbs were Afro-Argentines, the former slaves and their descendants, and mestizo men, who formed the basis of an Argentine archetype, the compadrito, a displaced gaucho, or cowboy, or more likely, his descendent or imitator, living in Buenos Aires' outskirts. The scarcity of women in Buenos Aires at this time led to an increase in and the legalization of prostitution, brothels, and dance halls where tango was the standard entertainment (Savigliano, 1995). While popular myth is that tango was born in bordellos, this is unlikely to be true, as most bordellos in the city did not allow dancing at that time and there were separate dance halls where men could pay professional dancers to be their partners (Dujovne, 2011). [29]

This lack of women also led to increased competitiveness between men for female attention, and both dancing and knife-fighting skills became ways a man could

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[29] Dujovne (2011) clarifies that in rural Argentina, dancing did take place in bordellos, since buildings that housed them in these areas were multipurpose. Tango, however, generally is not associated with these rural areas.

distinguish himself (Savigliano, 1995). Indeed, Argentine tango shares many movement traditions with Spanish knife-fighting and fencing, such as the idea of 'lazy movement', only moving just enough to follow your partner or opponent[30]. Additionally, as early tango dancers were all displaced or immigrants in some manner, Tabares suggests that the tango became a way that the various social groups of the arrabales could communicate with each other, not through language, but through music and dance (Tabares, 2014). This early period of Argentine tango is called La Guardia Vieja (the old guard), and this early music is rarely heard in milongas today.

The middle and upper socio-economic classes shunned the dance until it became the rage in Paris in the 1910's (Jakubs, 1984). However, Dujovne (2011) clarifies that tango was still very popular in its home country before it was exported, noting that over three million tango music scores had been sold between 1902-7 and that much of the resistance against the dance was by conservative elements of society.

Around this era, tango-canción, that is, tango song, became popular. Italian art song and opera was very influential on this tango music form, especially in the melody and singing style (Azzi, 2012; Thompson, 2005). The lyrics were written in lunfardo, a porteño[31] dialect from the poorer arrabal neighborhoods and they were largely written by men lamenting the unfaithfulness of women who left them or expressing longing for a previous life or place (Savigliano, 1995). A few tango singers and lyricists were women, such as Ada Falcon and Rosita Quiroga, and were integral to the tango scene, if lesser

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[30] From personal experience of the Physical Awareness Workshop, a combined Argentine tango, Spanish knife-fighting (La Navaja), and Spanish School of Fencing (La Destreza) Workshop April 2010, New York City with Carina Moeller (tango), James Loriega (Destreza), and Ramon Martinez (Navaja).

[31] Natives of Buenos Aires, literally, 'people from the port'.

known in recent times (Castro, 1986). Additionally, several early popular tango songs now credited as anonymous can be traced to the Spanish baroness Eloisa D'Herbil de Silva (Dujovne, 2011). Carlos Gardel, a French-Argentine singer, is seen as the exemplar of this style of tango music, and his 1935 death, marks the end of the *tango canción* era (Jakubs, 1984).

3.1.2 First Wave of Tango Globalization

By the 1920s, tango was a worldwide phenomenon (Castro, 1990), even spreading to non-European nations, including Japan (Jakubs, 1984). This tango dance-craze was driven by its risqué close embrace and footwork. In this global context, much of the social and political tensions giving rise to the dance form were reduced to an apolitical heterosexual battle of the sexes (Savigliano, 1995). Additionally, both the United States and Europe developed their own version of tango, known as ballroom tango.

While ballroom tango is danced to tango music, this dance has more in common with the waltz and the foxtrot than Argentine tango. This dance incorporates exaggerated movements, such as fast head flicks[32], fixed rhythmic patterns danced to fixed tempos, and a rigid, backward leaning embrace foreign to Argentine tango. Vernon and Irene Castle essentially created the American Ballroom style, watering down the tango of La Guardia Vieja, to make it more palatable for more staid American audiences (Groppa, 2004; Knowles, 2009). They claimed that the tango was not originally Argentine; instead declaring the Spanish gypsies brought it to Buenos Aires (Knowles, 2009; Castle & Castle, 1914). This misunderstanding led to early tango dancers in the United States

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[32] Head flicks are a feature of the International ballroom style rather than the American.

adopting gypsy attire for costume balls (Knowles, 2009). It is these versions of tango that are shown in most American and European movies, from *The Four Horsemen of the Apocalypse* (1921) starring Italian Rudolph Valentino to *The Scent of a Woman* (1992) and *True Lies* (1995) – all examples of American Ballroom Tango (Ingram, 1921; Brest, 1992; Cameron, 1995).

The Four Horsemen of the Apocalypse is an instructive example of the European and North American perception versus the reality of Argentine tango at the time. Rudolph Valentino, who had never been to Buenos Aires, is portrayed as a gaucho, and he is dressed in Argentine traditional cowboy garb, more common to the pampas than the city (Ingram, 1921). Valentino learned how to dance in New York City, not Buenos Aires. Many years later, Roberto Tonet[33], an Argentine and tango dance professional, remarked of him: "When we see someone dancing the tango, stiff arms and long steps, we laugh and call that dancing á lá Valentino" (Thompson, 2005, p. 15).[34]

3.1.3 The Golden Age of Tango

The period from the end of tango-canción in 1935 to 1955, the year a military coup deposed then-president Juan Perón, is known as the Epóca de Oro, or the Golden Age of tango, and forms the canon of Argentine tango music (Goertzen & Azzi, 1999). During these years, the vast majority of Buenos Aires danced the tango in numerous

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[33] Roberto Tonet is known for starring in *Forever Tango*, a very popular and influential touring Argentine tango show in the 1990s (Thomson, 2004).

[34] After giving a presentation on my interactive tango work to computer music students at the Universidad de Tres Febrero, one student asked me how I could have possibly learned or been fascinated by tango, since all the movies from the United States showed an enormously ridiculous dance that wasn't, in his estimation, tango at all.

dance-halls and music venues (Castro, 1986). In the heyday of tango, men learned by

dancing with each other, young boys serving as followers for the older before their debut

on the social dance floor, while young women learned from family members (Savigliano,

1995). Argentine tango was the main social outlet for the young, and the primary means

by which they found their spouses. Moreover, Argentine tango became a powerful

national symbol of Argentina in general, and the Peróns, in particular. Juan Perón, was

said to resemble Carlos Gardel (Milanesio, 2014) and Homero Manzi, a tango lyricist,

devoted two tango songs to Eva Perón (Gonzalez & Marianella, 2013).

The early tango ensembles were small, often consisting of only flute or violin and

guitar. The bandoneon, a new free-reed instrument similar to the accordion, was imported

from Germany to become the most distinctive sound of Argentine tango (Azzi, 2012).

Ironically, in Germany, it was originally a substitute for the organ or harmonium in small,

poor rural churches, while later in Buenos Aires it was banned from being played in

churches for a time[35] (ibid). In the Golden Age, the small ensembles expanded to the

orquesta típica, a medium-sized group consisting of a string section, a bandoneon section,

contrabass, and piano. Juan de Caro was an early inventor in this scene, using extended

techniques to create rhythm accents, such as "lija" (sandpaper), a scratchy sound created

by dragging the violin bow on the strings above the bridge (Drago, 2008). Argentine

orquestas típicas rarely, if ever, used percussion instruments, and so all percussive sounds

were achieved through similar types of extended techniques (ibid). Another experimenter,

Oscar Pugliese, one of the later tango composers, employed unpredictable tempo and

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[35] Even in 1989, Maria Azzi notes that she attempted to play J.S. Bach in a church on her bandoneón in Buenos Aires, and a bishop would not allow it (Azzi, 2012).

timing changes, as well as his use of counterpoint, and developed a particular style of percussive accompaniment called yumba after his famous song, "La Yumba" (1946) (Drago, 2008). Other notable composers and band leaders include Juan D'Arienzo, Carlos di Sarli, and Anibal Troilo. The original recordings from these orquestas dominate the milongas today, and thus, these songs are highly influential upon the music composed and are among those selected for arrangement for the interactive tango system.

3.1.4 Tango moves into the Concert Hall

In September 1955, a coup d'état forced Juan Perón into exile, and a military dictatorship took over Argentina. This marked the start of a period of unrest, fragile democracies and military coups (Miller, 2014). According to some, the new government did not look on tango kindly, as it was strongly associated the previous Peronist administration (ibid). Citizens were banned from large gatherings, and curfews were imposed on the general population. However, the tide may have been turning to other Latin styles in any case, such as samba and rumba (Merritt, 2012). Neighborhood tango venues closed, and tango musicians, such as Pugliese and singer Adriana "El Gato" Varela, at the time begin playing and recording more for listeners than dancers (Merritt, 2012).

In this atmosphere, composer and bandoneon virtuoso Astor Piazzolla, a veteran of orquesta típicas (tango ensembles) of the Golden Age, such as that of Anibal Troilo, developed what he called "nuevo tango", which incorporated elements of both Western art music and jazz (Gorin, 2001). He was writing for the concert hall rather than for dancers, and in addition to his work as a professional tango musician, he studied with

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composers such as Alberto Ginastera and famously, Nadia Boulanger (Gorin, 2001;

Drago, 2008). Reception of his experiments in Argentina was initially hostile (Gorin,

2001). For example, both he and his guitarist received death threats for introducing the

electric guitar to the tango. However, he received a much better reception abroad, first in

the jazz world where he worked with artists such as Gary Burton, and later in classical

circles, writing for Kronos Quartet (Gorin, 2001; van Damme, 2004). As Piazzolla

became a celebrated name abroad, he also gradually became accepted and loved in

Argentina (Merritt, 2012).

3.1.5 Tango in the Dirty Wars

Meanwhile, the Argentine tango dance world moved to the underground. During

the Dirty War (1976-83), the ruling military junta, or dictatorship, engaged in state

terrorism against its people, and it included on its blacklist many artists and musicians,

including Pugliese, a communist who had been jailed by Perón so many times that he

wore pajamas under his suit when he performed in case he was arrested again (Stocker,

2013; "A sense of where you were", 2001).[36] This junta, however, was known for its

particularly brutal tactics, killing up to 30,000 people, called desaparecidos or

"disappeared ones" (Stocker, 2013). Piazzolla was among the thousands who left

Argentina in fear of their safety or were exiled (Gorin, 2001).

Milongas and classes were held in transitory spaces, even condemned buildings.

In her book, *Paper Tangos* (1998)*, Julie Taylor describes the Buenos Aires tango dance

scene of the 1970s and early 1980s from a deeply personal viewpoint. She says:

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[36] Additionally, his orquesta members placed a rose on his piano, denoting that he was
absent and understood to be in jail (Thompson, 2005).

Most of the places I have gone to dance lead a double life. I manage to describe the locale and suddenly, with an exclamation, the person listening to me recognizes it as the seat of a soccer club or the scene of a wedding or a bachelor farewell, or as a nightclub or cafe…I had neglected to stop by one of my new favorite locales for a year because I had heard upon arriving anew in Buenos Aires that it had been condemned by the municipality…When I asked, they responded somewhat cryptically, "Of course it's closed, but there is still dancing — igual se baila" (Taylor, 1998, p. 24).

She also references lingering fear from the Dirty Wars, and her personal interpretation of Argentine tango as an expression of violence: political, gendered, and personal (Taylor, 1998). Tango professionals still in Buenos Aires during this period also note the feeling of being rejected and unacknowledged (Merritt, 2012). This era is sometimes referred to as the 'lost generation of tango' (ibid).

3.2 Argentine Tango in the Contemporary Era

In Buenos Aires, Argentine tango dancing is far from universal, but the practice continues to exist as a growing subculture, and it remains a powerful national symbol. Far more porteños[37] have grown up listening to tango music than experiencing the dance, themselves. However, since the tango renaissance, the numbers of both porteños and foreigners dancing tango around the world have increased. Meanwhile, tango tourism has become an important part of the Argentine economy, and new practices and experiments

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[37] Porteños refers to residents of Buenos Aires.

continue to evolve. This project, *Interactive Tango Milonga*, grows out of this contemporary Argentine tango context.

3.2.1 Tango Renaissance and Second Wave of Tango

In 1983, the show *Tango Argentino* opened in Paris, and the Argentine Junta government collapsed. Opening in 1986 on Broadway, this show re-introduced Europe and the United States to tango as it was being practiced in Argentina (Taylor, 1998; Merritt, 2012). Dancers in these shows, such as Julian Copes and Maria Nieves, would teach tango in post-show classes and workshops (Merritt, 2012). It was not until 1992 that the show played in Buenos Aires, but it began to have an impact on the Buenos Aires tango scene very soon after its debut, along with the Fernando Solanas film, *Tangos, El Exilio de Gardel* (1985) (Taylor, 1998). Furthermore, in the 1990s, the Argentine government created cultural centers offering free tango classes (Merritt, 2012; Dunn & Sclar, 2007). A younger generation, lead by Gustavo Naveira and his partner, Olga Besio, began to learn and teach the tango in the context of social dance (Merritt, 2012). Naveira dismisses both the notions that the fall of dictatorship freed tango and that *Tango Argentino* renewed tango interest, crediting these cultural centers with regeneration of the social tango scene, saying:

> No, the important thing for tango at this time was that the new president, Raul Alfonsin, took a very significant step. He created a network of cultural centers throughout Buenos Aires, and created a program to hire people to give classes in a wide variety of subjects to the people of the city, at no cost to the students. What they discovered was that, while someone would teach photography and have five

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students, or teach painting and have ten students, or teach guitar and have fifteen students, people who taught tango dancing had fifty, seventy, a hundred students in their classes. […] This was very new – a large-scale structure and program that made it really easy for anyone to learn how to dance tango. And all the teachers taught as best they could, with no organization to determine who was "right" and who was "wrong". I know many teachers who are claiming to be "authentic tango" teachers, who started dancing tango in my classes! (Dunn & Sclar, 2007, n.p.)

Dancers such as Fabian Salas, Pablo Veron[38], and Mariano "Chico" Frumboli studied tango with older masters, and began to innovate with the form, as well as teach it at home and disseminate it abroad, leading multiple workshops in emerging tango communities (Bevilacqua, 2008; Plebs, 2009; Merritt, 2012). This tango danced by the new generation of dancers was called "nuevo tango", although many dancers maintained they were not doing anything new (Merritt, 2012; Bevilacqua, 2008; Plebs, 2009). Veron, in particular, argued that Argentine tango has had continuous reinventions, and that the term "tango nuevo" belonged to Piazzolla (Bevilacqua, 2008).

Many of these pioneering dancers are now based outside of Buenos Aires, and tour globally teaching and demonstrating tango dance ("A sense of where you were", 2001). The vast majority of existing United States Argentine tango communities and others around the world have their roots in this renaissance rather than the tango craze almost a century earlier.

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[38] Veron started as professional dancer in Argentine Broadway-style productions as a child, and he also had a stint on the influential *Tango Argentino* show (Veron, 2015).

3.2.2 Tango Commodification and Globalization

Since the tango renaissance, Tango dance tourism has been booming (Dávila, 2012; Fitch, 2015). Destinations like La Boca's Caminito tango district and tango dinner theaters thrive, and the industry serving the global tango community as well (Dávila, 2012; Fitch, 2015). In the late 1990s and early 2000's, the Argentine government began renovating old, crumbling tango venues and devoting substantial resources to promote and nurture tango tourism and the growing re-emerging tango scene (Fitch, 2015). Some of these strategies also disrupted the local tango scene, such as moving the annual Buenos Aires tango festival from the summer months to March, winter in Buenos Aires, in order to coincide with vacations in the Northern Hemisphere (Gubner, 2014). These initiatives were, in part, a reaction to Argentine peso instability, and a strategy for developing an industry that could only take place in Buenos Aires (Fitch, 2015). Thereby, this specialized industry could draw foreign expenditures and investments (ibid).

The commodification and globalization of tango presents a complicated reality as to what Argentine tango is, and to what extent foreigners can participate fully in its cultural and professional activities (Savigliano, 2004; Dávila, 2012; Fitch, 2015). For instance, tango tourism now exists in cities around the world, not just in Buenos Aires, such as the International Istanbul Tango Festival, which draws a significant number of foreigners and professional Argentine tango professionals. However, most middle-class Argentine tango aficionados could not afford a trip, especially after the Argentine peso crash of the 2000s (Dávila, 2012).

While a thriving and vibrant global Argentine tango community promotes Argentine culture and provides many substantial benefits to those involved, when

developing a cultural intervention such as interactive tango, is important to consider, ethically, all aspects of that community's impact. The questions of who has access to cultural resources, what factors are limiting access, how to avoid disrupting local communities and innovation, and how to avoid cultural misrepresentation and appropriation inform the design of *Interactive Tango Milonga*. How questions of access impact design of the interactive tango system is discussed in Chapter 5.4.5.2.

3.2.3 Tango Experimentation and Hybridization

Additionally, the new era of globalism and experimentation has led communities to dance tango in new ways. One example is contact tango, a dance combining contact improvisation and Argentine tango (*Contact tango,* 2012; Cura, 2013). Tango fusion, the combination of Argentine tango with other styles of dancing, is an example of foreign dancers mixing tango movement vocabularies and technique with dances from other cultures. The fusion of tango and blues dance, for instance, is known as 'blango', and events, classes, and festivals have been advertised in cities across the United States such as Charlotte, North Carolina, and Denver (Blango Nuevo, 2014; cmDance, 2017). This project can likewise be seen as instigating the development of a fusion style, the combination of tango with interactive dance and art.

3.2.2.1 Tango Queer

Tango Queer is another, more popular style allowing dancers to change leader and follower roles during the dance as well to ignore normal tango gender conventions (Savigliano, 2004; Fitch, 2015). Mariano Docampo says that:

In Tango Queer nobody takes for granted neither your sexual orientation nor your

choice of taking either one role or the other. What is "normal" here is the

difference and when you dance you do it with whomever you want to and taking

the role you prefer (Docampo, 2009).

The first International Tango Queer festival began in Hamburg, Germany in 2001, one

year before the first gay milonga at La Marshall at the El Beso tango club (Docampo,

2009; "Queer Tango Argentino Festival", 2011; La Marshall Milonga, 2016). This style

is associated with the LGBT[39] movement, and in Buenos Aires this movement is more

associated with women dancing together than men (Savigliano, 2004). Men dancing with

one another have been common throughout tango history as an expression of masculine

skill; thus, the act is not associated with homosexuality (Savigliano, 2004). Additionally,

the movement can be seen as challenging not just to the heteronormative conventions of

the dance, but patriarchal conventions in which only men ask for dances and men

determine dance trajectories, navigation and the make the majority of choreographic

decisions (Savigliano, 2004; Docampo, 2009; Fitch, 2015).

Tango Queer not only presents a new style of dance, but questions its

chauvinistically inclined foundations and allows women access to roles and experiences

that they have previously been denied. *Interactive Tango Milonga* also engages with

shifting the power structures implied in the leader and follower roles through the design

of music-movement relationships. An explanation of this process is discussed in Chapter

6.5.2.2.

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[39] Lesbian, Gary, Bisexual, Transexual.

3.3 Concluding Notes on Argentine Tango History and Social Context

Tango is a powerful Argentine national symbol with a rich history, but it also transcends boundaries as a dance and music tradition practiced by communities around the world. Erin Manning states, "Despite these echoes toward a politics of Argentine national identity, I maintain that tango involves a transculturation, a state of becoming through alterity" (Manning, 2003, n.p.). Manning argues that tango practice, in which individuals, including strangers, may come in intimate contact through touch, movement, and improvisation regardless of nationality or background[40], creates a conduit for the self to come into dialog with the other and thus, transcend borders (ibid).

A tension need not exist between Manning's view and tango as a specific Argentine socio-political and cultural tradition. When we participate in tango practice and community, these aspects are not separate from one another. Tango technique, movements and social settings are shaped by the Dirty War, through loss of specific dancers and their technique, as well as the dwindling of the tradition and through the movement that survived, later rediscovered and transformed. These same movements, techniques and social settings enable the transcultural border crossing that Manning describes as well as the transcendent experience of connection that this project seeks to both study and enrich. Both aspects differentiate Argentine tango from the other movement practices named 'tango' introduced previously in this section, whether danced by porteños or the global tango community.

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[40] Note that contemporary tango communities may not be diverse with respect to socio-economic status, thus the variety of background may be limited in this respect (Dávila, 2012).

Interactive Tango Milonga arises from and engages with this tango tradition and community. As Argentine tango has long been politicized, this project cannot be disentangled from that legacy. While this project does not exist as a collectivist entity influenced by Pugliese's communism like the contemporary tango ensemble Orquesta Típica Fernandez Fierro (Entel, 2007), the act of giving dancers musical agency disrupts traditional power structures of the dance. As contemporary Argentine tango is generally danced to fixed recordings this project does not usurp the musician's role[41], but aims to engender dynamisms in social, musical, and political tango practice.

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[41] A possible future direction of the project is collaboration with live musicians.

CHAPTER 4

CONNECTION AND THE EMBODIED ARGENTINE TANGO CONTEXT

In tango practice, the various meanings and aspects of connection such as mental state, movement technique, and musicality are intertwined. In conversation and interviews, dancers generally do not distinguish between connection as experience and connection as movement technique, suggesting it is experienced as a gestalt.[42] Dancers also report different qualities depending on partner, occasion, music, and preceding events. Connection is seamlessly integrated as a part of lived experience. *Interactive Tango Milonga* intervenes in this space, becoming another constituent variable underlying the formation and character of such experience.

This chapter shines a light on how connection emerges from Argentine tango practice and provides a theoretical framework for the impact of the interactive tango system on dancer experience. Connection is analyzed through the lens of its relation to other musical and embodied experiences and then, through accounts from the wider tango community, drawing on tango research literature as well as a series of semi-structured interviews conducted as part of this research. Tango technique, bodily mechanics and social mores are then addressed to show how this sense of relation develops from concrete aspects of tango tradition.

4.1 A Theoretical Framework for Connection Experience

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[42] See section 4.3 for explication of specific Argentine tango technique.

This section introduces a theoretical framework for understanding and predicting connection experiences within the interactive tango system. Approaches employed reject Cartesian mind/body dichotomies and are grounded in embodied paradigms, such as phenomenology. Such approaches are taken because 1) they have been shown to have efficacy in the analysis of lived experience, multimedia technology and tango (Essl & O'Modhrain, 2006; Armstrong, 2007; Broadhurst, 2014; van Alphen, 2014; Paine, 2015) and 2) they enable bridges between lived experience and cognitive science theories and research (Protevi, 2009; Broadhurst, 2014), allowing the incorporation of diverse perspectives. As the purpose is to provide scaffolding for the analysis of specific encounters related to this research, a full philosophical or scientific treatment of tango embodied experience and connection is outside the scope of this document.

4.1.1 Lived Experience, Mechinic Assemblages, Connection

Merleau-Ponty (1968) posits that in lived experience, the perceiver is not separated from the perceived. If we are flesh, the world is also flesh (ibid; Kozel, 2009). Skin is not a barrier between self and other, but a part of a permeable intertwining with the world (ibid). Deleuze and Guattari (1988) articulate further by framing the subject as a flux, a process, a doing instead of a thing or a being. This lived-subject process is constantly combining with and moving away from other processes in the world. In their terms, the lived subject is a 'mechinic assemblage'. As in Merleau-Ponty's late work, no distinction is made between the lived subject and external entities (i.e., the world). Deleuze & Guattari helpfully extend this notion, considering the flux of the lived subject

within the same framework as they consider everything else in the world: as assemblages (ibid). For instance, they describe a book as:

> As an assemblage, a book has only itself, in connection with other assemblages and in relation to other bodies without organs. We will never ask what a book means, as signified or signifier; we will not look to anything to understand it. We will ask what it functions with, in connection with what other things it does or does transmit intensities, in which other multiplicities its own are inserted and metamorphosed, and with what bodies without organs it makes it own converge. A book exists only through the outside and on the outside. A book itself is a little machine. (Deleuze and Guattari, 1988, p. 4)

Malins (2004) substitutes "[drug using body]" for "[book]" in the preceding passage, demonstrating the flexibility of the assemblage concept for analysis. [Tango dancing body] could also easily be substituted for [book] or any number of entities. Deleuze and Guattari (1988) define this framing of the subject in opposition to the framing of the self and other entities as a static collection of identities that can be described in terms of binary identities (e.g., man/woman, addict/non-addict, dancer/non-dancer).

For instance, to use Gibson's (2006) example, a blind man may be labeled a 'disabled and 'dependent' as opposed to 'able-bodied' and 'independent'. "Within this coupling, the (blind) man and (seeing) dog oscillate between alone and together, selves and not-selves, becoming multiple selves" (ibid, p. 187). So-called able-bodied individuals also combine with other people and machines (such as GPS devices) in order to navigate. Rather than being perceived as independent/dependent or themselves/others, individuals can be seen as reliant on 'networks of mutuality' (ibid).

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Connection may also be framed in terms of assemblages. When the lived subject combines with tango, the body moves toward another body, combining with an embrace, the other's rise and fall of chest, the feel of the dance floor, the particular moment in the tango song. In the next moment, the song has moved to another sounding measure in the music, the space between dancers has shifted, the feel of the floor has changed in the new location. This tango dancing body has now left some of the assemblages of the previous moment and combined with newer sensations, things, ways of being. Some relations have remained constant, such as with partner, with tango social etiquette, with tango movement vocabulary, with tango history and cultural context, but will fall away when the tango dancing body pauses dancing during the cortina[43], finds a new partner, stops dancing for the night, and leaves the milonga.

Manning (2009, p. 16) writes, "Connection, not the locus of beginnings, but the invisible-but-palpable links between two bodies. To move together, the connection must be alive." As assemblage, connection, also a process, can be said to exist or 'live' through these assemblage combinations, each specific in itself. Like the blind man and his dog, each tango dancing body requires the other to move and reciprocate in order to make sense of the world. The tango dancing body requires the ebb and flow of the space of other dancers to know where to travel in next. The tango dancing body employs sounding musical structures to form gesture, time, and movement relations in the dance. As Gibson (2006, p.187) remarks, this postmodern framing reconfigures experience "in terms of a shared vulnerability, a becoming-with-others where bodily boundaries are blurred."

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[43] Cortina, literally 'curtain, refers to the break between tango song sets during a milonga.

4.1.2 Enactivism, Coordination, Reciprocity

Other theorists echo the view of the embodied subject as multitude of activities interleaving and combining. The cognitive paradigm of enactivism, as presented by Francisco Varela and his collaborators, analyzes consciousness not as a singular process, but as an emergent property of many, focusing on the relations between agent and environment (Varela, et. al., 1991; Thompson, 2007; De Jaegher and Di Paolo, 2007). Unlike other cognition paradigms, phenomenology occupies a central place. The living subject, or organism, is reframed as an autonomous system, that is a "recursively self-sustained network" (Barandiaran, 2016, p. 3). De Jaegher and Di Paolo (2007, p. 487) describe it as "a system composed of several processes that actively generate and sustain an identity under precarious conditions."

Autonomous systems resemble mechinic assemblages in that they are always in flux, combining with, moving away from, incorporating and excluding surroundings. Like Varela, Deleuze & Guattari see the organism as an emergent structure (Protevi, 2009, p.135). The "identity under precarious conditions" that enactivists define is not the static stratification into binaries that Deleuze and Guattari position their framework against. Instead, it is a dynamic identity which paradoxically is often experienced by a living subject as what Shusterman (2009, p. 31) describes as an "immediately felt qualitative unity", but is marked by impermanence and disintegration upon reflection into a sense of selflessness and of "no one home" (Varela, et. al., 1991, p. 61).

The activity that most concerns the enactivist paradigm is sense-making, described by De Jaegher and Di Paolo (2007, p. 488) as "the creation and appreciation of meaning." Rather than passively perceiving the world or existing as the world,

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enactivist subjects physically act and engage make the world (ibid; Varela, et. al.,
1991). Shusterman (2012, n.p.) also notes that "our perception always involves some
movement or action, and our action is always based on some form of perception."
Manning's (2009, p. 15) phenomenological account is illuminating: [44]

> My movement creates the space I will come to understand as 'the room.' The
> room is defined as my body + environment, where the environment is an
> atmospheric body. Without that particular moving body that particular
> environment does not exist. [..] There is no 'body itself' here because the body is
> always more than 'itself', always reaching that which it is not yet.

De Jaegher & Di Paolo (2007) expand sense-making, previously focused on
individual agent/environment interactions to include agent/agent(s) relations i.e. social
sense-making, using a dynamical systems approach. Participatory sense-making occurs
during coordination, defined as "the non-accidental correlation between behaviors of
two or more systems that are in sustained coupling, or have been coupled in the past, or
have been coupled to another common system" (ibid, p. 497). While synchronization is
critical to tango and broader musical practice, coordination includes other kinds of
patterned behaviors, such as mirroring and anticipation. During these behaviors,
"individual sense-making processes are affected and new domains of social sense-
making can be generated that were not available to each individual on her own" (ibid,
p. 497). Van Alphen (2014, p. 327) applies this concept to tango movement dynamics:

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[44] Note that Manning's passage is from the work *Relationscapes* (2009), which engages
with Albert North Whitehead's philosophies, and illustrates reciprocal reaching-toward
and as such, she does not necessarily address enactivism directly in this work.

The act of dancing is not reducible to individual behaviors. The coordination itself can break down, without either of the two dancers being responsible. Surely, when the music ends both dancers stop dancing. However, it often happens that the synchronization itself can surprise both dancers at the same time. For example, both dance partners suddenly smile because they know they just shared a moment of perfect interpretation of the music, or just made a weird new move together without having explicitly intended to do so. Somehow they entered into each other's sense-making with respect to the music and the spontaneous movement.

Van Alphen (2014) also applies another related enactivist concept to tango: 'mutual incorporation'. [45] Mutual incorporation is "the process in which the lived bodies of both participants extend and form a common intercorporality" (Fuchs & De Jeagher, 2009, p. 465). The results of this process are strongly reminiscent of becoming-with-others, as the distinctions between autonomous agents blur as they begin to embody one another. Van Alphen (2014, p. 327) describes the experience as "expanding into another body." Fuchs & De Jeagher (2009, p. 477) write, "Mutual incorporation is mutual affection", noting that reciprocation is critical for the process to take place. This dictum is also obviously true for connection. Van Alphen (2014, p. 328) remarks, "[M]any followers will probably affirm that bad leaders unidirectionally delimit their autonomy and experience." Since followers cannot fully participate or reciprocate, they cannot experience mutual incorporation when placed in that situation.

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[45] Van Alphen (2014) describes a third related enactivist concept, consensually coordinated action, which will be addressed in the next section, section 4.2.3.

Kimmel (2012; 2015) also addresses Argentine tango movement dynamics from a generally cognitivist point of view. His focus is on the improvisational process, which he characterizes as a multimodal and multicausal "resonance loop", which can be seen as similar to the reciprocity of mutual incorporation. Improvisation skills such as dynamic repairing and re-routing, with both partners reacting on-the-fly, are an integral part of this process (ibid). Kimmel (2015) also notes that specific aspects of tango embrace and technique contribute to the creation of resonance loops by enabling physical transferences of energies and intensities. For instance, a 'straight' posture[46] combined with a 'proper' embrace allows movement, such as a pivot or step to mechanically travel from one body to another.

Beyond dyadic mutual incorporation and intersubjectivity, tango dance also has the potential for reciprocity among a crowd of dancers and a dancer couple, in a sense a 1 to N relation (i.e., tango dancing *body* becoming-with dancers on the floor) or perhaps even (1 to 1) to N relation (i.e., tango dancing *couple* becoming-with dancers on the floor). As a couple dances and moves through the dance floor, they take up the dynamically occurring available space, which is, in a sense, created by the other dancers on the floor. Through this mechanism, they can have the experience of dancing with everyone that is on the floor. Another potential for non-dyadic mutual incorporation in tango social dance is the patterned rhythmic synchronization of dancing and responding to the same music.

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[46] 'Straight' and 'proper' in terms of Argentine tango technique, the details of which can vary with style and which are subject to debate within the tango community. See Chapter 4.4 for a description of Argentine tango technique.

A problematic aspect of Kimmel's (2015) analysis is his separation of tango movement from musical listening. While he allows music as part of resonance loops, he writes, "Transposing well-heard music into motor commands requires dexterity and timing skills in their own right, no matter how good one's ear" (Kimmel, 2015, p. 8). Thus, he implies that musical listening skills are not necessarily coupled with timing and dexterity skills. This positioning is flawed because 1) his view is not consistent with the enactive understanding of sense-making and perception as being intrinsically tied to action, 2) a growing body of research has suggested that human musical perception, in particular, is strongly tied to the motor system such that humans perceive music as embedded with gesture[47] (Leman, 2008; Schiavio, et. al., 2014; Schiavio & Cummins, 2015), 3) thus, the process of learning musical skills, including listening skills, suggests that such integration is a priori, not after the fact, as Kimmel suggests later in his tract (Schiavio, et. al., 2014; Schiavio & Cummins, 2015). Listening skills, in particular, those related to temporal parsing (Kimmel's example), are unlikely to be found in isolation from the motor skills required to step to the beat, as he suggests. Indeed, empirical research in embodied music cognition suggests that music listening does impact motor response to music without specific training (Leman, 2008). Perception and action remain linked.

4.1.3 Moments, Time, History

If assemblages and more specifically, living subjects, are in a constant state of becoming, we must examine what we mean by the moment and more broadly, time and

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[47] The relationship between movement and musical perception will be addressed in detail in section 5.3.2.1.

history, in terms of the lived experience of connection. Varela, et. al. (1991, p. 63) describe the discreteness of experience as follows:

> An examination of experience with mindfulness/awareness reveals that one's experience is discontinuous –a moment of consciousness arises, appears to dwell for an instant and then vanishes to be replaced by the next moment.

Dancers at times also remark that they encounter such a loss of self and mindfulness during connection and also compare their experiences to meditation[48] (Seyler, 2009), suggesting that dancers at times may also be experiencing this discontinuity during dance. However, in other mental states including other connection experiences, the individual may experience an emergent coherency between moments and thus, a continuous, if precarious, self (ibid).

This moment of experience occurs over a time period, the length of which is influenced by various cognitive/physical processes such as short-term memory functions. Varela, et. al. (1991) estimate this duration generally varies between 0.15-0.5s depending on context, which can be measured by determining the time window in which events humans perceive as happening at once versus sequentially[49]. This duration is thus pivotal for dancer perception of synchronization and thus, mutual incorporation.

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[48] Surveys conducted as part of this research also support this statement as well. Results and study design are discussed in relation to connection experiences in section 4.4.8.1 and considered in more detail in Chapter 7 in the context of the interactive tango system.

[49] Note that Wessel & Wright (2001) estimate a smaller window for optimal musical instrument response latency (<10ms) than Varela's estimation for a moment. It is likely that the windows for unison actions vary according to context and cognitive system involved.

This discrete moment does not exist in isolation, but is shaped (or 'enacted') by previous moments – moments that are filled with interactions that the lived subject, or agent has had with its surroundings (including with other agents) (ibid). In enactive terms, this is part of a process called 'structural coupling', and applies to all autonomous systems (Varela, et. al., 1991; Thompson, 2007; Barandiaran, 2016). As the agent shapes the world, the world also shapes the agent. Indeed, Varela goes as far as writing: "What is cognition? Answer: A history of structural coupling that brings forth a world" (Varela, et. al., 1991, p. 206).

The history of structural coupling has also been investigated and expanded in relation to social and cultural interactions, such as tango. Van Alphen (2014, p. 328) points out that, "the embrace is more than just a physiological constraint on our individual action, it is tradition." As argued in the previous chapter, tango movement technique and dynamics, social mores, and musicality arise out of culture and history. In order to tango, dancers must agree on (or enact) social codes and specific ways of moving and reacting (ibid; Baerveldt & Verheggen, 2012). Baerveldt & Verheggen (2012) have given this social agreement or enactment the term 'consensually coordinated action,' while Kimmel (2015) borrows a term from Warren (2006) to denote a similar concept as 'consensual interaction frames' to describe dancers mutual wishes to dance and adherence to social rituals. How the individual actions engage and add to shared tango history impact connection experiences not just for the individual and partner but also for other tango dancing bodies in aggregate (van Alphen, 2014). Additionally while Argentine tango, as a socio-cultural practice is intrinsically normative (Tateo, 2014), the

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practice also consists of individual variations on ways of dancing and perceiving tango dance (van Alphen, 2014).

4.1.4 Extensions, Breakdowns, Attention

Clark & Chalmer (1998) use the example of a man writing down an address on a piece of paper to illustrate the concept of 'active externalism', the idea that the external environment is actively, i.e., in terms of "here and now", part of cognition. In their original example, the cognitive extensions are inanimate (eg. paper, pencil), but like mechinic assemblages, aspects of the external world that are part of cognition may also be cogniting or not, as they are significant mainly in terms of their functionality and their potential linkages. While similar to enactivism, this framing brings into focus how external objects may be appropriated for cognitive use, such that they may be seen not only in terms of extensions but also in terms of cognitive tools or instruments.

As part of tango, each dancer performs cognitive tasks for the other. For instance, the leader performs the task of navigation for the follower[50]. In a sense, when she is walking backwards, she is using him as she would an instrument for navigation, and he is performing the cognitive tasks that she is not[51]. Her use of this navigation tool requires skills that she has spent time, perhaps on the order of years, learning. When she is dancing into the space she cannot see, she is not consciously thinking of her leader as navigator or exactly how she performs all the processes allowing her to do so. Instead,

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[50] Similarly, the dog also navigates for the blind man.

[51] Other aspects of tango connection may be framed in this manner as well, such as when the leader sends the follower into a boleo (i.e., whipping kick) he is relying on her to carry out his intention, a cognitive process.

the leader disappears or merges into the whole action and she is simply dancing. She is

engaged in 'unreflective skillful action', which "unfolds in the absence of self-reflective

thought or conscious self-awareness" (Brownstein, 2014, p. 546).

In Heideggerian terms, the follower experiences the leader as 'ready-at-hand'

(Heidegger, 1962; Armstrong, 2007). But when the leader suddenly steps on her foot this

follower shifts out of the unreflective state and suddenly, the leader becomes visible. She

now must manage his feet and legs, as well as her own separately, and how they are now

entangled, how their embrace has become so tightly-wound and uncomfortable. Both the

leader and her own legs are now 'present at hand' (ibid), and she is now in reflective

action, managing how she disentangles herself and recovers. Whereas before, when the

leader was 'ready-at-hand' she had experienced the connection as alive[52], that sense has

now disintegrated. These 'breakdowns (ibid)' are critical for understanding how

connection emerges, fluctuates, intensifies, and subsides. Similarly to how brain injuries

are invaluable to neuroscience research, implying the location, function, and interaction

of neural processes, the causes and results of connection breakdowns are revealing.

The breakdown, shifting from unreflective to reflective state, tends to be caused

by a change in attention, such that the dancer cannot maintain a focus on dancing as a

holistic activity. As discussed in Chapter 2.2.3.4, cognitive resources such as attention are

finite (Baddeley, 2003; Franconeri, et. al, 2013). When the dancer attempts to direct

awareness towards too many things, her ability to carry out specific action collapses.

Straightforwardly, this is what triggers a breakdown. Attention depletion may accumulate

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[52] In Manning's (2009) terms.

more gradually, as a result of the dancer attempting to track too many entities, or it may occur suddenly, as a result of an expectation violation (see Table 1).

Table 1

Summary of the Causes of Connection Breakdowns

Tracking Overload	Expectation Violation
• Overthinking / Self-reflection • Self-criticism • Skills not fully integrated into a gestalt (e.g. beginning dancer) • On-going distractions (e.g. partner talking through dance) • Unfamiliar environment or social codes	• Timing mismatch (e.g. partner steps off-rhythm, too late or early) • Miscommunication • Tool breakage (e.g., rough spot on floor) • Sudden distraction (e.g. loud noise)

The most common time to experience breakdowns during the dance is during the learning process (Dreyfus, 1996; Armstrong, 2007; Kimmel, 2015). The learner first encounters the multimodal skills required for tango dancing as separate processes that she much keep track of separately. She must practice repeatedly to integrate those skills into a gestalt, or such that they converge into one holistic process to which she gives her attention (Dreyfus, 1996; Sutton, 2005; Armstrong, 2007).

Dreyfus (1996) classifies embodied learning into five stages: Novice, Advanced Beginner, Competence, Proficient, and Expertise. He theorizes that once learners have become experts, they are involved in 'skillful coping' in which the body no longer necessarily needs a set of goals to act, but is acting in "direct response to familiar gestalts" without needing to interact with mental representations or symbols (ibid, n.p.). Thus, the task's draw on attentional resources is much reduced, lessening breakdown occurrence. Even when breakdowns occur, the learner is able to recover much faster. For

instance, a very skilled follower may be accustomed to having her feet occasionally stepped on and while she may momentarily be distracted and her sense of connection may subside, and if the breakdown does not repeatedly occur, she may easily recover both her footing and her sense of immersion in the moment.

However, many tango dancers are not experts, and are at many different skill levels. Dreyfus' (ibid, n.p.) description of Competence is enlightening:

> Now, coping becomes frightening rather than exhausting, and the learner feels great responsibility for his or her actions. Prior to this stage, if the learned rules didn't work out, the performer could rationalize that he or she hadn't been given good enough rules rather than feel remorse because of a mistake. Now the learner feels responsible for disasters. Of course, often, at this stage, things work out well, and a kind of relation unknown to the beginner is experienced, so learners find themselves on an emotional roller coaster.

He also compares the emotional rollercoaster of Competence to the tendency of beginners to be emotionally-detached about their mistakes or breakdowns. Tango dancers' emotional reactions to breakdowns are likely be influenced by their stage of learning. These reactions will likely be received by their partner and may also affect dancers around them.

Self-criticism also causes breakdowns because of its use of attentional resources. However, such self-reflection may also impair aspects of connection and tango apart from the demands placed on attention. In his analysis of unreflective skillful action, Brownstein (2014) invokes Limb & Braun's (2008) study that invested the brains of musicians engaged in jazz improvisation via fMRI brain imaging. They conclude that

musical creativity involves processes related to self-expression as well as a suppression of self-monitoring and related processes. Musical creativity is an integral part of tango movement and connection, and thus its inhibition would also affect connection. However, it is unclear why lack of self-monitoring frees creativity, and attention could still be a significant factor.

By examining breakdowns, we have learned that attention, or directed awareness, is critical to tango dancing bodies. Kimmel (2015, p. 7) writes, "Reliably tracking what counts in a moving body is what orients dancers." That 'what counts' does not remain still, but shifts and divides in the moment to encompass the sounds of the bandoneón, embrace, floor, tracing foot, then other aspects of dancing. While the entire history of structural coupling, including consensually coordinated action, has left traces that have shaped the tango dancing body, that body only consciously experiences the traces that dancer attention is directed towards at any one moment. Since attention is always in flux, experience is always shifting to include and exclude frames of reference and meaning.

Additionally, because breakdowns are one of the main tools for discovering the unknown, they are also critical to tango technique. For instance, when a leader dances with a new follower, that leader does not know the extent of her tango background or skills. She could be an expert or it could be her first day dancing. He only begins to understand her context by leading her into steps. If she responds in such an unexpected way that connection subsides, he has learned that he must change the way he is dancing in order to preserve connection. Perhaps he does not lead her into more advanced tango figures.

Breakdowns, paradoxically, may also increase the sense of connection after the fact, in memory. Because connection may be between many entities or assemblages in tango, a breakdown may occur between two or more assemblages simultaneously, in the same manner as if they were one. For instance, when a tango dancing couple accidentally continues dancing after the end of the song together, each caught unawares by the cadence. The sudden expectation violation will cause a break into reflective action, but because they entered into the state as one, the event will act as confirmation of the intensity of their previously connected state.

4.2 How Dancers Describe Connection

When asked what makes tango most distinctive or what is most important to the dance, the majority of dancers tend to cite connection (Olszewski, 2008; Seyler, 2009; Cara, 2009). Tango, itself, is often broadly described as a dialogue and connection is likewise often defined as communication (Olszewski, 2008; Seyler, 2009; Cara, 2009; Tateo, 2012; Cant, 2012), Seyler (2009) in particular uses the terms interchangeably. While connection is often described as an intense transcendent state, it is also experienced at different levels, with most practitioners insisting that it must be present in some form in order for the dance to take place (Manning, 2009; Seyler, 2009; Cant, 2012).

A dominant thread of connection and tango experience more broadly is intimacy. Dujovne (2011, n.p.) says, "Not through our eyes but through out physical contact and intuition, we dancers immediately know something deep and private about one another." Some dancers find this intimacy the distinguishing characteristic of tango, setting it apart

from other dances, particularly in comparison to other Western partnered social dances (Cara, 2009; Dujovne, 2011; Cant, 2012). This feeling is attributed to the close physical contact of the embrace and the mutual dependency of each partner on the other, a necessity for tango improvisation (Seyler, 2009; Cara, 2009; Dujovne, 2011; Cant, 2012; Zubarik, 2013). This intimacy does not have to be sexual. In fact, it likely is not. Social tango dancers tend to de-emphasize the sexual connotations so prevalent in the popular imagination of the dance, instead focusing on general sensuousness or the feeling of bonding with another (Seyler, 2009; Cara, 2009; Dujovne, 2011; Borgialli, 2015).

A related quality that dancers cite as necessary for connection or a feature of connection is trust (Cara, 2009; Seyler, 2009; Cant, 2012; Zubarik, 2013). It follows that the lack of trust in one's self, partner or the situation creates serious disturbances in the ability to feel connected. After an unpleasant dance, Cant (2009, p. 223) writes, "[D]ancing with strangers can be difficult, adding to the stress of the encounter. Fear of the unexpected can cause tension, and the more a body tries to relax, the more it contracts through concentration [..]." However, she has other dances with strangers that she describes as positive, more connected experiences (ibid).

Many dancers and tango research focus on this juxtaposition between strangers and the intimacy of the dance when describing connection (Seyler, 2009; Cant, 2009; Dujovne, 2011). More generally, the social ritual of tango helps to create this sense of trust and counteract insecurities and instabilities (Cara, 2009). In her account of a milonga, Cant's specific trust of new partners ebbs and flows with quality of the embrace (Cant, 2009). Merritt (2012, p. 105) notes while tango enables connection experiences, the social codes and conventions can also work against it, presenting the "lamented

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aspects of social tango", which she describes as "surveillance, display, exhibitionism, anticipation, waiting, self-doubt, pressure to perform, potential for rejection." Several dancers in her interviews cite tango as resulting in both transcendent joy and complete devastation (ibid). These experiences correspond with Gibson's (2006) analysis of the vulnerability that 'becoming-with-others' entails and the uncertainties that such dynamics engender.

Some dancers strongly associate connection and tango, in general, with spirituality. Seyler, a tango researcher, describes the aims of her mixed-methods exploration of the Philadelphia tango community as springing from her experience of tango dance as spiritual (Seyler, 2009). Cara (2009) describes connection as metaphysical, citing surveys as well as tango literature and lyrics. For instance, a tango instructor she interviews comments, "[T]ango dancing is something very secret" (ibid, p. 453).

Connection may also be framed as a type of remedy for both psychological and physical illness. For instance, in Buenos Aires, tango therapy is becoming increasingly common, and many tango dancers cite dancing as a form of catharsis (Merritt, 2012). Tango has also been explored in relation to couple therapy (Wagner, 2012), as an anti-depressant (Pinniger, et. al., 2012), its stress-related hormone reducing effects (Quiroga, et. al. 2009) and as an ameliorant for Parkinson's disease (Lötzke, 2015). Merritt (2012) also notes that dancing and intense connection experiences are often compared to use of recreational drugs, and tango has been investigated as an addiction (Targhetta, 2013).

Many tango dancer descriptions of intense connection also tend to support varied interpretations and metaphors discussed above: spiritual, metaphysical, and drug-induced.

For instance, one tanguero described the feeling by saying it was as if he were flying (Seyler, 2009, p. 356). Another aspect supporting these metaphors is the sense of losing individuality or merging with a partner, music and/or the other dancers on the floor. One dancer describes this feeling as the "self-other mystery" and another commented about "a truer sense of self where your sense of self is actually nothing there" (ibid). Dancers also experience timelessness as a result of strong connection on the dance floor, one dancer saying, "A good dance might be that you lose track of time and where you are, and its just the moment, almost like a meditation" (Merritt, 2012, p. 108).

Connection can also be seen as part of larger Argentine culture and expression. Porteños[53], for instance, tend to see connection as more quotidian than foreigners do as they perceive it in their everyday activities (Dujovne, 2011; Merritt, 2012). Dujovne (2011) suggests that tango is part of a cultural openness, part of the idea that "in five minutes, porteños tell you who they are" (Dujovne, 2011, n.p.). She contrasts this openness with her encounters in Chicago, where people were friendly but kept their physical and social distance. Merritt (2012) also notes that porteños generally are less likely to cite connection as the main draw for tango since they perceive that quality in other areas of their lives.

4.2.1 Structured Interviews on the Connection experience

As part of this research, I conducted a series of semi-structured interviews[54], asking tango dancer subjects about their experiences and understanding of connection. The interviews were carried out in conjunction with the user studies and as such are

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[53] Porteños refers to the residents of Buenos Aires.

described in more detail in Chapter 6, as well as their relevance to system performance and experiences. Results should be seen as explorative since the number of subjects was small. Subjects were also interviewed about dancer musicality and those results are discussed in section 4.3.8.1.

4.2.1.1 Methodology Overview

Semi-structured interviews were conducted on four occasions between October 2015 and January 2017. There were 17 social Argentine tango dancer subjects[55] recruited from the Phoenix metro area ranging in age from 18 to 68 years old. All dancers primarily danced in their gendered role with 8 male/leaders and 9 female/followers. Dancers also were at a variety of skill levels with ranging 3 months to 14 years of tango experience. The average tango experience was about 4 years. The highest self-assessment of skill was 'Advanced Intermediate' and the lowest self-assessment was 'Beginner'. This broad self-assessment of skill had a relatively low correlation with years dancing. The vast majority of dancers were not familiar with interactive music and art, with only one dancer claiming experience.

The question (3) and follow-up (3a) was only included in the last two interviews, and thus were asked of 10 participants, 5 male and 5 female. Age range (20-60 years) and tango experience (10 months - 8 years) was not significantly altered in this subset, and experience with interactive systems and art is unchanged.

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[55] The interactive tango user study had a total 20 participants (10 leaders, 10 followers), but 3 dancers were not able to complete the semi-structured interviews on connection and musical relationship due to time constraints.

4.2.1.2 Summary of Findings

The results of this survey largely echoed themes in previous research. All dancers viewed connection as integral to the dance. Several dancers mentioned the quality of merging or feeling as if they were one with their partners, the music, and other dancers. For instance, one subject used the imagery of "Siamese twins" to describe feeling as if he and his partner were thinking the same thoughts. The complementary characteristics of intimacy and trust also appeared in many responses. When prompted to elaborate, some dancers mentioned that in order to be strongly connected, they had to let themselves be vulnerable. Relatedly, they often described connection experiences as relaxed and comfortable. Feeling comfortable may be both a pre-condition of intense connection states and a result.

Dancers reported varying frequencies and intensities of connection experiences. Some dancers experienced connection almost every time they danced at some level. One dancer saying that he felt connected in all dances when he wasn't dancing with a very beginner dancer. Others reported that it was rare for them to feel truly connected. It is possible some of these differences may be attributed to dancers differing interpretations of connection. Some dancers seemed to define much less intense experiences as connection than others, who seemed to reserve connection to refer to transcendence. However, not all differences can be attributed to this thresh-holding, as differing individual qualities, skill levels, and dancer roles could also play a role. For instance, empirical studies imply that people have varying abilities to slip into immersive states (i.e. hypnotic suggestibility) and also, that it affects individuals tendency to become absorbed in music (Fachner, 2006). Additionally, social self-monitoring also varies

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across individuals (Ajzen, et. al., 1982), and this also impacts connection states. Many dancers explained that if they or their partner was overthinking, too concerned with technique, and/or self-conscious, connection was disrupted. For example, one leader in the study who emphasized relaxation and comfort in the connected state also reported experiencing connection relatively rarely. Dancers also remarked that often they could not say why they connected with some partners particularly well, especially when they had intense connection experiences with strangers.

While skill and tango experience would seem to be a factor in connection experience, especially in beginning dancers, this study did not reveal such a pattern. More subjects would be needed, especially at the beginning skill level, to clarify such results. Dancer roles also did not seem to affect reported intensity and frequency of connection, although in her more extensive ethnography, Seyler (2009) found that the follower role tended to engender more experiences described as transcendent and/or spiritual.

Dancers were very divided about the role of music in connection experiences.[56] Many defined connection in relation to music saying that connection was, "paying attention to the same things in the music", or otherwise indicating that connection was primarily about shared musical perception. Others emphasized that connection begins with the music before they even encounter their partner on the dance floor. One dancer found music to be the one ingredient essential for connection and dance in general. However, other dancers saw music as less pivotal, perceiving their bodily connection to their partner as being most essential, and the musical connection as equal in importance,

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[56] See section 4.3.8.1for survey results regarding dancer musicality and relationship to music.

secondary, or coming later. Relatively more dancers in this study reported music as critical to connection and to tango experience and in much stronger terms than in other studies of foreign dancers (i.e., non-porteños).[57] It is possible that, in general, the dancers who chose to participate in this study are more concerned with music than other dancers. About a third of participants self-identified as amateur musicians or had played an instrument in the past. It is also possible that dancers were primed by their participation in the interactive tango system to frame connection in strongly musical terms.

4.2.2 Related Experiences and Mental Processes

Aspects of connection, such as complete absorption in an activity (dancing), strongly resemble Mihaly Csikszentmihalyi's concept of flow, a state of intensified concentration (Merritt, 2012; Csikszentmihalyi, 1990). Time seems to disappear along with distractions, and one is entirely in the present, focused on a task (ibid). Many causes of connection breakdowns are similar or the same as breakdowns in flow.

Judith Becker's work on trancing also reveals a consciousness similar to intense connection states, involving timelessness as well as the sensation of losing one's individual self and becoming one with music, associated with both 'deep listening' and religious ritual (Becker, 2004). Intense connection experiences are described as the 'tango trance' by some in the tango community (Merritt, 2012). Like this text, Becker incorporates an enactive approach, approaching trance from the viewpoint of structural coupling and framing trance as a process/activity rather than a state.

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[57] Immersion in tango music and lyrics was reported as the most important aspect for porteño dancers (Merritt, 2012).

While the feeling of being at one with a partner is integral to connection, being in a flow or trancing does not necessarily require another person. However, Becker (2004, p. 127) points out that analyzing only the individual is missing important aspects of the process:

> Thinking of the relationship of emotion and music and trancing as a biological process with a co-defined, historically enacted ontology, as a group creation in which self-contained individuals have undergone structural changes through their interaction with other self-contained individuals, helps to provide an integrated embodied analysis of the relationship of music and emotion and trancing. By this approach, the trancer is not isolated as the wild card in a description or analysis of trance events, but can be seen as closely interconnected to everyone else who is participating.

Tango community members remark upon feeling in communion with not only their partner, but with the rest of the dancers on the floor, reflecting that just dancing alone with their partner at home did not engender the same kind of feelings (Merritt, 2012). Connection is also similar to William McNeill's 'muscular bonding' defined as "the human emotional response to moving rhythmically together in dance and drill", also noting the features of timelessness and blurring the lines between the individual self and others engaged in synchrony (McNeill, 1997, n.p.).

Zubarik (2013) relates the kinesthetic experience of tango to Theodor Lipp's concept of Einfühlung, literally "feeling into" in German. Loosely translated, the word means empathy, but Lipp uses the term to mean an "involuntary, instinctive, unmediated mimicry of an external Other" (ibid, p. 276). This framing seems to be another way of

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describing the experience of intersubjectivity and mutual incorporation described in section 4.2.

Most of these experiences are described as pleasurable and some resemble ecstasy. Involvement via movement (e.g., playing, dancing) tends to lead to different types experiences than listening alone (Becker, 2004; Turino, 2008).

4.3 Kinetic Connection and Dance Technique

This chapter brings the previous theoretical discussion directly into the rhetoric of tango dance. I introduce Argentine tango technique and movement vocabulary, addressing the embrace, specific moves, musicality, and semi-formalized social norms, revealing how connection emerges from tango practice.

4.3.1 Preface on Tango Styles

The practice of Argentine tango varies globally, across regions as well as porteño dance venues and from dancer to dancer. A full explication of tango variants and movement vocabularies is outside the scope of this document, and so this section will focus on tango technique common to all styles. However, in the interest of accuracy, this section may refer to a technique as being mainly practiced by one or the other of the two largest schools of Argentine tango dance, with the understanding that distinctions made are simplifications and cannot represent the entirety of and crossovers between

practices[58]. For a background in the historical development of tango and the range of

expressions within the tango form, see the historical discussion in Chapter 3.

The first style, tango nuevo[59], refers generally to the style of tango dance which

became popular during the early tango renaissance and spread by dancers such as

Gustavo Naveira, Mariano "Chicho" Frumboli and Mariana Montes (Merritt, 2012).

While the term 'tango nuevo' is problematic[60], no other terms are in common parlance

for this tango style. The second style, milonguero, is a style of tango generally danced in

a tight, forward-facing close embrace taught by dancers such as Susana Miller (ibid;

Zubarik, 2013). [61] In practice, the boundaries between styles and dancers employing them

are often fluid.

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[58] Merritt (2012) found in her research that many Argentine tango teachers largely reject stylistic distinctions and claim there is one tango (i.e., within Argentine tango, as ballroom forms are not generally addressed or engaged with).

[59] Literally, 'new tango'.

[60] Refer to Ch. 3.3.1 for a discussion on the term 'tango nuevo'. For this section, tango salon, the other major Argentine tango style, is not addressed as a separate style as it is not always distinctive in contemporary practice (Zubarik, 2013). Additionally, while the term 'tango nuevo' was applied in more or less consistent ways to characterize tango style or milieu of dancers across the literature, the application of the term 'tango salon' to a tango style sometimes varied; thus 'tango nuevo' is the preferred term and referred to as the main style alternative to milonguero.

[61] The term 'milonguero' also refers to a regular dancer who frequents a milonga (Merritt, 2012).

4.3.2 Introduction to Argentine Tango Technique

In Argentine tango, kinetic connection flows mainly from the upper chest. Even without contact[62], a dancer can receive the impulse to move by watching this upper body movement. An urge to step backward is common when another body is encroaching on one's space. If a person steps to the side, we can likewise mirror this motion, and if the step is backward, move to take the open space[63]. The leader initiates with his upper body first, inviting the follower to move in response. When walking in sync, their feet hit the ground together, as his lower body lags slightly behind his upper. The walk, or camineta, is seen as 'columna del baile' or backbone of the dance (Borgialli, 2015, p. 6). Many more subtle movement signals may be crafted upon this interaction, especially with the addition of the embrace (Zubarik, 2013). Connection facilitates not only gross movements like steps and figures, but also continuous and fine movement features. Argentine tango has a relatively small collection of basic steps compared to other social dances, but they may be combined and expanded in a multitude of ways (Cant, 2010). While the leader most often determines the steps and timing of the dance through invitations to move, the follower shapes the dance through the timing and character of

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[62] Despite the fact that one can lead and follow to some extent without contact, touch is essential to Argentine dance (Ninci, 2016).

[63] This framing of tango movement mechanics is influenced by an introductory Argentine tango lesson and demonstration given by Jason Laughlin in Durham, NC, 2005.

response (ibid). The bodily mechanics of connection have been observed to be similar to contact improvisation (CI) techniques (Ninci, 2016).[64]

Both dancers have opportunities to embellish, that is, add movements of one's own impulse, in addition to the steps led or followed by a partner (Rauscher & Brooks, 2010; 2012a). Dancers often take note of their partner's embellishments, and incorporate them into the led or followed dance. However, the aspect of connection and partnering is so essential to the dance that it is impossible to conceive of Argentine tango existing as a solo form. As the old saying goes, "It takes two to tango."

4.3.3 Embrace (El Abrazo)

Connection is transmitted via the embrace, through momentum and touch. Most Argentine tango styles may be danced in the closed position (Zubarik, 2013). While milonguero style is only danced in close embrace, tango nuevo and other styles allow an opening and dynamism of the embrace (ibid). In milonguero style, couples tend to share the same axis, achieved by the forward tilt of each dancer towards the other, so their chests, but not hips, touch (ibid).

In tango nuevo, both open and closed embrace are possible, and the embrace is elastic, that is, it can change throughout the dance, depending on movements and lead. In this style, dancer axis can also alter throughout the dance; however, for the majority of the dance, leader and follower tend to maintain their own axes, even in a closed position,

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[64] See Chapter 3.3.3. for a brief discussion of contact tango and other tango fusion styles.

Figure 1. Tango Embrace. Left depicts a milonguero-style close embrace. Middle is a nuevo-style close embrace. Right is a nuevo-style open embrace.

often via a triangle position[65] (ibid). In this embrace, dancers stand closer to one another

on the closed side of the embrace, to the follower's left and the leader's right. This side of

the embrace is often called the 'dark side' of the embrace. The other side of the embrace,

to the follower's right and the leader's left, is called the open side. The arms, even in an

open embrace, generally do not form the basis for the lead. Cant says, "arms should not

push, pull, grip, or be too rigid" (Cant, 2012, p. 220). In an open embrace, the arms help

to communicate the movement of the upper torso, but the arms usually should maintain

the curve or space of the embrace and not move in isolation[66] (Borgialli, 2015).

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[65] The nuevo-style embrace is often called the "v-embrace" in the U.S. tango community. Anecdotally, nuevo and other contemporary tango dancers often use a more milonguero-style close embrace while still opening up for particular moves. Again, there are many variations as well as innovations in technique in Argentine tango practice.

[66] Some tango moves use hand and arm movement and pressure (e.g., some boleos (kicks) (Rauscher & Brooks, 2012a, 2014a), and some teachers emphasize the use of hand pressure in the lead (Cant, 2010). The leader's hand on the dark side, generally in the closed position, is commonly used to aid in signaling some moves (e.g. leans).

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The quality of the embrace is critical to dancer connection experience (Zubarik, 2013). Both Argentine tango teaching philosophy and recent research support this conclusion (ibid; Borgialli, 2015). Zubarik's research (2013), surveying 19 tango dances with varying experience levels, suggests that close embrace tended to engender experiences that her subjects describe as "flowing into each other" (ibid, p. 283) or "fusion" (ibid, p. 285), which appear to be relatively intense connection experiences. However, the open embrace was less associated with these feelings. In a related study in which dancers experienced in open embrace were taught closed embrace, then interviewed about the experience, she found that the close embrace increased both subtlety of communication and intensity of emotional response, both positive and negative (ibid). She found that "purely physical errors immediately trigger emotional responses" (ibid, p. 282), i.e., technique errors were interpreted by partners in some manner as signaling negative emotions or intentions, even though their partner was still learning the technique in the workshop.

4.3.4 Brief Overview of Common Argentine Tango Figures[67]

This section defines the Argentine tango figures and moves relevant to the design of *Interactive Tango Milonga*. The walk, or camineta, described in the introduction (section 4.3.2) is the only tango move, which, by necessity, appears in all dances. While other figures may be almost as common, dancers may or may not employ them.

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[67] Video examples of all the figures described in this section may be found at: http://www.courtney-brown.net/Dissertation/ExampleTangoFigures. The password for these videos is: dissertationtango.

4.3.5.1 Boleo

A boleo[68], literally 'whip', in Spanish describes a whipping motion of the follower's leg (Borgialli, 2015, Rauscher & Brooks, 2012b, 2014a). The leg may remain on the floor or it may fly up in a kick (Rauscher & Brooks, 2012b, 2014a). The flying boleo, or kick, is a less common figure, because it is dangerous on a dance floor. Boleos may be circular or linear, forwards or backwards (ibid).

4.3.5.2 Giro

A giro is a common turn in tango (Borgialli, 2015). Unlike in dances like salsa or swing, partners to not break embrace. The follower may walk around the leader, who is at the center, or both follower and leader may walk around an imaginary center (ibid).

4.3.5.2.1 Calesita

A calesita[69], or 'carousel' is a turn in which the leader walks around a pivoting follower (ibid).

4.3.5.3 Cruzada (Cross)

Generally, the cruzada or cross refers to a fundamental move of Argentine tango when the follower crosses her left leg over her right leg, usually resulting in a change of weight (Borgialli, 2015). [70]

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[68] Also spelled 'voleo' in Spanish, but more commonly spelled 'boleo' in tango circles.

[69] May also be spelled 'calecita' in some tango literature.

[70] Thus, crosses are generally in the direction of the open side of the embrace. Crosses on the dark side are also possible, but generally, due the asymmetry of the embrace, they are more advanced figures, not a foundational move.

4.3.5.4 Ochos

An ocho, literally 'eight' in Spanish, is a tango figure in which the follower draws a figure eight on the floor with her feet via stepping and pivoting (Borgialli, 2015). The leader may perform several steps while leading ochos, including performing the pivoting steps along with the follower.

4.3.6 Adornos (Embellishments)

Adornos, or embellishments, are tango figures performed independently by an individual that are not part of the lead or follow of the dance (Rauscher & Brooks, 2010, 2012a). They are seen as ornaments or decorations. Followers generally perform more adornos more often than leaders. A common adorno is the lapíz ('pencil') in which the foot draws a circle on the floor (ibid). Another common decoration is lightly kicking or briefly crossing one foot in front of the other, which can be performed while stepping, during ochos, or during a parada, a pause or literally, stop. Rauscher & Brooks, Atlanta-based tango teachers, call these decorative kicks 'tucks' (Rauscher & Brooks, 2010, 2012a).

4.3.7 Improvisation

Argentine tango, even relative to other Western partnered social dances such as swing or salsa, is an improvised dance, lacking basic step patterns set to particular rhythms[71]. The *Tango Virus*[72] creators describe tango as 'concatenative', comparing it to

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[71] While some instructors teach an eight-step basic and most instructors teach sequences, these are generally intended as didactic tools, rather than a basic step in the sense of swing or salsa. Each step must be explicitly led and the timing of such steps may vary.

an alphabet (Causa, et. al, 2005, n.p.); however, unlike symbols, tango figures are not always clearly delineated from one another and the internal energy, timing, and trajectory of each figure vary highly and are critical to expression. While tango movements are codified and stylized (Zubarik, 2013), the basic technique, particularly in the context of tango nuevo, can and has been used for invention (Merritt, 2012). For instance, one famous dancer, Norberto "El Pulpo" [73] Esbrez, is known for finding creative ways of generating ganchos[74] (i.e. interlocking kicks between leader and follower) (Rauscher & Brooks, 2014b; Merritt, 2012). This flexibility can be seen as both emerging from and critical to the focus on technique over steps relative to other social dances.

However, unlike more freeform dances like contact improvisation, music plays a critical role in dance structure in tango practice (Ninci, 2016; Ladas & Ladas, 2013). Improvisational skills are inextricably tied to musical response and listening.

4.3.8 Dancer Musicality

In addition to the mechanics of kinetic connection, dancers engage in musical connection, interacting in how they respond to music with their movement (Olszewski, 2008; Borgialli, 2015). Tango's lack of fixed rhythmic patterns in dance allows for a greater freedom of dancer musical expression but may present difficulties to novice dancers. Olszewski (2008, p. 72) claims that "'dancing to the music' is something for intermediate to advanced dancers."

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[72] See Chapter 2.3.3 for further discussion of the *Tango Virus* installation.

[73] 'The Octopus' in Spanish.

[74] 'Hooks' in Spanish.

For example, in response to Seyler's (2009, p. 267) survey of the Philadelphia scene, one dancer commented, "[tango music] has no time counting: [it is] not structured to 4 or 8 counts." For the classically-trained musician, this comment might seem puzzling, as tango songs played at social dances are either quadruple (tango), duple (milonga), or triple (waltz) meters and the majority of phrasing[75] is in groups of eight or another multiple of four. However, many dancers commented on tango music's complexity and unpredictably (ibid). The perception of tango music as very complicated may stem from dancers' unfamiliarity with the style of music, its relative complexity to more popular musical styles (e.g., rock), the lack of drums or percussion articulating stressed beats of the meter, and the use of syncopation.

Merritt (2012) notes that for most porteño tango dancers, music tended to be pivotal to their experience of connection and transcendence within the dance. They described tango dancing as a way to become lost in the music and the lyrics (ibid). However, non-Argentines cited music in their experiences at a much lower rate, and she suggests that it was a much longer process for foreigners to become both familiar and comfortable with the music (ibid).[76]

Homer and Christina Ladas, well-known American tango teachers and performers, begin the teaching of musicality by demonstrating what they call the

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[75] Of course, exceptions exist.

[76] From my experience as a member of the tango community, I have noticed that many American dancers, even a few experienced ones, have trouble hearing when the end of a musical phrase occurs in traditional tango music, even when, in terms of Western music, the melody, harmony, and rhythmic phrasing are very obviously telegraphing an approaching cadence.

'walking beat', the sound of a marcato bandoneón fall occurring on strong beats[77] (Ladas & Ladas, 2013). Essentially, they are first teaching non-experts how to listen to tango music, how to distinguish phrases and rhythmic patterns, and later suggesting response. They also remark on how they feel the changing rhythms (and tempo) of tango music are more engaging for their dancing than pop music and alternative tango[78] songs, which tend to have much more repetitive rhythms (ibid). In their lesson, they both explicitly and implicitly promote an idea that tango dance is an individual's interpretation of the music, a faithful as possible translation from musical feeling to movement. For instance, they discuss feeling frustration at missing the first instance of a síncopa[79] (i.e. measure with a characteristic tango syncopation) and not having a chance to respond in the moment. This view tends to place the dance in subordination to the music.

However, another view is that tango movement is in 'collaboration' with music, as Olszewski (2008, p. 72) states, implying a more equal relationship. Instead of expressing music via movement, the tango dancer may take on the role similar to that of a musician in an improvising ensemble, using tools such as opposition, canon, unison, and call and response. However, in traditional tango, the music will still determine critical elements of structure and the music will not respond or react to dancer movement. While the distinction between the roles may be fluid, allowing a collaborative perspective allows more freedom and variety in movement response and engenders a deeper musical

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[77] Beats 1 and 3 in 4/4.

[78] Alternative tango refers to non-traditional tango music played during milongas and practicas, including electrotango, which fuses EDM with tango.

[79] While acknowledging that missing the síncopa is not actually making a mistake.

understanding. Additionally, the skill required for such a collaborative role is much greater than in interpretation.

One of the aims of the interactive tango system is to shift dancers from musical interpreters to collaborators, leading dancers to take on a more active role in their musical interaction even in traditional tango settings.

4.3.8.1 Semi-Structured Interviews on Dancer Relationship to Music

As part of my research, I conducted a semi-structured interview[80] asking tango dancer subjects about their relationship to music as a tango dancer. Methodology is summarized the previous section 4.2.3.2.1 and detailed in Chapter 6. The follow-up questions (1a) and (1b) were only asked in the last two interviews. For sample composition, refer to section 4.2.3.2.1.

4.3.8.1.1. Summary of Findings

A few responses corroborate the notion that for non-Argentines understanding and responding to tango music required time and commitment. One dancer described his initial difficulties in doing so: "As a leader I felt handicapped, because I could not relate to tango music." One tango couple also remarked upon the complexity of tango music compared to their previous musical experiences, with the leader expressing intense frustration at the lack of quality teaching available in this area. However, this was not a universal sentiment and did not appear in any comments when the subject self-identified as participating in extensive non-tango musical or dance activities currently or in the past.

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[80] See Chapter 6 for a detailed accounting of user studies and research.

While almost all the dancers perceived music as a critical part of the tango dance experience, one leader admitted that it was not important to him, seeing it more as a "social lubricant." A leader, an amateur musician, remarked that the musical selection playing, particularly his familiarity with it, determined his mood not only during the dance, but also his affect and personality during the entire social dance experience. One subject commented, "If I don't like the song, I don't dance as well." Another amateur musician also followed this rule and further articulated that for him, connection started with music and only if he was feeling the music could he connect with his partner.

A number of leaders, but not followers, referenced music as structuring their dance, one subject referring to the music as a "box" which he could "push the limits, explore its edges." A number of followers referenced how music made them feel, and they tended to use the words 'expression' and 'response' with greater frequency than the leaders, some implying that dancing was in a sense, an active listening. In general, the survey responses appear to imply a dominant view of the dancer as musical interpreter versus active collaborator.

Many dancers had trouble articulating their musical and somatic experiences and the vast majority struggled when referring to specific musical concepts and structures. This result is unsurprising, as the majority of dancers had not received extensive formal musical training.

4.3.8.1.1.1 Follower Agency Over Musical Response

The perception of allowable agency over musical response in tango dance differed greatly between followers. While leaders rarely commented directly upon the problem of

shared musicality, it was often at the forefront of follower responses. This issue of follower agency is critical to the interactive tango system because the system gives musical agency to all individuals using the system, regardless of dancer role, and further gives more musical responsibilities to the follower than the leader.

A few followers abdicated the responsibility of musical response to their partners, saying that they should not impact this aspect. Instead of interpreting music, they were constantly engaged with deciphering the leader. One follower mentioned her difficulty in following because it involved suppressing her own musical response to synchronize with the leader. Dancing tango was a process of surrendering agency, except in the case when the leader interpreted the music similarly as the follower.

Another set of followers felt that they had limited musical agency via adornos, passing movements of their free leg and during paradas, stops or pauses for which traditionally, followers determine duration. Suggestions of musical interpretation could sometimes be transmitted through these adornos and moments of relative freedom. However, they still largely deferred musicality to the leader for the led and connected aspects of the dance.

Finally, some followers also saw musicality as full collaboration between themselves and their partner. They felt the freedom to suggest different musical interpretations as well as musical corrections within the led dance. For instance, one dancer described having a strategy for nudging a leader into greater rhythmical precision if she felt he was off the beat. This was the opposite strategy to a follower who belonged to the first group, who felt she was required to move in ways that felt off-beat and wrong if that is what was led. Another described herself as dancing her own musical feel and

experiencing connection when both her and her partner synchronized with one another, not seeing it as her role to automatically concede this aspect to the leader.

In general, followers who deferred the most musical aspects to leaders tended to be older than those who felt they had more freedom. The two followers who were the most extreme in this respect were also the oldest subjects. Meanwhile, followers most engaged with their own musical interpretations tended to be both younger and have additional musical experience beyond social dance. Followers who gave intense, well thought-out responses about their relationship with music also tended to feel more agency in the dance. Years of tango experience or self-reported skill did not seem to correlate or affect these attitudes.

4.3.8.1.1.2 Perception of Rhythmic Accuracy and Arrival

The vast majority of dancers perceived that rhythmic arrival generally occurred via their feet movement. Dancers varied in their expectations and definitions of rhythmic arrival, with advanced dancers tending to allow more possibilities and have more flexibility in how they defined 'arrival'. For example, one of the less experienced leaders had a very rigid definition of how tango dancers responded to musical rhythm (i.e. the musical beat should occur at the point of the walk at the exact moment when the dancer is balanced between two legs) gleaned from a recent workshop. Other dancers did not share this precision, and interestingly, one dancer mentioned it not in terms of rhythmic arrival but as a technique to get a specific effect (legato). The few dancers feeling rhythmic arrival in other areas of the body tended to be more advanced. The precision to which

dancers described rhythmic arrival was related more to their musical backgrounds as well as correlated with their response styles in general than with tango experience and skill.

In general, dancers who felt that they or their partners were off-rhythm experienced unpleasant feelings of being "off" and "not belonging," and this was generally how they determined that they or their partner was not moving on rhythm. They also associated being off rhythm with losing balance or other breakdowns that disrupted their original intention.

4.3.8.1.1.3 Dancer Musicality Strategies and Tools

Many dancers had trouble articulating particular strategies and tools for musical response and interaction in their tango dancing when the question was first asked, citing moving instinctually or by feeling. Popular strategies among dancers involved listening and narrowing focus on particular aspects of the music. No dancers mentioned any strategies for creating dynamic variations and only one dancer responded to musical form and repeating sections in his dance.

Leaders, but not followers, mentioned that they had listened to commonly played tango songs over and over in an attempt to learn them. One relatively beginning leader, with slightly less than one year of tango dancing experience memorized song structures precisely and sometimes counted the measures in phrases[81] to structure his dance. He found dancing to new music and songs very difficult.

Some dancers, both leaders and followers, also mentioned finding an instrumental line and then dancing along. Dancers were much more likely to categorize and respond to

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[81] He assumed that phrases were always eight measures long. However, while such phrasing is common in Golden Age tango music, many exceptions exist.

musical parts by instrument rather than structure. For instance, they dance to the 'violin' rather than 'melody'. Only one dancer, the same leader who created repeated sections in his dance, mentioned that he found ways to move in opposition to musical structures.

A few dancers cited particular movement techniques that they had been taught or had discovered themselves. One follower mentioned rhythmic breathing as a tool that had helped her connect to both the music and her partner. Another leader mentioned that he sometimes stepped so that the musical beat fell in the moment when he was between both legs, as a tool to produce a legato and smooth feeling dance. However, most dancers did not mention specific movement techniques for musicality.

4.3.9 Argentine Tango Social Context and Codes

Argentine dance social dance events, such as milongas (formal) and practicas (informal), are held in various venues including dance halls, dance studios, restaurants, diners (e.g. Cochabamba 444), churches[82], parks, and occasionally at private residences. A relatively smooth floor, allowing pivoting, is a central requirement for a tango venue. Milongas, as more formal events, are stricter in following social codes and generally imply more formal attire. The way that dancers are dressed and how their style follows tango conventions can have a big impact on how many dances they receive, particularly in the case of women (Merritt, 2012).

Tango songs are generally played in sets of three to five songs, called 'tandas' (Olszewski, 2008; Borgialli, 2015). Each tanda is generally the same style of music: tango, waltz, milonga (in this context, the music/tango style), or alternative. Dancers are

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[82] Milongas at churches are generally held outside of Buenos Aires and Argentina.

generally expected to dance with the same partner the entire tanda (ibid). A dancer may end the dance early, by saying "thank you" but generally, this is only the event of extreme displeasure or urgency. For this reason, dancers avoid saying "thank you" or "gracias" until the end of the tanda or altogether (ibid). The time between the tandas is called the 'cortina', and during this time, dancers find a new partner, talk to acquaintances, and take a break from dancing. Non-tango music is played during a cortina. Milongas almost always follow the formal structure of tandas and cortinas, but practicas may or may not (Merritt, 2012). Many practicas have continuous music playing, and it is up to the individual dancers to decide when to start, stop, and switch partners.

Dancers generally respect the space of the dance floor. It is considered rude to cut across the floor during dancing, but acceptable during cortinas. Talking during dancing is frowned on in milongas (Borgialli, 2015), but may be acceptable for some practicas, particularly those held after tango lessons. However, dancers often engage in small talk between songs during tandas. Different tango venues may have different and varying codes for tango dancers depending on location, venue history, and associated tango style.

Dancers use the 'cabeceo' to find new dance partners (Merritt, 2012; Borgialli, 2015). The cabeceo is a meaningful look that dancers exchange when they are searching for a partner for the tanda. If a dancer does not want to accept a dance from someone looking at her (leader or follower, male or female), then she avoids his eyes or looks away. If the cabeceo is accepted, they may both nod or raise eyebrows. Dancers may move to the dance floor without speaking, or one partner may then ask the other verbally.

The cabeceo is used extensively in Buenos Aires[83], but in other locations, depending on venue, it may be more common for dancers to ask others to dance without this ritual. For instance, when describing how tango dancers pair up in San Francisco, California, Olszewski (2008) does not mention the practice. Borgialli (2015, p. 28) recommends to "see what the locals are doing."

Argentine tango, unlike swing or salsa[84], is a traveling dance, and so there are codes for how couples enter and use space on the dance floor. The line of the dance in Argentine tango is always counter-clockwise, and dancers traveling the opposite direction can be said to be against the line of dance (Olszewski, 2008; Borgialli, 2015). Dancers may stay in place in moments to execute moves such as giros, or they may take a few steps against the line of dance, but should attempt to keep the general pace of the rest of the dancers (Borgialli, 2015). Crowded dance floors have lanes, which dancers are expected to respect, and leaders are often expected to make eye contact (similar to a cabeceo) with the leader that they are taking the space in front of (ibid). Leaders are responsible for making sure not to lead the follower into moves which are dangerous for her or other dancers (e,g. flying boleo into the crowded dancer floor). These codes, sometimes called 'floorcraft', are in place in order to avoid collision and injury as well as "show consideration to other dancers" (Seyler, 2009, p. 420).

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[83] Merritt (2012) describes nuevo practicas in Buenos Aires as having dispensed with the cabeceo; however, anecdotally, I generally found that it was used more often than not.

[84] Swing and salsa are generally slotted, meaning that couples dance generally in one space, or slot.

4.4 Concluding Notes on the Embodied Argentine Tango Context

Connection is commonly characterized heterogeneously, not as one thing or experience per se, but a collection of processes, tendencies, and impressions. Foremost in this characterization is connection as the process of bodies moving together using points of contact[85] transferring energy and intention between partners via tango technique. The details of this process (eg. the shape of each participating body, the smoothness of the floor, the musical moment in the tango song, the opening and closing up of space in the bodies around the dance floor) are constantly shifting. Each dancer is continuously readjusting to both these details and the other's transfers of energy and intention. A moment spent connected is unrepeatable.

The intimacy of moving together as one leaves a strong impression on participants. Dancers allow themselves to be vulnerable. They embrace closely, sometimes with strangers, as the saying goes: cheek to cheek. This openness requires trust, not only of the other bodies, but in the rest of surroundings as well. Tango social rituals largely act as structures enabling this trust, but can also work against it. Foreign practitioners tend to view the intimacy of connection as exceptional, while porteños tend to see it as permeating their everyday lives.

Many, but not all, dancers incorporate musical relations into their characterization of connection and music and musical response, or musicality, is a critical aspect of tango improvisational practice. For some, connection does not begin with their partner, but with music. The significance of moving together is grounded in shared musical response. In

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[85] The points of contact are not necessarily tactile, although that aspect generally most commented upon in tango technique and dancer accounts.

contrast, some dancers frame connection as primarily with their partner and other bodies. Music may be seen as important to the experience, but subordinate to the transfer of bodily energy between dancers. Most commonly, dancers frame connection without such hierarchy, considering each element without obvious weight.

This process of moving together engenders perceptions in varying degrees of 1) timelessness 2) a disappeared or merged self 3) being in the present moment. When dancers experience these qualities at high intensities, they may compare or attribute the experience to the spiritual, metaphysical, or drug-induced state. The frequency at which dancers experience these states varies with each dancer, but trust tends to be an integral ingredient to its emergence.

CHAPTER 5

DESIGN CONSIDERATIONS FOR EMBODIED INTERACTIVE TANGO

EXPERIENCE

This chapter addresses how the experience of connection in tango dance can be transformed by the interactive tango system. To gain insight into this question, this chapter examines 1) how users encounter and understand tools such as musical instruments and interactive multimedia systems, and 2) the mechanics of how sound may act as a conduit for connection. Finally, this chapter articulates design considerations made manifest by previous sections, discussing concerns flowing from the aim of both enriching and maintaining the conditions that give rise to connection experiences.

5.1 Embodied Experience in the Interactive Tango System

The body has potentialities for becoming-with interactive multimedia systems, like the blind man and his dog, that are shaped by limitations, properties, and abilities of body, multimedia system, and surrounding context. An interactive multimedia system using body may expand to encompass the system. The locus of action may seem to shift from the fleshly body to a place between the individual and the system. Like the tango dancing body, the connection that the interactive multimedia system using body has with the system is volatile, varying as directed awareness shifts. The interactive multimedia system using body must learn the skills to interact with the system, for which a performance practice or tradition may or may not exist.

At times, the interactive system may seem to disappear, folded into unreflective skilled action, and at others, the system will be present, a state in which the body must

actively direct self-reflective awareness towards it in order to effectively use the system and expand creative possibilities. As a new learner, the interactive multimedia system using body may feel detached from the breakdowns that cause this reflective state, but as the body spends more time with the system, the body will begin to feel more responsible for both breakdowns and productive results. Correspondingly, the emotionality of the interactive multimedia using body increases.

Breakdowns are also salient in other ways to the interactive multimedia system using body. The interactive multimedia system using body may explore the limits of system potentialities. The body does not know the limit until the system breaks down. Similarly, when body and system are one rather than distinct entities, the body is confirmed of the connection that once existed between itself and system. The body remembers the actions that led to this history of connection.

While important differences between the tango dancing body and the interactive multimedia system using body exist, both assemblages are essentially interactions. They share critical characteristics. Broadhurst (2014, p. 233–234) writes:

Technological enhancement does not offer an extension of our affective epidermis, so to speak, which we do not already feel when we display emotions on behalf of others to whom we are 'close'. Rather, this empathy is a necessary condition for the effects that such technological employments have on us. We are disposed to respond to events that affect objects that we have appropriated as being part of our body, and when we love, it seems that another identity is appropriated by our own and becomes part of it.

Thus, the tango dancing body using the interactive system may be conceived of as a nested interaction, an interaction within an interaction, a dance within a dance. However, the hierarchy of relations, like each interaction itself, is in constant flux. For instance, is the tango dancing body using the interactive system or is the body using the interactive system tango dancing? It is worth noting that the social context further multiplies the nesting and potentialities of interactions. Dancers are not just dancing with each other, but also with the system, and with the other dancers. They are not only interacting with system and other dancers, but also with the floor, onlookers, and the rest of their surroundings. The directed awareness of each body will clarify these relations in the moment for that body, but all are there, available for that body's experience.

As in dancing tango, these relations are not available via the same forms of bodily awareness for every tango dancing body. For instance, the expert user has ways of skillful coping without using focused attention in order access a cognitive map (Dreyfus, 1996). Different users, also, may be experts in some aspects and at other skills in other aspects. The addition of the interactive system will initially increase cognitive load, and thus should be more difficult (i.e. result in more connection breakdowns) for less skilled tango dancers.

This section clarifies the parameters underlying this multilayered interaction arising from the perspective of the interactive multimedia system using body. As part of this investigation, I also clarify interaction in the sounding context, explicating how musical agency and production gives rise to intersubjectivity.

5.2 Interaction in Interactive Media Systems

Two significant aspects that differentiate the tango dancing body from the interactive multimedia system using body are 1) the multimedia system using body is interacting with a system, which may include a computer, sensors, and other physical or virtual aspects, rather than another tango dancing body, and 2) the separated traditions and cultures structuring the consensually coordinated actions of tango dancing bodies and interactive multimedia system using bodies.

5.2.1 Interactive Media System Potentialities

While all tango dancing bodies have different bodily limitations, abilities, and affordances, they generally are able to reciprocate dynamically in ways that engender mutual incorporation[86] and aspects of tango connection experience. Interactive multimedia systems, on the hand, have considerably more variation in terms of the potentialities for patterned coordinated actions of the complexity required for such encounters[87]. Some of these potentialities may be the result of intentional design, but also may emerge through the combination of performance practice/culture[88] exploiting physical/virtual affordances (e.g., turntables, samplers and hip-hop culture (Rose, 1994), the use of the WiiMote in musical interaction (Paine, 2015)). As argued in Chapter 2, the

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[86] Note that by definition, a tango dancing body is engaged in at least some rudimentary aspects of connection. See section 4.2.

[87] Strictly speaking, in this context, I am concerned with the sense of the mutual incorporation experienced by the body not the system, which is an extrapolation of the term's original use, requiring at least two bodies instead of a body and a system. The question of whether any particular interactive multimedia system can itself experience mutual incorporation or experience at all is far beyond the scope of this discussion.

[88] That is, consensually coordinated action.

context of interactive dance systems (e.g. gallery, stage, home, etc.), who uses them (eg. music/movement professionals, general public, etc.), chorographical fixedness, movement-music relations, including musical content, and methods of sensing have substantial impact on these potentialities.

While not explicitly tying his work to processes of intersubjectivity and becoming-with, Armstrong (2007, p. 146) proposes that digital musical instrument design use the model of "computation-as-interaction" and suggests that musical interfaces, or interactive multimedia systems, can engender compelling engagements by resisting human action. These resistances may be effective at least partially because they invoke the sense of a reciprocity rather than a reaction, suggesting a collaboration with another independent agent and moving the body towards mutual incorporation.

He writes that these resistances "will be those that are neither so transparent to human action that they demand little thought or effort, or so ungraspable that they forever remain beyond motor and cognitive capability" (ibid). This statement relates to attention and the use of cognitive resources. That is, tasks generally have to have a certain complexity or difficulty (i.e. employ enough cognitive resources such as attention) to be absorbing but that too much difficulty will result in frustration (ibid; Csikszentmihalyi, 1990; Dreyfus, 1996). This passage also points to a new type of breakdown, which could be analyzed in terms of tango dancing bodies[89]. This breakdown is caused by a lack of demand on cognitive resources rather than depletion. Generally, such breakdowns are

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[89] The lack of potentiality for engendering more intense connection states that some advanced dancers experience when dancing with beginners, in terms of limited movement vocabulary and an overly repetitious sequencing of steps/moves, could be seen as a breakdown along these lines.

non-starters rather than interruptions, that is, they entail a lack of potentiality on the part of the system (or dancer).

5.2.2 Consensually Coordinated Action and Culture in Interactive Media Systems

In contrast to tango, culture and social mores do not provide a consistent performance practice or set of expectations for interactions with most interactive multimedia systems. The interactive systems have generally been developed by artists for their own idiosyncratic use or for use by the visitors in art galleries and have not been in wide distribution for the length of time required to create a community of users, specific pedagogical methods or teachers. In short, while exceptions exist, specific interactive multimedia systems tend to be novel and thus, in comparison, do not have a substantial history of use and associated norms.

Thus, as Paine (2015) notes, visitors of interactive art installations often use the methodology of discovering breakdowns and limits to ascertain how the system responds and what its scope of response is. This behavior is in contrast to how dancers learn tango, usually through taking lessons and attending practicas where they exchange feedback with other dancers. Of course, many interactive multimedia systems inherit aspect of culture and performance practices from their context. For instance, many NIMEs are extensions of traditional musical instruments, and use on the stage is consistent with the culture surrounding musical performance. The interactive tango system, as well, can be thought of as an extension of tango and inheriting the consensually coordinated actions within tango. However, dancers will still have to develop a specific performance practice using the system, as traditional tango movement is not sounded.

The technology used in interactive multimedia system may itself have cultural significance, affecting interaction potentialities. For instance, Tanaka, et. al. (2012) found that users associated WiiMotes with television remote controls, and this influenced their use as a musical controller. Machines and computers have also been viewed in juxtaposition to humans in media and other cultural outlets (i.e. human/machine dichotomy), as a way of defining what is human, similarly to how sometimes humans are juxtaposed against animals. As this line of thinking tends to separate the machine as 'other', it could explain how dancers experience intersubjectivity in the interactive tango system.

5.2.3 Intersubjectivity via Musical Agency

Dancing Argentine tango, even when not using an interactive system, is generally a musical action, similar to playing an instrument (Turino, 2008; Keller, 2008). Although no intentional sounds are produced, dancers move to articulate rhythms and phrases and strive to match gestures to what they hear in the music. Dancers may employ technique to dance without music, but previous musical listening and parsed timing structures tend to inform or color their movements. A lack of musical skills significantly impairs tango dancing abilities. The interactive tango system capitalizes on a set of already existing abilities in tango dancers, but additionally, this claim raises an interesting question: how are dancers associating their movements to sounding outcomes when their movements are rarely sounded? This section addresses this question and by articulating how this process allows sound to be a conduit for movement and emotional information.

5.2.3.1 Music and the Motor System

Recent research suggests that as part of musical listening, humans empathically experience movement (Matyja & Schiavo, 2013). Decoding gestural vestiges in music is not reliant on complex cognitive analysis or symbol/representation manipulation, but involves the simulation of motor system functions mirroring the actions of sound production (ibid; Reybrouck, 2005). Overy & Molnar-Szakas (2009, p. 489) remark:

> [M]usic is perceived not only as an auditory signal, but also as intentional, hierarchically organized sequences of expressive motor acts behind the signal; and that the human mirror neuron system allows for co-representation and sharing of a musical experience between agent and listener.

Their model, SAME (Shared Affective Motion Experience), predicts that via the motor information present in music, human agents can perceive the affective and physical state of other music-producing human agents such that they feel their presence.[90] They write that, "[O]ne is not alone when one listens to music" (ibid, 499).

The expressive motor actions that humans can perceive in musical signals are 1) intention, or a longer-term aim 2) goals, or the short-term aims facilitating the longer term intention, 3) kinematic, i.e. spatial body movement, 4) muscular activity configurations required for movement production (Overy & Molnar-Szakas, 2009; Matyja & Schiavo, 2013). Thus, Matyja & Schiavo (2013) hypothesize that musical understanding is mediated by our 'vocabulary of acts' (Rizzolatti & Sinigaglia, 2008),

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[90] Schiavo & Høffing (2015) note that a string quartet player did not realize that another player was such in deep distress that he was crying during their joint performance. Such disconnects raise questions – perhaps relating to awareness/attention, and what affects are transferred during specific musical performances and why. This is an important consideration but outside the scope of this text.

i.e., our accumulation of motor knowledge obtained by past experience. Keller (2008, p. 209) remarks that the mirroring motor system "resonates most strongly with actions that belong to the observer's own behavioral repertoire while listening to music or viewing dance." A violinist, for instance, perceives music differently, especially violin music, from a person who does not have the motor experiences of playing the violin. Matyja & Schiavo (2013) limit the scope of this enaction music cognition framework, by acknowledging that it does not account for all musical listening, such as theoretical kinds of sense-making, as in musical analysis (e.g., Schenkerian), which may involve parallel processes.

If music elicits an empathetic response grounded in motor simulations, then it suggests that tango dancers are accessing aspects of this motor information to create their musically engaged gestures. In responding to music, they are also building linkages and creating a vocabulary of motor movements and auditory response. Even though the music is fixed and from an external perspective may not alter, their movement does affect how they perceive the music. Anecdotal data from the user studies of the interactive tango system indicate that musicians begin with more musicality skills than dancers without musical backgrounds. This research suggests that in part, by playing music, they have a richer vocabulary of acts associated with musical knowledge. Musical listening and rhythmic action may also be easier to learn in the context of singing or playing instruments as those actions involve more unambiguous feedback, i.e., immediate auditory response. The interactive tango system allows dancers to experience a more direct causal relationship between their movement and music, increasing the music-

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producing vocabulary of acts, and thus with practice and repetition, theoretically improving musical response even when dancing to fixed music.

Furthermore, if music induces intersubjectivity within the listener, such that the listener perceives the presence of another, invoking specific physical and emotional states, it suggests that real-time musical creation has the potential to facilitate connection in Argentine tango. Instead of empathizing with the far away musicians and singers in the fixed tango song via sound[91], in the interactive tango system, dancers empathize with other dancers via sound enaction. For instance, musicians report similar experiences of intersubjectivity when playing in an ensemble (Keller, 2008; Schiavo & Høffing, 2015; Volpe, et. al., 2016). They experience their relation to one another mainly via sound rather than touch.[92] While connection is mediated through the Argentine tango tradition, this concept has implications for similar states induced by participatory music. Further, musical ensembles can offer valuable clues about dancer experience and strategies which can be applied to coping in the interactive tango system.

5.3 Design Considerations

Technological innovation, understandably, is often driven by engineering innovations, perspectives, and performance benchmarks. More broadly, the field of human-computer interaction and specifically, digital musical interaction, has also been driven by engineering perspectives and, historically, a computational framework of

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[91] Or, less commonly, live musicians.

[92] Visual cues are also common (Volpe, et. al., 2016).

cognition (e.g. GOFAI[93]). Thus, metaphors and mapping strategies have often been developed with these viewpoints, focusing on an input/output, action/reaction of sensor readings to audio response (Paine, 2015).

However, in the last ten years, an opening up of perspectives considering situated and ecological aspects of experience has begun to drive invention. Historically, the field of interactive music has not produced generalizable design strategies for creating compelling and absorbing interactive systems for participation and performance outcomes. Often, successful articulated strategies have been relevant to only a small subset of musical contexts (e.g. experimental music). In response, a variety of researchers have identified that considering the situated body is critical to designing interfaces that are enthralling to both participants and spectators and have begun the process of building design strategies to engender replicable successes (Essl & O'Modhrain, 2006; Armstrong, 2007; Tanaka, 2012; Paine, 2015; Donnarumma, 2016).

To develop a new musical instrument, such as the interactive tango system, is to design an intimate engagement, a becoming-with. Instead of using design frameworks culled from technical aspects and concerns, the design of the interactive tango system flows from considerations emerging from the analysis of embodied tango connection. Technical limitations and reductions are considered as they arise in implementation, rather than immediately influencing design. In the emerging tradition of the enactive and embodied approach to musical interface creation, then interactive tango system design

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[93] GOFAI – Good Old-Fashioned Artificial Intelligence, referring to the input/output, symbol-processing view of the mind, often emerging from a more Cartesian perspective (Haugeland, 1985). 'Computational' in this context refers to symbol-processing rather than efforts to simulate aspects of cognition in software.

emerges from considering the situated body. The lack that some perceive in so-called

disembodied musical practices can be more precisely defined as a lack of potentialities

for intersubjectivity. The consideration of the situated body is critical because it allows

the participant or spectator to experience empathy, the becoming-with-others

foundational to the aesthetics of musical interaction and more broadly, artistic

performance practices.

This section utilizes the theoretical framework and explication of Argentine tango

practices developed in previous sections to address specific design considerations flowing

tango connection experience and intersubjectivity. First, this section investigates design

concerns arising from the tango dancing body in terms of the history of intertwined

perception/action relations, introducing a unified tango movement-music perceptual

space. Then, this section addresses design concerns arising from mutual incorporation

and consensually coordinated actions of Argentine tango. Finally, this chapter presents

concerns relating to musical agency and analyzes possible breakdowns such as competing

design considerations in order to present the full complexity of the problem-space.

5.3.1 Tango Movement in Musical Space

As tango movement is traditionally unsounded, this section articulates how

structural coupling of the tango dancing body may inform system design. The problem is

essentially determining the dynamic relationships and correlations between sound-

producing and tango actions. In order to solve this problem, this section examines 1) how

tango dancers are already responding to music (i.e. existing musical perception and tango

movement couplings) 2) the correspondences between sound-producing actions in other contexts (e.g. music) and tango actions.

5.3.1.1 Tango Musicality Design Considerations

Tango dancers already engage with rhythms and musical phrasing through their dance. A majority tends to associate rhythmic arrival and onset with the actions of their feet and also acknowledge musical síncopa and other rhythms by mimicking or articulating them with foot movement. They may delimit musical phrases by starting and pausing movement, beginning when the phrase starts and stopping when the phrase ends. Capturing foot movement and onset is critical to the interactive tango system and should impact musical phrasing in a direct manner.

Dancers respond to tempo by dancing faster or slower, particularly to end-of-phrase rubatos, suggesting an obvious movement-music translation. Dancers are also following and responding to specific melodic lines (e.g. violin) and varying their articulation of steps in accordance with that instrument. For instance, they often perceive more freedom of rhythmic response when engaged in legato, smooth instruments and move in a more flowing manner. Thus, tying a melodic line to the movements of a couple or dancer should be easily parsed, and musical instruments may be associated with particular types of movement articulations.

5.3.1.2 Correspondences Between Sound-Producing and Tango Actions

Many aspects of tango movements are suggestive of musical outcomes. For instance, dancer step onsets often inadvertently produce sound and very occasionally,

dancers purposely create sound in this way.[94] Thus, a correspondence between musical

note and foot onset should feel like a natural response. Further, the timbre and dynamics

of the resulting musical notes should mimic the dynamics of foot/leg acceleration and

force.

In general, variations in tango movement effort should influence musical

response. Effort can be seen as the introduction of energy into the system, which may be

translated into sound in various ways (Essl & O'Modhrain, 2006; Nesfield, 2012), such

as increasing volume, note density, instrument density, and timbral thickness. However,

as in physical systems, energy introduced into the tango system should decay, similarly to

how physical energy encounters entropy (ibid). This implies that dancers must move

continually to build sound energy. Circling movements in tango dance (lapíz or giro) are

often perceived as building energy, particularly if they are repeated and chained together

and centrifugal force increases. Dancers may even experience dizziness and loss of

control during chained giros if they are not careful. The system should respond to the

dancers, building energy via volume, brightness, timbral thickness, and vibrato during

rotational and circular movement in ways that also could potentially sound chaotic as the

movement becomes chaotic.

Movement density is also suggestive of musical parallels, as generally, one makes

more gestures to create denser textures or musical notes. Some common tango moves

also suggest particular articulations and musical gestures. For instance, a fast boleo

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[94] This seems to be a feature of individual dancers in particular spaces, and is not taught
by any school or style. For instance, one of my private teachers at DNI Tango in Buenos
Aires occasionally articulated the end of movement phrases or a beat in a síncopa by
tapping or landing on the floor in such a way to create sound, particularly in one of the
very resonant rooms.

recalls a sharp, loud staccato attack, not unlike the sound of its namesake whip. However, most tango moves can be articulated in many ways. The character of the movement is more important than which tango step it is in terms of correspondence to a perceived or imagined sound result since current research suggests that humans perceive gestural vestiges in sound via motor simulation rather than symbol processing.[95]

5.3.2 Reciprocity, Mutual Incorporation and System Design

As reciprocal action is critical to a sense of mutual incorporation, individual dancers should each have musical agency and be able to hear and understand the musical consequences and responses of their movement and the movements of other dancers, particularly their partner. Separation of musical roles should aid dancers in the task of distinguishing their own musical response from the rest of the dancers. Turino (2008), for instance, notes that in participatory music contexts, such as in contradance[96] musical ensembles, some players take on more virtuosic roles, such as the fiddler playing the melody, while the guitarist can take the less difficult task of creating a rhythmic accompaniment. Roles may also be exchanged for different songs, allowing each participant to express themselves in various ways.

The rich dynamics of tango connection also afford musical response. For instance, musical outcomes may arise from the relationship between two dancers rather than only their individual moves. These relations may be articulated by spatial and timing

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[95] See section 5.3.2.1 discussing music and the motor system.

[96] New England folk dance and music related to traditional music and dances of the British Isles.

similarities in the movement, especially torso rotational trajectories. This concept may also be expanded to include relations between multiple couples and individuals.

5.3.3. Consensually Coordinated Action and System Design

This section illustrates design considerations arising from the consensually coordinated actions of Argentine tango

5.3.3.1. Tango Movement Technique Design Considerations

As the embrace is pivotal to tango technique and small mistakes may cause disruptions in the dance, sensors or motion capture markers should not be placed in the way (e.g. on the chest or other points of connection). The system should also be able to detect two separate bodies even when intertwined. Further, since connection flows from the upper chest, capturing the rotation of the upper torso would give the system valuable information. As sensors cannot be located on the upper chest, they could be placed on the upper back, which will still capture the upper torso movement.

While connection is led from the torso, much of the larger movement gestures happen in the legs, particularly the feet, and thus also are important parts to track. Motion trajectories of the feet can be repetitive (especially in beginning to intermediate dancers) as tango is largely walking. During most of the dance, foot/leg trajectory as a whole should not drive timbre variations or volume envelope in a direct way, as it is 1) repetitive, and 2) the dynamic envelopes involved in walking do not appear in tango music or instrument timbres. Instead, the system may utilize the acceleration and motion features at time on onset and movement peak, as suggested earlier. The system may also

detect when dancers are performing other types of tango moves with affordances for more direct gestural mapping. For instance, tango ornaments such as a lapíz or a kick.

These tango ornaments also provide a unique opportunity. As adornos are the moves that each dancer may perform on their own, outside the led dance, they may take on this role in the system as well. When a dancer makes a decorative tango move, she is also creating a musical decoration, which should also match the articulation of her movement. Thus, if the system recognizes adornos, it may be an avenue for dancers to create sounds outside their orchestrated role in the system.

5.3.3.2. Tango Music Considerations

As Argentine tango music and dance are tightly coupled, the interactive tango system must create music that follows this style. In particular, the style should generally reflect the kinds of tango songs that are played at social dance events. Additionally, interactive songs should provide structural elements such as general articulation of the meter (e.g.. bandoneóns playing staccato quarter notes on every beat), melody, and phrasing. These musical elements should be responsive to tango movement and clearly articulated in all but extreme cases. For instance, when dancers move in such a way as to invoke the extremes/limits of musical response, such as dancing as fast they can or standing still for an extended period of time, then these elements should be obscured depending on context.

However, the complexity of tango music should be preserved, such as the syncopations and tempo/timing flexibility, as many dancers perceive musical complexity as being crucial to the dance. For instance, dancing to more simple forms of music bored

them (e.g. electrotango). So, while the beat may be obvious via bandoneón notes or other musical devices for an extended time, the musical response should also allow these complexities and syncopations. Determining the level of musical complexity and how often it should arise is a principle challenge as tastes and skill levels may vary with each tango dancer.

5.3.3.3. Design Concerns Flowing From Tango Social Context

The most obvious design consideration flowing from the tango social context is that the Argentine tango system must accommodate many dancers. Even if only one couple is wearing the sensors and controlling the music, they must be able to dance in an actual milonga or practica, where they are surrounded by many other couples. The system should also be portable, so that it may be taken into the spaces where milongas and practicas are held. Milongas and practicas, for instance, are not held in motion capture labs and should also allow dancers to wear the attire customary for social dance events.

The system should not obstruct the floor or interfere with other dancers sharing the dance floor. As many social codes (e.g. floorcraft) are followed to prevent obstructions and collisions on the floor, this aspect of the system is critical. The system must also allow dancers to change partners, at least by the end of every tanda. Dancers should be able to move on and off the dance floor freely as well as easily exchange dancer roles within the system, at least within the timeframe of the cortina. This tanda/cortina framework of social tango dance does allow the system some time to be reset or roles to be exchanged every three to five songs. The formal structure of the tango dance floor (e.g., lanes, dynamic openings of space) may allow for musical response, as

well. If tango mistakes and losses of balance are translated into the sounding tango system, it may also serve as warnings to other dancers. Additionally, as the leader has more responsibility in terms of floorcraft and navigation, more musically responsibility might be given to the follower, as she may have access to more cognitive resources during the dance.

5.3.4. Musical Agency

Dancer musical agency is crucial in order to enrich connection and provide a sounding conduit for nonverbal communication, so the system must be able to track and respond musically to individual limb movement. Another important design concern is the orchestration of interactivity, balancing the need to reduce cacophony with multiple agencies.

Relations between individual movement and musical response for each dancer should be made transparent. Timing is an important element for this, as musical responses should occur simultaneously with the intended action. For many aspects of musical response, this should occur instantly. For instance, when a foot stomps the ground, we expect the resulting sound to occur at the moment of contact. Other perceptions are, by their nature, accumulative, as in movement density, which does not arise from only one gesture, but requires perceiving movement over time. Thus, varying timescales with the nature of the perception is an important design concern and research focus.

In order to promote agency, the system should allow dancers to make mistakes and create less than pleasing results. When both the dancer and the system make a bad

sound/movement together (e.g. a loud dissonant sound when the dancer loses balance), it generally reinforces the perception of movement-music coupling and agency over sound.

Allowing such instabilities in the system also creates resistances in the musical system that the dancers must learn how to handle. As Hogg & Norman (2013, p. 116) write:

> Agency only has significance in a world that offers resistances; not to be identified with free will, agency is directed negotiation carried out within the limits of physical reality and of the behaviour of persons and things.

That is, resistance to bodily intention has been structurally coupled to the perception agency via a history of interaction with both the physical and cultural aspects of the world. Additionally, allowing for extremes and unpredictable[97] sounds in the system in response to extreme movement choices also allows for more creative use of the system by giving more room for dancers to discover new performance practices and techniques not explicitly designed (ibid).

5.3.5 Breakdowns, Reconsidered

This section addresses potential breakdowns in tango connection caused by the interactive tango system. First, by aligning design concerns with the structural coupling and consensual coordinated action of tango, I reduce many potential breakdowns due to cognitive resource depletion, including breakdowns resulting from both tracking overload and expectation violation. For instance, by allowing the interactive tango system to travel to where tango social events normally occur allows the dancer to dance in a familiar

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[97] That is, including sounds perceived as unpleasant by many in the tango community.

setting. The dancer does not have to spend cognitive resources on processing a strange location/venue. When the system responds with sounds that the tango dancing body already associates with movement, the system avoids expectation violation. The system does not require any movement that is not already part of tango practice and does not require the dancer to track anything not already part of the potentiality of traditional tango practice. Thus, the design concerns outlined in the previous sections are crucial factors in decreasing breakdown occurrences and allowing tango dancing bodies to experience connection.

The next sections analyze the interactive tango system for potential breakdowns that remain unaddressed by previous concerns. First, the section addresses design considerations that may be conflicting. Second, the section examines potential differences between tango dancing bodies that may become problematic during system interaction, addressing concerns of inclusion and accessibility.

5.3.5.1 Design Considerations in Competition

While the interactive tango system should allow extreme musical response to extreme movement, including sonifying mistakes and problems such as off-rhythm sounds in order to enable musical agency and creative expression, such mistakes and off-kilter sounds may interfere with musical comprehensibility. A mistake is usually limited to one couple in a traditional tango setting. When transposed to the interactive milonga, this mistake may spread to the rest of the dancers on the floor via sound, disrupting everyone. If one couple has a bad dance, then possibly, everyone does. This risk also

adds weight to the actions of any couple wearing sensors and may interfere with their abilities to keep from self-monitoring and reflecting upon their musical actions.

Partially, this is a question of developing expertise using the interactive tango system. Many tango dancers do not partake in milongas and even practicas before attaining a level of skill where they feel comfortable asking or accepting a dance in that setting. Developing workshops and pedagogical tools for the system is a non-trivial aspect of this work, particularly because the interactive tango system is intended for long-term use, rather than a one-time entertaining encounter. The system may also have different settings for varying skill levels, only allowing mistakes and extremes in social settings to dancers who are willing to take the risk.

Further, expertise only reduces mistakes. No matter how skilled a body is, that body has limitations and potentials for failures. Dancers must cope with musical expectation violations and mistakes when they use the system. Musical mistakes may sometimes be perceived as negatives, but dancers may learn to incorporate them into their improvisations as ambiguities allowing potentialities for play and experimentation. It is likely that some dancers may not want to make accommodations to this style, while others may find the situation more compelling and dynamic.

5.3.5.2 Tango Dancing Body Limitations

Other potentialities for breakdown lie in the capabilities of each tango dancing body. If the system requires a certain amount of effort to create energy in the system, then we must address that bodies have differing abilities to produce that effort. For instance, many older tango dancers cannot move as fast or with as much force as younger tango

dancers. Dancers may also differ in their physical potentialities for articulation, such as creating smoother or staccato movements. For instance, one of the dancers in the user study had a hip injury, and could not move as smoothly as some of the other dancers nor produce the same amount of sharpness. The interactive tango system should accommodate as many dancers as possible, and thus should allow flexibility in the spread of musical response to movement continuums. The designation of movement extremes should take into account what extreme means for each particular dancer.

Musical literacy and listening skills is another area where tango dancing bodies have differing potentialities. Different tango dancing bodies will have distinctive learning trajectories and it is possible that some have bodily limitations constraining listening skills. Training is an important tool in this case and care must be taken in the introduction of the system to new dancers in order to prevent feelings of frustration and inadequacy.

Another potential difference between tango dancing bodies is in access to resources. The interactive tango system should accommodate tango dancing bodies in various socio-economic strata, and should not, for instance, require dancers to own or use special equipment or devices such as smartphones, particularly when deployed in areas where a substantial number of residences do not own them[98]. When presenting the system, necessary equipment should be provided so that dancers are not excluded because of a lack of resources.

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[98] For instance, in 2015, only around 40% of Argentines owned smartphones. From http://www.statista.com/statistics/621034/smartphone-user-penetration-in-argentina/. Accessed March 7, 2017.

5.4 Conclusion

As dancers become one with their partner, musicians merge with and expand their selves to include their musical instrument. This experience is both intimate and volatile, moving the body towards intersubjectivity. Breakdowns are inevitable in this process but also serve as a useful tool for exploration, analysis, the development of a sense of agency, and can be exploited to creative ends. The design of the interactive tango system flows from these encounters, taking into account not only the experience of one body, but also the nested relations and history that lies between bodies. This design furthers the goal of a dynamic interactive tango practice, so that the connection between tango dancing bodies is both shifted, enriched, and remains palpably alive in the space between bodies.

CHAPTER 6

INTERACTIVE TANGO SYSTEM IMPLEMENTATION

This chapter presents the implementation of the interactive tango system,

detailing the process of designing from user experience flowing down to the

implementation of motion capture, analysis, and music technology. The development of

working, testable prototypes takes primary importance in this process. I employed an

iterative design process, creating successive prototypes, testing, adjusting with feedback,

and then adding new features. Innovation lies in system design, process, integration and

application rather than in the development of specific algorithms and system performance

outcomes. When feasible, I relied on existing libraries, codebases, and algorithms,

building scaffolding to integrate them into the system in such a way that the system is

reliable, scalable and durable, having high performance outcomes.

I begin by presenting my model of the unified tango music-movement, derived

from the analysis of the previous chapter. An overview of system design follows,

breaking down the implementation into main tasks: motion capture, motion analysis, and

music generation/arrangement. The remaining sections present the details and tasks

associated with these main tasks, addressing future work when appropriate.

6.1 Unified Tango Music-Movement Perceptual Space

I model tango movement-music perceptual space as a multidimensional

continuum representing distinct categories of perceived energy. Tango dancer effort is

required to produce and sustain these energies, always subject to decay. A stronger effort

produces more energy and takes longer to decay and vice versa. The perceptual space

stretches across varying time granularities from the gestural/continuous to the event/trigger.

6.1.1 Perceptual Continuum

The types of energies currently implemented in the interactive tango system are: movement density (sparse/busy), articulation/textural (legato/staccato), and spatial (closed/open). More perceptual energy correlations may be applied to tango music and movements (e.g., light/heavy in the Augmented Tango System (Sinnott, 2008)) than these three, but they were chosen because they represent relatively obvious movement and musical differences. These perceptual categories also are fairly low-level descriptors as compared to a light/heavy perception, which could be modeled by combining several perceptual categories. Since they are relatively low-level, some perceptual categories could be arrived at by combination or also, arise emergently.

Tango Music-Movement Perceptual Continuum

Figure 2. Tango Music-Movement Continuum

Movement density can be seen as a first- or second- order energy, in which states of low energy are 'sparse' and states of higher energy are 'busy'. The articulation/textural energy may be seen as a higher order energy, (i.e. third or fourth), in which low energy states are 'legato' or smooth/rounded and higher energy states are 'staccato' or rough/pointed.

The spatial category is an energy of relation, rather than individual movement state. Tango dancers may be more tightly synchronized and physically closer[99] or else performing moves that are distinct in terms of timing and space as well as being further apart. Both a lack of any energy input and having equal amounts of both closed and open energy are at the center of the continuum. More synchronized and close contact energy is judged as 'closed', whereas further apart and distinctive movement pushes energy to more 'open' state.

6.2 System Overview

The interactive tango system is divided into three main processes: motion capture, motion analysis, and music generation/arrangement. The motion capture system tracks tango dancer movement via inertial sensors (i.e. Android Phone and Shimmer3[100] sensors). Motion analysis receives the input from the motion capture, determining energy content for each axis of the perceptual continuum (movement density, articulation/textural, spatial/relational) at multiple time granularities. Other tasks included in motion analysis include gesture recognition for adornos and conditioning signals in order to map gestural information to the sound producing components. Music generation/arrangement consists of selecting which notes to play and when to play them, the orchestration of what and whose (which dancer(s)) motions affect playing sounds, determining which and how many instruments are playing, and how the dynamics and timbre vary or transform over time.

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[99] Note that the motion capture system does not currently measure physical proximity. See section 6.4.4.3 for more implementation details.

[100] http://shimmersensing.com. Accessed March 2017.

Interactive Tango System Overview

Android Phone + Shimmer Sensors

Motion Capture

Custom C++ Software

Motion Analysis

Perceptual Continuum/ Events → **Music Generation/ Arrangement**

Sound + Music Generation

Ableton Live + Max4Live
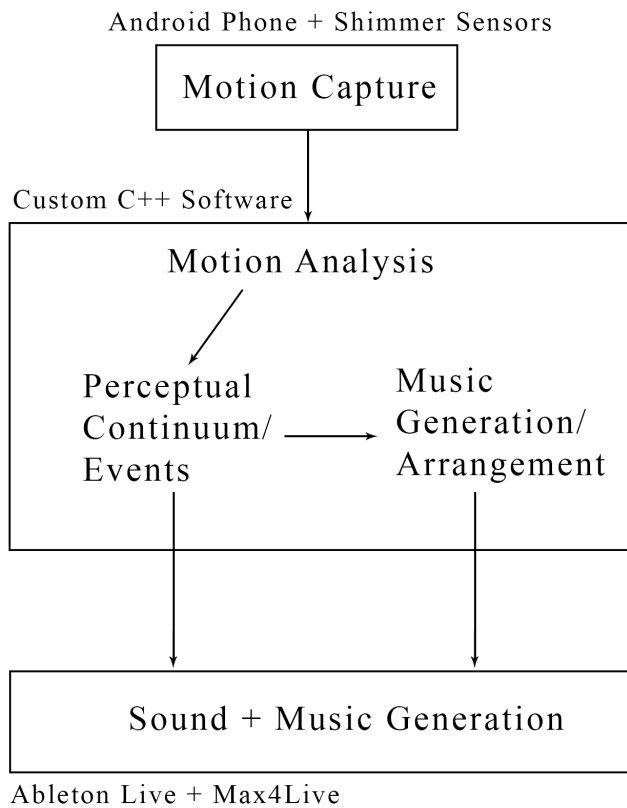
Figure 4. Overview of Interactive System.

I developed custom software, created in C++, using the Cinder framework[101], in order to perform motion analysis and the majority of tasks related to real-time dynamic music generation and arrangement. This software does not produce any sound but drives sound output and music generation created using Ableton/Max4Live[102] and custom plug-ins. I use OSC (Open Sound Control)[103], a UDP-based[104] protocol originally developed for sending sound parameters between devices and software to transmit data from each part of the system to the other (see Figure 5).

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[101] http://libcinder.org/. Accessed February 2017.

[102] http://www.ableton.com/en/live/max-for-live/. Accessed February 2017.

[103] http://opensoundcontrol.org/. Accessed February 2017.

[104] User Datagram Protocol.
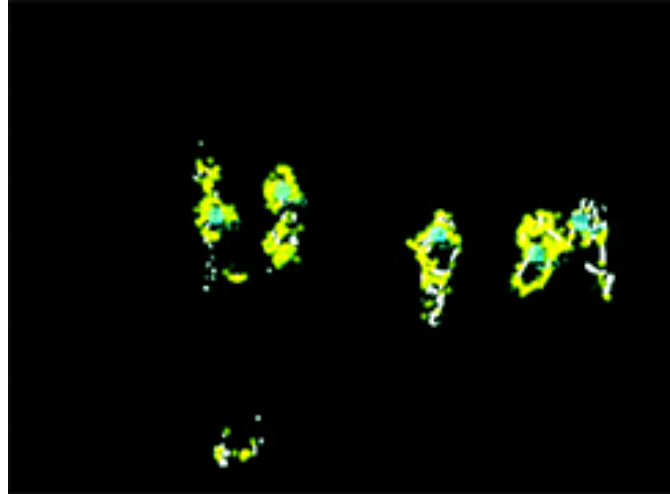
6.3 Motion Capture and Tracking[105]

Initially, markerless optical motion capture was an attractive option due to lack of movement constraints. A preliminary prototype with the goal of discovering group movement in tango used a high resolution single overhead camera with an appropriately large spatial cover to track dancer couples (see Figure 2). The downside of this approach is that it cannot track individual bodies and also fails to provide full segmentation of the body into limb segments associated with dance moves. This motion capture system would deliver the appropriate data for individual dancer agency.

The next prototype focused on the problem of individual body part tracking. Using six to eight Kinect V1[106] cameras covering a reasonable-sized dance floor, the

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[105] This section has been modified from a previously published paper:
Brown, C. & Paine, G. (2015). Towards an Interactive Tango Milonga. *Proceedings of the 41st International Computer Music Conference - ICMC '15*, Denton, TX, University of North Texas.
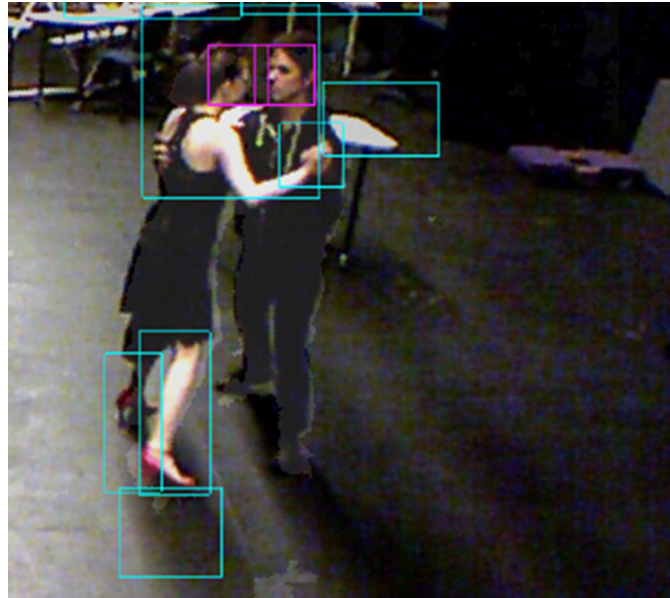
Figure 6. Showing Face and Skin Tracking Results. The blue rectangles indicate skin, and the pink rectangles indicate faces

system could also be both affordable and portable[107]. However, even under favorable conditions, the skeletal tracking failed to recognize a couple as two dancers. Hence, computer vision techniques were applied to the video stream using the Cinder C++ framework, OpenCV,[108] and OpenNI.[109] I employed the general strategy of feature detection, comparison, and then, tracking detected objects/features across frames. This process was iterative, as motion/object-tracking algorithms would often lose the body parts and the system would be forced to repeat the detection phase. Using face detection

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[106] http://www.xbox.com/en-US/xbox-one/accessories/kinect. Accessed February 2017.

[107] Note that this initial research was undertaken in late 2013 and early 2014, and so Kinect V2 was not yet in wide distribution.

[108] http://opencv.org/. Accessed February 2017.

[109] http://github.com/OpenNI/OpenNI/. Accessed February 2017.

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via Haar feature-based cascades[110] (Lienhart & Maydt, 2002; Thakur, et. al., 2011), skin detection (Jones & Rehg, 2002), and motion compression tracking (Zhang, et. al., 2012) showed promise, but the failure rate remained too high for the required robustness. See Figure 3, showing an optimal performance of this tracking. In this example, the face tracking is largely successful, with some false positives. Most instances of the tracking lost the faces and head easily, for too long, i.e., seconds. Adding markers likewise did not prove fruitful, as resolution of the Kinect V1 cameras were not high enough at the distances required.

In light of the complexity of the optical motion capture solutions, we moved to wearable inertial sensors. While wearable sensors added impediments for dancers entering the floor, it solved the open problem of distinguishing interlaced dancers' limbs. Inertial sensors also have superior scalability, in that many more dancers may be dancing on the floor without causing motion capture problems than in an optical system. Further, the position of each body was far less important than the motion trajectory. Shimmer3 sensors were chosen because they were a small and affordable out-of-the-box solution. They use Bluetooth[111] Class 2 technology to send sensor information wirelessly, and could be put on quickly, perhaps between tandas. Originally, two were placed on each outside calf, and on the torso, specifically the upper back. Thus, the sensors did not interfere with the embrace or interleaving foot movement.

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[110] http://docs.opencv.org/trunk/d7/d8b/tutorial_py_face_detection.html. Accessed February 2017.

[111] https://www.bluetooth.com/. Accessed February 2017.

Figure 7. Shimmer3 Sensor on Dancer Ankle.

However, the sensors had trouble maintaining connectivity, even for one couple dancing in open embrace in a small space. Interlocking body parts were also problematic, since human bodies absorb substantial Bluetooth radio frequencies. Connectivity was lost early and often during the dancing, that is, within the first thirty seconds. The solution was to network the sensors via an Android 4.3 phone. The Android is placed on the dancer's back, replacing a Shimmer3 sensor. The leg sensors then send information via Bluetooth to the Android. The Android then forwards this information via OSC and Wi-Fi to the computer. Meanwhile, on a separate thread, the Android sends its own sensor information via Wi-Fi. While Androids are larger than Shimmer3 sensors, they are positioned on the body where their size does not interfere with the dance. Occasionally, the Android does interfere with hand placement during the embrace, and so a smaller sensor would be preferred. This solution has so far generally been successful; however, UDP transmissions, like OSC, can fail when the Wi-Fi radio band is saturated, as can be common in large crowds using smart phones. Thus, in the future, this project will move

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to XBee[112] for both the Shimmer and Android data, as XBee uses different radio band for wireless transmission than Bluetooth or Wifi and is therefore less likely to suffer interference.

6.3.1 Note on Performance Issues and Future Work

The Shimmer3 sensors can send data at rates up to 512Hz, but each Android phone Moto D can only support relaying data at the 102.4Hz data rate. To ensure reliability, data is sent at the lowest setting of the Shimmer3 sensors, 51.2Hz. This difference seemed to be driven by operating system constraints in combination with phone hardware capabilities, as initially, the phones could not handle even the 51.2Hz rate. Several workarounds were implemented, allowing the sensor application to use more resources as well as run at high performance levels in the background.

As signal rate increased, certain aspects of the system showed marked improvement, such as gesture recognition (see Section 6.4.6). Additionally, some motion analysis requires higher sample rates than is possible with the current system. For instance, I implemented the gait analysis algorithm (Madgwick, et. al., 2011; Madgwick, 2013) developed by x-osc technologies, modifying the source code[113] to work with Shimmer3 instead of x-osc[114] sensors and found that at the lower sampling levels, results were highly inaccurate and thus, unusable. One of the priorities going forward will be

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[112] http://www.digi.com/lp/xbee/. Accessed February 2017.

[113] http://github.com/xioTechnologies/Gait-Tracking-With-x-IMU/. Accessed February 2017.

[114] http://x-io.co.uk/. Accessed February 2017.

increasing sensor sampling rate, either by upgrading phones or relay devices or in software, by circumventing operating system controls on device resources.

6.4 Motion Analysis

The motion analysis system transforms motion capture data into units of tango movement perception. The outcomes include 1) movement energy measured in terms of the perceptual continuum, 2) step/peak onsets, 3) adorno recognition/categorization, and 4) filtered signals for gestural control. This section first discusses technology and system overview, then addresses the three units of tango movement perception.

6.4.1 Motion Analysis Technology and System Overview

The motion analysis software was developed in C++/Cinder. The advantages of using this framework were: 1) C++ is optimized for fast performance and real-time systems, 2) Cinder is a light-weight library incorporating several frameworks for media use, including OSC, OpenCV and OpenGL[115], so that less time is spent on configuration and project setup but the developer has maximum flexibility, 3) many signal processing libraries and algorithms are initially written in C/C++, 4) I have prior experience and expertise with C/C++ programming, including professional audio software development experience.

The motion analysis system is implemented via a signal processing tree in which each node points to the nodes on which it depends, similar to many audio engine

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[115] http://www.opengl.org/. Accessed February 2017.

implementations such as in ChucK[116], a programming language for sound synthesis and music generation. The nodes of the tree correspond to analysis and signal transformation processes. For instance, in order to low-pass filter an incoming signal, there is an input node and a low-pass filter node. The low-pass filter node points to the input node[117], and thus may access a read-only buffer. The nodes process or transform the signal in a processing/update loop. The nodes at the top of the tree structure must execute their updates before nodes at the bottom. The aspects of music generation/arrangement are also included and connected in this structure and are discussed in section 6.5.2.

6.4.2 Tango Movement Perceptual Measures

To obtain a perceptual measure, the system 1) conditions the sensor signal, performing low-pass and high-pass filtering to remove noise and other variables, such as gravity effects, 2) extracts low-level features (e.g., windowed average), 3) scales and normalizes the values of those features to a specific range of low to high (e.g. 0-1), 4) combines weighted values to form the perceptual measure over a specified time window. See equation below for clarification, where *n* is the number of samples, *w* are the weights, and *a,b,c…* are low-level features:

$$p = \sum_{k=0}^{n} aw_0 + bw_1 + cw_2 \ldots$$

[116] http://chuck.stanford.edu/. Accessed February 2017.

[117] Note that the buffer of the input node would be filled by the OSC signal data prior to node execution.

The choice of weight for each feature, determining how much feature impacts the perceptual measure is currently determined intuitively, with adjustments made after testing system response via dancing.

These perceptual continuum values are calculated at application update rate and stored in buffers so that dependent processing nodes may access the information over any arbitrary time window not larger than the buffer length. Note that smaller time windows, such as those less than 0.5s, combined with higher output signal sample rates may be heard as more continuous, whereas larger time windows (i.e. more than 0.5s) and lower output sample rates or event-driven output will be heard as discrete. However, all the perceptual measures implemented in the system are derived from extracted features themselves the result of windowed functions. Then, time granularity is dependent on the constituent feature window durations.

6.4.2.1 Feature Extraction

This section details the main features extracted from sensor signals, including windowed variance, step/peak detection, and cross-covariance. Unless otherwise noted, the system extracted the features from the Shimmer3 accelerometer signal sensor (for feet movement) and the Android phone accelerometer signal (for torso movement), low-pass filtered by the system to remove noise.

6.4.2.1.1 Windowed Variance

The statistical variance over a time window is used as a measure indicating movement density. The derivative of the windowed variance is also a measurement of the suddenness of movement, as it is related to the jerk. It is implemented as a running

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difference between variances at n and n-1. This measure is valuable to articulation/textual perception.

6.4.2.1.2 Cross-Covariance[118]

Cross-covariance between two sensors can be used as a measure of spatial and temporal similarity and has been used previously in Aylward's work with dancers (Aylward & Paradiso, 2006; Aylward, 2006). For example, the cross-covariance is found between the left ankle sensor of the leader, and the right ankle of the follower. Therefore, it is serves as a measure of relation between the two dancers.

Cross-covariance is implemented via the IT++[119], a mathematical/signal processing library for C++ optimized for matrix operations and similar to applications such as MATLAB[120] and GNU Octave.[121] Following Aylward (2006), I use peak values of the cross-covariance over a time window as a measure of spatial similarity. Additionally, I divide the result of the cross-covariance by the mean of the means of the windowed variance of each input signal in order to reduce variation due to movement density.[122] This addition was effective in increasing its use as a measure of spatial similarity.

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[118] This section has been modified from a previously published paper (Brown & Paine, 2015) with the reference below.

[119] http://itpp.sourceforge.net/4.3.1/. Accessed February 2017.

[120] http://www.mathworks.com/products/matlab.html. Accessed February 2017.

[121] http://www.gnu.org/software/octave/. Accessed February 2017.

[122] Due to the nature of the measure, the influence of movement density cannot be completely disentangled or removed.

6.4.2.1.3 Step/Peak Detection[123]

Each step onset is detected via thresh-holding the of each ankle sensor, in all the rotational axes (i.e., x, y, z). Although many approaches and algorithms were tested (e.g., Purcell, et. al, 2005; Libby, 2008; Madgwick, et. al., 2011; Wang, et. al., 2012; Madgwick, 2013; Cleland, et. al., 2013), the use of a hard-coded threshold in this case proved the most effective for the application.[124] After dancing I concluded that false positives are more desirable than false negatives in this case and this informed the value of the chosen amplitude thresholds. False positives give the impression that something unknown may be happening, whereas false negatives call into question an embodied sense of agency.

This process, as it is implemented for inertial sensors, detects not only steps but also signal peaks that occur because of kicks and similar movements. Such movement moments are perceived as having many of the same properties, and so distinguishing between step and kick is a low priority.

Implementation of peak detection is based on the peak finding function from Octave GNU codebase, and modified to work in the signal process tree paradigm, across buffered values. Once peaks are found, they are compared against an experimentally determined threshold. Peaks may trigger the recognition of an onset at any axis (x, y, z) but each axis has a separate threshold. Several valuable measures are obtained from this

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[123] This section has been modified from a previously published paper:
Brown, C. & Paine, G. (2015). Towards an Interactive Tango Milonga. *Proceedings of the 41st International Computer Music Conference - ICMC '15*, Denton, TX, University of North Texas.

[124] Following the suggestion of a former colleague, Jeff Feasel, to inspect the visual graph of both the jerk and snap (i.e., second-order acceleration signal) during foot onsets.

analysis: step onset, peak height at onset (scaled differently based on axis and corresponding threshold), number of steps over a time window, and the time since the last step.

6.4.2.2 Scaling and Response Curves

The next step in developing perceptual category measures is scaling the values. The system currently in use remains rudimentary and informed by recording tango signal and feature data to find general minimums and maximums, then testing and adjusting those values according to system response. Generally, the linear mapping of the input to scaled value felt the most natural while dancing, as determined by self-experimentation. I tried other techniques, such as polynomial regression, in order to find more natural responses and categorize responses more naturally into low, medium, and high values. However, the linear solution remained the most naturally responsive and time pressure led to a pause in development in this area, which remains ripe for future work. In addition to using regression techniques, machine learning may be a viable solution.

6.4.2.3 Perceptual Category Definitions

The following section addresses how I define each movement-music perceptual measure: movement density, articulation/textural, and spatial.

6.4.2.3.1 Busy/Sparse

Movement density depends on two features, windowed variance and windowed step count. Higher values for both lead to higher value in the perceptual measure, i.e. busier, and vice versa. The two features are weighted equally.

6.4.4.3.2 Legato/Staccato

The articulation/textural measure depends on two features, the first derivative of the windowed variation and the mean peak at detected step onset. The former feature is weighted more than the latter as via experimentation it wasn't found that the height of the onset peak was only loosely correlated[125] with a perception of staccato movement. Previously, this measure included windowed step/peak onset count, as number of peaks is likely correlated with more staccato, rougher movement. However, this measure conflates with movement density, and removing the feature from the perceptual measure definition allowed higher density movement to be considered smooth and thus, generally enabled more flexibility in musical outcomes.

6.4.4.3.3 Closed/Open

The spatial movement space is a measure of both synchronicity and spatial similarity rather than physical proximity as the inertial sensors do not measure absolute position. Three features are used in its calculation: cross-covariance between mirrored sensors of a leader/follower couple and two measures derived from the comparison individual perceptual measures (i.e., movement density and articulation/textural) of each leader and follower. These two measures are determined by finding the Euclidean distance between the perceptual measures of each individual dancer, as such distance measures have been shown to be a measure of similarity for applications such as clustering (Xu & Xia, 2011) and other perceptual scaling applications such as musical timbre (McAdams, et. al., 1995). The first measure is weighted most heavily, as it is a

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[125] Via informal testing myself rather than user study.

measure of spatial similarity, and the second measure, the similarity of movement density between partners, is given the next most weight. Similarity of articulation/texture is weighted the least, as this aspect is communicated/perceived in more subtle ways in the dance. However, in future work, I would like to explore giving more subtle elements more weight, so as to bring them to the fore.

6.4.6 Adorno Recognition

The implementation of adorno recognition and sounding response is a priority for implementation but is not critical to system outcomes. The feature is desirable because adornos 1) have an obvious structural analogue in tango music (i.e. musical ornamentation), 2) are relatively common in both movement and music tango practice, 3) are an idiomatic way for dancers to gain momentary gestural control via foot movement. On the other hand, ornamentation, almost by definition, is an addition to essential musical and movement structuring elements (e.g. main melody).

Real-time gestural recognition remains an active area in engineering research and out-of-the-box solutions for generalized applications have only just begun to be released, indicating that the implementation of this feature would require a fair amount of time for development. The relative importance of this feature had to be balanced with the available time allotted for development and the necessity of producing testable prototypes. Fiebrink's Wekinator[126] appeared to be a solution that would mitigate the development time and allow for implementation of this feature (Fiebrink, 2009).

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[126] http://www.wekinator.org/. Accessed February 2017.

Wekinator provides an interface to Weka[127], a machine learning suite, and provides a framework for training and deploying machine learning algorithms via OSC designed for use in musical and art applications (ibid; Schedel & Fiebrink, 2011). Other solutions such as Gillian's (2014) gesture recognition toolkit[128] (GRT) required more scaffolding code and development, which was beyond the scope of this work.

6.4.6.1 Dynamic Time Warping

The interactive tango system employs the Dynamic Time Warping (DTW) algorithm in the Wekinator suite[129], which uses Salvador & Chan's (2007) implementation of FastDTW[130] to recognize the gestures. DTW compares an input signal with an example signal by reducing the distance between them via a sample re-alignment which does not preserve original time durations (i.e. time warping), outputting a distance-based similarity measure (Ratanamahatana & Keogh, 2004; Caramiaux & Tanaka, 2013). Training, then, is the process of adding example signals to a gesture category. This algorithm was chosen because 1) it was developed for time-series data and no additional temporal segmentation of the incoming signal is required, 2) it requires relatively few training sets, 3) it works reasonably well in real-time.

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[127] http://www.cs.waikato.ac.nz/ml/weka/. Accessed February 2017.

[128] http://www.nickgillian.com/wiki/pmwiki.php/GRT/GestureRecognitionToolkit/. Accessed February 2017.

[129] http://github.com/fiebrink1/wekimini/. Accessed February 2017.

[130] http://code.google.com/archive/p/fastdtw/. Accessed February 2017.

6.4.6.2 Recognized Adornos

The system recognizes two adornos: circling (e.g. lapíz) and tucks/boleos. They were chosen because they were relatively common in tango dance and their movement patterns seemed relatively distinct from other tango movement. Tucks and boleos are not distinguished from one another in the system. While the boleo is a led move rather than an adorno, the trajectory of the ankle for both the ornamental tuck and the boleo are almost the same. Additionally, boleos generally serve a momentary decorative function in the dance, in contrast to moves such as walking, giros and ochos. The system currently only recognizes reasonably high velocity kicks, as the sounding response is only appropriate for such actions.

6.4.6.3 Signal Flow and System Overview

The custom C++ motion analysis application sends an OSC data stream of extracted features and filtered sensor readings to Wekinator, a stand-alone application. Wekinator then sends gestural recognition results via OSC back to the custom C++ software. The gestural recognition results are then transferred to the appropriate node in the signal tree for processing/updating. For performance reasons, Wekinator runs on a stand-alone machine. Networking is trivial because inter-application communication is already via OSC, which is built upon the UDP networking protocol.

6.4.6.4 Development Process and Results for Gestural Recognition

The development process was typical for machine learning applications, having a training phase and a testing phase. For the DTW, categories corresponding to each

gesture (in this case, an adorno or tango move) were created, and then example gestures were input for each category, 'teaching' the algorithm the gesture.[131]

The system recognizes four tango gestures: stillness, steps, lapíz/circling and boleo/kick. The first two gestures were trained because they reduced false positives and increased recognition accuracy. They were not mapped to any sounding response. When the adornos are detected, the system sends the gestural information (i.e., conditioned/filtered accelerometer and gyroscope signals) from the sensor on the ankle producing the gesture to the sound-producing application (i.e., Ableton/Max4Live) for the duration of the gesture.

Each foot gesture is considered separately by the system. This decision was the result of testing, as when signals from both feet were used in the DTW algorithm, recognition worsened. I experimented with several approaches for extracting feature sets for using DTW in gesture recognition informed by a review of activity and gesture recognition research (e.g., ten Holt, 2007; Figo, et. al., 2010; Lara & Labradaor, 2103; Neelasagar & Suresh, 2015). Currently, the interactive tango system sends the low-pass filtered accelerometer signals, the quaternions indicating the rotational position of the sensor, second-order signals of both accelerometer and the rotational quaternions, and the peaks (maximum and minimum) of the accelerometer data. The addition of the rotational quarternions (i.e. sensor rotational position) increased recognition accuracy markedly but did not produce satisfactory results when used in isolation.

The system was trained the system primary using my own and my tango partner's movements, as well as a limited number of training gestures from four (2 leaders, 2

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[131] In fact, giving more examples for comparison with an incoming signal.

followers) user study subjects. Results were obtained by recording sample gestures at different starting points, as DTW does not recognize a gesture until the end. For instance, I only recorded the first half of boleo movement, so that recognition occurred around or before movement peak.

While the system generally correctly recognized gestures in isolation, during tango dances it confused relatively similar movements. For instance, the system had a difficult time separating the circling/lapíz adorno from the steps in the giro, or any particularly circular steps. Likewise, the system often could not distinguish circular fast or sharp crossing steps from boleos. While these false positives could be, to some extent, 'trained out', this process also increased false negatives. Real-time Performance also was impaired when a large sample sets were trained into each Wekinator project, and so this also put a limit on the use of additional training to iron out false positives or negatives.[132]

6.4.6.5 Future Work

Initial explorations into gesture recognition showed promise in terms of the potentials for interaction. In terms of my own experience using the system, the addition of adorno recognition and response offered fascinating glimpses into my partner's dancing that I had not previously been aware of, as well as substantially increasing my sense of musical agency and possibility. Thus, while not integral to initial prototypes,

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[132]A quirk of the Shimmer3 sensors significantly negatively impacted gesture recognition development. The sensors, even when calibrated, return values in an arbitrary range if they are used after charging without power cycling them one or sometimes more times. The rest of the interactive tango system uses 2nd order data, so the absolute ranges of the sensors had little impact, but in terms of gesture recognition, it caused confusion until the discrepancy was detected.

gesture recognition of tango gestures merits a more thorough investigation for future outcomes.

The first step is moving away from the lightweight approach taken via Wekinator, and exploring frameworks allowing more flexible approach in terms of algorithm adjustment and implementation. Secondly, many recognition errors occurred because the system lacked the context needed to categorize the move correctly, both in terms of the preceding movement and the lack of data from other body parts. These results suggest that an algorithm able to better take context into account, such Hidden Markov Models (HMMs) per the approach taken by Bevilacqua et. al. (2010), may prove more fruitful. While sensor data from the other leg and torso worsened recognition in the current implementation (i.e., DTW) they may be more useful for HMM analysis. Additional sensors, particularly pressure sensors placed under the feet, would likely improve results substantially. However, such sensor additions come at a cost. For instance, it is a burden to take one's shoes off and on, fitting such a sensor just right, during the cortina. The solution may work for special cases, such as for performative outcomes, not the focus of this work, or if the system was distributed and tango dancers could have the option of owning rather than exchanging sensors.

6.4.7 Continuous Gestural Information

In addition to sending conditioned acceleration data from sensors during adornos, the system also continuously sends signals from the torso sensors to the sound-producing application. Many tango moves result in relatively repetitive foot trajectories, the torso movement is more varied, and further, since rotational torso movement is an integral part

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of tango communication, a sounding response allows another mode for expressing connection dynamics. The shaping of musical response to these signals is discussed in section 6.5.3.1.

6.5 Interactive Tango Music

This section describes the generation and arrangement of music in the interactive tango system.

6.5.1 Musical Content

The tango music arranged for the interactive system includes both an original composition, "Fragments", and an arrangement of Carlos Gardel's "Por Una Cabeza" (1935). The original composition was written for another envisioning of an interactive tango system, and thus, was easier to arrange for the current system. The tango music is generally in the style of Golden Age music, but nuevo tango composers Astor Piazzolla and Pablo Aslan were also highly influential on the original composition. Arrangements were also highly influenced by studying the compositional and orchestral techniques of Pugliese and Canaro, composers who pioneered many aspects of the now characteristic tango sound (Drago, 2008). For instance, I borrowed Pugliese's 'yumba' texture to use as an accompaniment pattern[133]. I did not employ rhythmic complexity[134] common in, for instance, Pugliese's style, as interactive arrangement via dance has the potentiality of emergent complexity.

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[133] The textural affect was originally used in the tango song, "La Yumba" (1946), named for its sound effects (Drago, 2008).

[134] Beyond standard tango síncopas and patterns such as 3-3-2.

I initially considered arranging the songs in an electrotango style, but decided against doing so because 1) electrotango is often accompanied by an unchanging tempo articulated by drum/percussion and tempo flexibility is a priority in this system design, 2) the use of electrotango music in milongas appears to be declining[135], 3) the addition of new or experimental sounds via synthesis or digital audio effects may be distracting or off-putting to participants who are already grapping with a novel way of dancing. The interactive music is orchestrated for instruments relatively common in tango music: bandoneón, violin, cello, bass, guitar, harmonica, and piano. Digital effects and musical synthesis techniques not normally heard in the tango music are generally avoided.

6.5.2 Interactive Music Generation and Arrangement

The majority of music generation/arrangement takes place in the customized C++ software via the arrangement of melody and accompaniment patterns stored in a database. The Ableton/Max4Live application layer generally functions as an organized repository of MIDI melody and harmony notes and music player. The C++ software sends control signals to Ableton Live/Max4Live to drive sounding output. Operations that access or modify MIDI data or directly modify audio output (e.g. reverb) are also implemented as Max4Live plug-ins. Ableton Live also handles timing. A Max4Live plug-in sends OSC to the C++ software with current tempo and beats in order synchronize music generation/arrangement.

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[135] Anecdotal, from personal experience in the New York, Arizona and Buenos Aires tango scene.

6.5.2.1 System and Database Overview

Tango Music Generation/Arrangment Database

Figure 8. Tango Music Generation/Arrangement Database.

Music generation/accompaniment was accomplished via "choose your own adventure," in which music sections are implemented as nodes in the signal processing tree, which point to and access read-only buffers made available from motion analysis nodes. The music generation/accompaniment nodes use the output from various motion

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analysis nodes, such as movement density, to create a perceptual profile.[136] The system then chooses a random unit of music from the tango song database from all the pieces of music fitting this perceptual profile (see Figure 5 for database diagram).

This approach is similar to David Cope's *Experiments in Music Intelligence*, one of the first early stylistic algorithmic music generation computer programs, in that it combines musical fragments from a large database (Cope, 1992). However, instead of recreating works within the style of chosen composers, this process is utilized to generate tango song variations in response to perceptual input measures. The music generation of this system was also preceded by musical compositions of open forms such as eighteenth century musical dice games (Hedges, 1978) and works by composers such as Earle Brown (Welsh, 1994) and John Cage (e.g. gamut technique) (Pritchett, 1988).

The database is currently implemented as a set of files, in which each table is a separate file[137]. Each tango song is stored in a separate folder containing song specific data[138]. Overall song structure is embedded in the database and generally, does not alter depending on dancer movement. That is, song sections consist of a set number of phrases and section order does not alter. This decision was made in order to preserve musical coherence, particularly as tango songs, including those currently arranged for the system, have contrasting sections in different musical keys. However, which particular phrases are played and in what order the phrases appear is fungible.

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[136] An array of integers representing scaled output from perceptual continuum nodes.

[137] Database scale is small enough so that the development cost implementing database management software at this stage would exceed benefits.

[138] Separate sets of tables for distinct tango songs was faster to implement. Merging song databases is on the feature list at a low priority.

When a section consists of distinct phrases, the choice of section is randomized. In the future, perceptual parameters will influence phrase selection in this case, but currently only one section has more than one distinct phrase per section. Phrases themselves vary according to perceptual input in terms of duration, onsets of melody fragments, orchestration, and the note density of the melody.

Tango songs are arranged into melody and accompaniment fragments. The melody generally determines the overall song structure, and so once a melody fragment is selected, its associated harmony and song structure profile informs the selection of the rest of the musical elements including accompaniment and any ornaments.

6.5.2.2 Orchestration

The interactive tango system chooses instruments based on articulation/textural energy. When dancers move in more staccato or rough ways, the system chooses instruments which have more discrete and percussive characteristics such as piano or guitar. However, if the dancer is moving more smoothly, the system selects a more continuous instrument such as the cello, violin, accordion, bandoneón or harmonica. Other facets of orchestration specific to song structures will be discussed in the following sections.

6.5.2.3 Melody

Melodic fragments are triggered by follower step onsets. No sound plays until the first step, and the system will stop playing if the dancer stops stepping or creating signal peaks. The general algorithm for selection of melody fragments is as follows:

1. If no current melody fragment is playing, select a starting melodic fragment (i.e., MelodyOrder == 1) from the currently playing section. If there is a playing melody fragment, select from the pool of melody fragments that may follow the currently playing selection. If the currently playing melody points to no other fragments, it is the end of phrase and select from starting melodies.

2. Obtain perceptual profile (i.e., movement density) from the perceptual nodes and select the appropriate melody. If the melodic fragment is starting the phrase, the perceptual profile will include orchestration information (i.e., whether the system should choose a more staccato or legato instrument), else it will not since orchestration cannot change in the middle of a phrase.

6.5.2.3.1 Melodic Variation Implementation and Segmentation

Melodies vary according to note density, corresponding to the movement density perceptual measure. Three versions are currently supported: busy, medium (i.e., the original melody), and sparse. Note density does not always increase in a one to one manner, but is idiosyncratic in order to preserve a sense of melodic identity/coherency.

Melodies are generally segmented into fragments of one to two beat durations. Phrase endings, including the measure before, have shorter segments, allowing dancers to precisely time cadences. These irregularities, including the lack of one to one note density increases, help create more varied and richer musical results.

In the musical example below, it may appear that the melodic fragments may begin with a rest or silence, but as implemented, all melodic fragments begin at the start of the first note onset. The duration of each melodic fragment depends on movement

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density and foot onsets/peaks. Melodic fragments have a set minimum duration, which increases as the movement/note density increases. Thus, a new step onset will not trigger a new melody if the previous one is not finished playing for the minimum duration. This minimum duration is set at a length of a sixteenth note (i.e., for sparse), and increases to the length of a beat for busy melodic fragments. The minimum duration allows busier melodies to play further through the melodic fragment, preserving both musical coherency and agency. Even if the dancer creates other step onsets throughout this duration, the system will still be playing notes and creating onsets from the current fragment.

Figure 9. Fragments: Melody Variations.

According to how dancers move, melodic lines may sound as more or less within Argentine tango common practice. By remaining within perceptual extremes or creating onsets on uncharacteristic divisions of the beat, dancers may move away from stylistic confines, creating tension which may be released by driving melodies in ways that produce results that conform to common tango aesthetics. Dancers may also easily create melodic lines that may not sound pleasing to them. This melodic variation mechanism

provides both a means for dancers to create larger musical structures and resistance in the system, providing opportunities for creativity.

6.5.2.3 Accompaniment

The accompaniment starts playing on the beat following the first step, and stops playing when the dancer stops creating step onsets/signal peaks. If the dancer stops at the end of the phrase, the accompaniment stops immediately, but if the dancer stops in the middle of a phrase, the accompaniment will play twice more before stopping. The system selects accompaniment fragments based on the harmony profile (i.e., section and harmony id) of the selected melody fragment. Melody fragments may have different harmony profiles for the start and the end (past halfway through) of the file.

Accompaniment patterns may be any arbitrary length of beats, but current tango songs implement them as one measure each. The system selects a new pattern when the old one has finished playing and the dancer is still moving, and the new pattern starts on the beat. Therefore, except in the case of very legato sounds with a continuous instrument (e.g. accordion) the accompaniment pattern generally articulates the beat as is common in Argentine tango songs.

Accompaniment patterns may consist of one or more fragments, implemented as separate clips in Ableton Live. The fragments may be layered on top of each other to create varied and thicker textures. Like the melody, movement density drives note density, currently implemented as orchestral thickness, and the articulation/textural measure drives the orchestration. Leader movement generally drives accompaniment perceptual parameters.

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An orchestration of all discrete instruments (eg. piano, guitar) would be categorized as staccato, whereas all continuous (e.g., accordion, cello) is legato. The articulation/textural measure for mixed ensembles is determined by averaging the articulation/textual measures of constituent instruments. The system selects the ensemble closest to the current movement articulation/textural measure. However, in order to preserve musical coherency, within one phrase, at least one instrument must be present throughout.

Fragments: Accompaniment Figures

Figure 10. Fragments: Accompaniment Figures

Accompaniment figures in the lower staff may be transposed into different harmonies and registers, as well as layered on top of one another. Such accompaniment figures as shown in the top staff generally appear as they are written harmonically, but may be in different registers. These figures always appear alongside other figures that articulate the rhythm more clearly, such as the lower staff. Unlike melodic fragments, accompaniment fragments preserve any rests at the beginning of each measure. As stated above, movement density is implemented as more or less layers of accompaniment figures.

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6.5.2.5. Ornaments

Ornaments are associated with a gesture and only play when a dancer plays that gesture. For the duration of the gesture, the ornament sends filtered acceleration and gyroscope signals to Ableton/Max4Live.

6.5.2.5.1 Circling

When a dancer begins the foot adorno, it triggers the circling adorno. The system selects a circling fragment based on the harmony profile from the current playing melody fragment, and like the accompaniment, the system selects a new circling fragment when the previous fragment has finished. When the dancer stops circling, the system no longer selects a new fragment.

The volume of the foot adorno is tied to the length of time the dancer has been circling, as if the dancer is adding energy by repeating the figure. Thus, circling fragments fade in. This also aids implementation[139], since momentary false positives often are not loud enough to be heard. The gestural information is also mapped to filters, reverb and a subtle chorusing effect in the signal chain of the circling fragment. Higher velocities of circling yield brighter timbres, louder, and thicker sounds, while slower velocities sound more muted and thinner. A dancer is able to create a variety of sounds and envelopes with this implementation. For instance, a dancer can build sound gradually with circling then suddenly throw a kick, generating a dramatic-sounding peak.

Circling is not modified movement density, as the nature of the move tends to evoke smooth, settled sounds. Thus, the circling fragments generally consist of chains of

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[139] Although, not enough to be used in user studies.

repeating notes, which may change pitch depending on harmonic context. This implementation also highlights variation in timbre and volume envelope.

Fragments: Circling Figures

Figure 11. Fragments: Circling Figures.

Example circling fragments are shown in the example above. These repeating note figures work in many structural and harmonic contexts, and so there is considerable random variation in which particular figure is selected by the system.

6.5.2.5.2 Boleo/Tuck

Boleos are implemented slightly differently from the rest of music generation/arrangement. Instead of referencing a pre-written fragment, the notes are generated via an algorithmic process. Dancers may distinguish sounding boleo ornaments because 1) figures tend to share a common melodic profile, 2) the figures are played at a louder volume, 3) figures tend to have more note density than the current playing melody.

The music generation is via Max4Live plug-in because only the Ableton Live/Max4Live application currently has access to MIDI note-level information, which is needed for the algorithm. The C++ software sends OSC containing relevant perceptual parameters to the Ableton Live/Max4Live application.

The algorithm essentially inserts notes between currently playing notes, thus generating an ornament as follows:

1.   Access the currently playing MIDI note and the note after.

2.   Determine ornament length (in MIDI notes) and note duration, which is based on movement density. The busier, the shorter the duration and the more notes to add as ornaments. Also, determine current key/scale (i.e. set of ordered MIDI notes associated with each section)

3.   a. If only one or two ornament notes to add, either place them between the current note and the next sound or as neighbor notes. Heavily weight stepwise motion in this randomized decision.

       b. If there are more than one or two notes to add and the interval between the current note and the next note is not large, then place a note at a random larger interval either below or above the next note. Weight the choice of a drop below more heavily. This will be the new starting note for the next function calls.

4.   Start over, and follow steps from #3 twice with the pivot note as the next note the first time, and the pivot note as the starting note the second time. This will recursively generate ornaments of any note size.

       See Figure 6.5.2.5.2 for an example

Figure 12. Fragments: Boleo Algorithm.

Music generation is handled in JavaScript objects. Unfortunately, this design decision impacts performance, as JavaScript is always executed on the lowest priority thread in MAX/MSP.[140] The musical response to boleos is not as immediate as would be preferred. Thus, converting the JavaScript objects to C++ externals is a priority for the next prototype of the system. Gestural mapping to dynamics/timbral sounding features is also priority, as it is not yet implemented for this ornament.

6.5.2.6. Future Work

As only one tango song has been arranged for the current prototypes, the immediate priority is interactive tango song arrangement and the development of utilities to further automate the process.[141] Longer term, instead of 'choose your adventure', the melodic variation process will move to a more generative approach (e.g. the music generation algorithm for the boleo), so that less music is written 'by hand'. This will expedite the tango song arrangement and allow more musical possibilities for each dance, since they will not need to be written ahead of time. In addition to implementing movement/note density as a parameter for variation, other perceptual continuum measures may also be more easily implemented.

This approach may involve decision trees, similar to boleo implementation, or perhaps a hybrid approach, involving other machine learning algorithms. Unlike the boleo algorithm, in which the melodic randomness mimics the flying, somewhat

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[140] JavaScript is single-threaded and while older Max/MSP versions allowed promotion of functions to the high-priority thread, these API calls are depreciated and do nothing despite both being recognized and not triggering errors.

[141] Unit testing has been implemented for song databases and would also benefit from more automaticity.

uncontrolled whipping trajectory of the boleo, this algorithm will need to have a memory of previously generated melodies in order to maintain stronger musical coherency for each individual dance.

Additionally, scaffolding in the codebase exists for countermelodies, which would allow an additional dancer to drive melodic fragments. As this feature adds significant thickness to the orchestration, it may be added to the song dependent on movement density and similar perceptual measures. This feature may be relatively easier to implement via note generation approach, as formalized rules exist for counterpoint in Western traditions.

Finally, the closed/open perceptual measure was implemented in previous prototypes as a parameter determining orchestral parameters. For instance, more openness led to more instruments in orchestration and vice versa. However, in order to streamline development, the number of instruments became a feature associated with movement density. In the future, this perceptual measure should influence orchestration, perhaps as a constituent parameter combining with the movement density parameter. The closed/open perceptual continuum may also influence the pitch/octave spread of the accompaniment as well, not only the number of voices/instruments playing at once.

6.5.3 Articulation and Timbral Variations

Max4Live plug-ins generally handle articulation and timbral variation in the Ableton Live application, including articulation, volume dynamics, and timbral variation created by filtering and other digital audio effects.

6.5.3.1 Staccato/Legato Articulation

The articulation/textural measure is translated into note duration via MIDI plug-in. The plug-in receives a continuous perceptual signal, and then translates the most staccato notes to 32nd notes, then slightly less staccato measures as notes as 16th notes, then following 8th note, then finally quarter note durations leading to the most legato notes, which last two measures or just as long as the next note onset. Initial prototypes utilized articulation presents in Kontakt sample libraries (e.g. an extremely staccato perceptual measure would result in a violin playing pizzicato notes). However, trouble-shooting revealed that the relevant sample libraries unpredictably dropped these control signals in high-performance situations such as interactive tango system deployment, leading to erratic changes uncorrelated with perceptual measures. This feature has been put on hold until better sample libraries are obtained or performance demands can be adequately managed.

6.5.3.2 Envelopes and Accents

Dancer movement density drives overall volumes of melody and accompaniment figures. The music is softer when the dancer moves less and louder when the dancer moves more. Additionally, the velocity of individual note onset is mapped to the relative height of the step onset peak combined with the relative suddenness of the onset generating leg, as measured by the derivative of windowed variation. This combination is a measurement of step velocity/force. Including the latter measurement increased the correlation between dancer perception of greater foot force and velocity in onset in self-conducted testing. The resulting velocity of midi notes is further modulated by movement

density such that a forceful onset in a more movement dense context is also louder than a similarly forceful onset in a less movement dense context.

6.5.3.3 Closed/Open

The closed/open perceptual measure is now mainly mapped to the sounding outcome via a reverb plug-in. As openness increases, the virtual space increases and vice versa.

6.5.3.4 Rotational Torso Energy and Timbral Variation

Rotational torso energy along the x-axis drives timbral variation and dynamics. Thus, giros and other rotations add more energy into sounds, whereas straighter movements, such as some walks, allow that energy to decay. Timbral variations are implemented via reverb, flange, and resonant bandpass filters.

When torso energy measurements exceed thresholds, they trigger fast onset, slow decay envelopes modifing reverb tails. Then, even during staccato note events, the dancer may enact continuous timbral change. Meanwhile, increasing energy affects different style tremolo and vibrato effects via flange and resonant bandpass filters. Increasing torso energy, increases LFO range and dry/wet of the flange, which is generally subtle.

Two unsynchronized oscillating resonant filters affect relatively higher partials of musical output, adjusting the range of center frequency of the filter according to audio input. More torso energy increases both filter gain and narrows the width of the filters, thus creating a brighter timbre having a dynamic character due to the oscillation.

While currently only x-axis energy drives timbral variation, in a future prototype, having the y-axis energy drive variation in a contrasting way would be an interesting

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feature. This energy is a good analogue for off-axis energy and would increase during leans forward such as volcadas and leans away such as colgadas. As off-axis moves occur with less frequency, this is a lesser priority than sonifying the x-axis energy of giros and other common turning movements, but this mapping would enrich musical interaction.

6.6 Orchestrating Interactivity

Mapping perceptual measures to specific dancer movement is, implemented in C++ software, integrated into the signal tree structure. There are dancer, couple, and dance floor nodes, pointing to perceptual and music player nodes. Orchestrating interactivity is implemented via adding and changing which perceptual and musical nodes these abstractions access. Thus, assigning various mappings to different dancers or couples, or adding couples to the system is trivial in terms of code structure.

As noted briefly throughout this section, for a single couple, followers generally drive melodic outcomes while leaders drive accompaniment outcomes. Both dancers could drive melodic ornamentation outcomes via performing one of the recognized adornos. As driving the melody engenders more responsibility and musical power, this arrangement subverts traditional tango power structures, in which the lead enjoys more agency. Indeed, because the leader invites the follower into movement, the leader maintains an indirect but imprecise agency over melodic outcomes. The follower may still create melodic onsets via adornos and ultimately has agency over timing details. This leader/follower arrangement was chosen because 1) it enables a balancing of responsibility and power of tango roles, and 2) as leaders tend to use more cognitive resources during dance, followers have more cognitive resources free for other tasks,

such as driving melodies. When my dance partner and I tested the system with the leader driving melody and myself as the follower driving accompaniment it felt that as a follower I had very little input. However, when we reversed the system as it is currently implemented, both of us felt as though we were driving musical outcomes.

6.6.1 Orchestration for Two or More Couples

The interactive tango system has largely been implemented for the use of one couple. Other dancers move to the music that they create and may exchange sensors during cortinas. However, the aim of the interactive tango system has been the development of the system towards ensemble use of two or more couples. While not yet tested via user study, the system currently supports the use of two or more couples. The mappings discussed in the previous sections may be distributed among any number of dancers. It may be that only enough movement-music translations exist to provide a strong sense of musical agency for two couples. This question is one that merits empirical inquiry, which will be addressed in future work.

The table below shows an implementation for distributing the music-movement translations among dancers in a two couple orchestration:

Table 2

Sample Orchestration of Interactivity for Two Couples

Couple 1	
Leader	• accompaniment accents and volume • torso timbral variation for: bandoneon, accordion, harmonica, guitar accompaniment • accompaniment staccato/legato orchestration
Follower	• melody onsets • melody accents and volume envelope

	• torso timbral variation for: bandoneon, accordion, harmonica, guitar melodies
	• melody staccato/legato orchestration
Relational	• closed/open reverb
Couple 2	
Leader	• accompaniment movement/note density
	• accompaniment staccato/legato note articulation
	• torso timbral variation for: violin, cello, piano accompaniment
Follower	• melody movement/note density
	• melody note articulation
	• torso timbral variation for: violin, cello, piano melodies

Note that each dancer in this orchestration may create sounding adornos. Aside from giving roughly equal responsibilities to each of the couples, this example distribute the two features that give the most immediate feeling of agency (e.g. melody note onset and movement/note density) to different couples. The couple creating onsets can still organically create a more note-dense result, but melodic contours will sound very different depending on whether the other couple is moving densely or sparsely. The next step in this process is to test this orchestration with dancers.

6.7 Future Work

Throughout this chapter, I have identified several major avenues for future research directions: learned response curves for perceptual features and scaling, gestural recognition, more perceptual measures (i.e. axes on the continuum), music generation, and the development of ensemble use of the system. The most immediate priority is the testing and refinement of interactive tango ensemble orchestrations in order to investigate dynamics between participating couples. The next chapter, describing user study design and results, will illuminate further the path forward and which improvements and new features to prioritize.

CHAPTER 7

INTERACTIVE TANGO USER STUDIES AND RESULTS

This chapter presents the assessment of the interactive tango system, including

research questions, methodology, results and discussion. As the impetus and artistic

outcome of the interactive system are, by their nature, experiential and participatory, the

aim of user studies is to provide insight into the impact of the system on experience. This

assessment helps to discover and clarify the problem space of social interactive dance and

interactive art interventions into social, participatory musical traditions.

7.1 Research Questions

The following questions articulate the aims of this user study:

1. How do tango dancers experience the interactive tango system? How might this

experience impact dancer connection and relationship to music? Does it impact how they

interpret later tango dance and music experiences?

2. Then, how do different aspects and prototypes of the interactive system contribute or

disrupt (a) dancer musical agency (b) connection and tango experience? What are the

priorities for additional features and modifications to the interactive tango system?

7.2 Methods

Three user studies were conducted between October 2015 and January 2017. The

preliminary study, Study 1, employed an early system prototype (i.e. Prototype #1) and

the two later studies (collectively, Study 2) used a later iteration of the system (i.e.

Prototype #2) informed by data from the first study. An additional study, Study 1.5, employed an instable version of the system, and thus was mainly used for debugging and design iteration rather than user experience assessment and thus, results were not obtained. The Internal Review Board (IRB) of Arizona State University approved this research, including all modifications and stages, and the initial letter of approval is included in Appendix A.

In each study, subjects were videotaped dancing for 15–25 minutes using the interactive tango system. Following the dancing session, they participated in video-cued recall (VCR) session, a technique for researching embodied experience that is less susceptible to self-bias (Omodei, 2005; Paine & Salmon, 2012). VCR also has been used to investigate experience in interactive media systems such as Rokeby's *Very Nervous System* (Jones & Muller, 2010) and Stelarc's *Thinking Head Project* (Paine & Salmon, 2012). Subjects were asked questions about their experience as they watch the video of the dancing session. In VCR, open-ended questions are preferred, but the interviewer may also ask follow-up questions. The following questions were asked during VCR:

1. Please tell me what you were feeling when dancing here.

What did it feel like dancing in Interactive Tango Milonga?

2. Did the music respond to your dancing?

3. What was your relationship to your partner during the experience?

After the VCR session, I conducted a semi-structured interview about their relationship to music and their experience of connection as a tango dancer. Questions for each study are included in Appendix B. At the end of the interview, participants fill out a short questionnaire with their demographic information. During Study 2 session,

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participants also filled out ranged scales addressing system performance. The questionnaire versions are provided in Appendix C. Each session, including dancing, lasted around an hour and a half.

The following section provides details about study participants, prototype features and the specific format and details of each user study. As sample size was small for each study, results should be seen as exploratory and an impetus for further investigation rather than confirmatory.

7.2.1 Participants

Participants were recruited by giving announcements at tango social dance classes and events in the wider Phoenix metro area. Subjects also suggested friends for the study or found their own partners for the session. There were 20 (10 male/10 female) subjects in total, participating in three user study sessions. All subjects danced the role associated with their gender. Age range was 18–68 (avg. ~ 34, std. dev. ~ 16) years. All subjects signed an informed consent form before participation.

Dancers had been dancing tango from 3 months to 14 years (avg. ~ 4 yrs.). Dancers were asked to rate themselves in terms of their skill level and also label themselves from beginner to professional which only very roughly correlated with years dancing. No dancers categorized themselves as either advanced or professional, the highest self-rating being 'advanced intermediate'. Across this sample, individuals did not appear to use a consistent metric for determining these labels. [142] Only one dancer

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[142] Argentine tango teachers rarely assess students by such metrics, although classes are often described in these terms (e.g. beginner, intermediate, advanced). Self-reported skill levels do not necessarily reflect standards with objective criteria.

reported experience with interactive digital art and music beyond 'beginning' or none. About a third of dancers volunteered that they were amateur musicians but no subjects were professional or student musicians or dancers. Anecdotally, even fewer subjects had a history of formal musical training.

7.2.2 Study Demographics and Summary

Table 3

Study Demographics And Format Summary

	Study 1	**Study 2A**	**Study 2B**
Prototype	Prototype #1	Prototype #2	Prototype #2
Dates	Sept.-Oct. 2015	Dec. 2016	Jan. 2017
Subjects	13 total 7 leaders 6 followers	10 total 5 leaders 5 followers	7 total 4 leaders 3 followers
Age Ranges	18-68 (33)	20-60 (34)	20-38 (29)
Tango Experience (in years)	0.33-14 (4)	0.5-9 (4)	0.8-9 (4)
Interactive Tango Experience (in sessions)	0-1 (0)	1-5 (2)	2-6 (4)
Workshop before?	No	Yes	Yes
Social?	No	No	Yes
Context?	Classroom	Classroom or Dance studio (mixed)	Dance studio

Note. Means appear in parenthesis below ranges

7.2.1 Prototypes

The user studies were used in the assessment of two prototypes. Features implemented are as follows:

Table 4

List of Features for Each Prototype

Prototype #1	Prototype #2
Leader mappings: • accompaniment note articulation Follower mappings: • melody note onsets • melody movement/note density • melody note articulation Relational • closed/open determines number of instruments in accompaniment orchestration Orchestration: • piano, bandoneón	Leader mappings: • accompaniment note articulation • accompaniment accents and volume • torso timbral variation of accompaniment • accompaniment staccato/legato orchestration Follower mappings: • melody note onsets • melody movement/note density • melody note articulation • torso timbral variation of melody movement/note density • melody note articulation Relational • closed/open reverb Adorno Recognition (any dancer) • boleos/kicks Orchestration: • piano, bandoneón, cello, harmonica, accordion, guitar

7.2.2 User Study Sessions

This section presents user study session formats and details. Interview forms and questionnaires are included in the appendix.

7.2.2.1 Study 1

The first study consisted of 7 tango couples (7 leaders, 6 followers) and sessions conducted during October 2015 using Prototype #1. Sessions took place on the Arizona State University Tempe campus. One follower participated in two sessions, dancing with a different leader each time. Each couple danced and participated in each session alone, with no other couples. No dancers had previously used the system, except the one follower who danced a second time. No subjects reported significant experience participating in interactive art or music.

Each couple was videotaped while dancing in the system. Subjects were asked to dance twice for seven to ten minutes each, totaling about 15 to 25 minutes of time dancing. They first danced in the system without an explanation of the movement-music relationships. After the first dance, they were given the explanation and asked to dance again.

7.2.2.2 Study 2A

Study 2A consisted of 5 tango couples (5 leaders, 5 followers) and sessions conducted during December 2016 using Prototype #2. The majority of subjects reported

no significant experience participating in interactive art or music before[143], with one subject reporting 'intermediate' experience.

Each couple participated in two sessions scheduled on two separate days, generally a week apart. Dancers kept the same partner for both sessions. The first session was a workshop, teaching the subjects to use the system and allowing time for them to explore system response. No assessment or interviews were conducted during this workshop session.

The second session was scheduled on a following day, so that subjects would have at least one night of sleep between the workshop and the experimental session in order maximize learning. During this session, subjects were video-taped dancing for 15–30 minutes using the interactive system. Each couple danced and participated in all sessions alone, except for the interviewer. The majority of the sessions were held in a dance studio in Scottsdale, AZ, with two workshops and one video-cued recall session on the Arizona State University Tempe campus.

7.2.2.3 Study 2B

Study 2B consisted of 3 tango couples (3 leaders, 3 followers) dancing together in one videotaped session lasting about half an hour. Three dancers had participated previously in Study 1. The session was conducted in late January 2017 at a dance studio in Scottsdale, AZ. All dancers had previously participated in Study 2A. Each couple took turns driving the system while the rest of the dancers moved to the music they created.

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[143] Not including the interactive tango system.

While using the system, dancers kept the same partner from the previous study, but when not using the system, they were free to switch partner and they did.

A final semi-structured interview was given. 5 of the 6 subjects completing the final interview had participated in the previous social session. The last subject, a leader, was absent, but had participated in the rest of the study, including the sessions in September 2016 and participation in interactive tango social events not part of the study.

7.3 Analysis and Results

This section addresses user study analysis, first describing analysis methods and then presenting the results. The results are organized as follows: 1) case studies of individual dancer experience in the system employing interpretative phenomenological analysis (IPA), 2) corpus analysis results, 3) analysis of negative and positive experience (i.e. failure analysis), and 4) summary of overall themes appearing in user study transcriptions and videos.

7.3.1 Data Analysis

VCR and semi-structured interview transcripts were analyzed via content analysis methods, including interpretative phenomenological analysis (IPA) and corpus analysis software. Detailed IPA results are presented for the three dancers who participated in all study phases, addressing their interactive tango experience and relationship to music and connection during study timeline.

All interview transcripts were also analyzed using AntConc[144], corpus analysis software for comparing word frequencies and finding word concordances (Anthony, 2016). User study transcript word frequencies were compared to one another and the meaning of significant differences in these frequencies were explored by a close reading of the text. Statistical significance of the differences between interview texts was determined using the log-likelihood measure, which has been shown to useful in corpus comparison (Rayson & Garside, 2000; Rayson, 2003). Rayson (2003) suggests that for corpus linguistics using a cut-off at the 0.01% statistical level as words in text are non-random and they are performing multiple statistical tests. However, in this application, corpus analysis is used as a tool for discovering differences in user experience via transcripts rather than for linguistic analysis and so traditional significance cut-offs have been observed (i.e., 5% statistical cut-off). However, results should be seen as exploratory because of the relatively small sample sizes of both subjects and corpora.

While subjects generally enjoyed using the system, there was a large spread of response, particularly in Study 2. A few subjects continued to have significant frustration and trouble understanding the tango system resulting in significant negative affect, while others had unusually positive experiences relative to other subjects. Interview transcripts were analyzed for negative and positive affect in order to uncover possible causes driving the varying outcomes.

Finally, during textual analysis, various themes appeared in user study transcripts and video data not captured by previous directed analyses. This section presents these results.

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[144] http://www.laurenceanthony.net/software/antconc/ accessed March 16, 2017.

7.3.2 Case Studies: Individual Dancer Experiences

This section presents three case studies of dancer experience throughout all phases of the interactive tango study. Subjects were chosen because they had been present for most or all of the user studies and thus, had the most experience with the system over an extended time. All dancers were experienced tango dancers with 4–8 years of tango experience. Dancer A had different partners for each study session. Two of the dancers (Dancer B and Dancer C) were partnered for the entirety of Study 2, but did not dance together the first sessions.

7.3.2.5.1 Dancer A

Dancer A is a male leader in his mid-twenties with four years of tango experience at the time of the first study (October 2015). He did not mention any prior musical or instrumental training. He participated in all study phases, including final interview, except for the social dance session of Study 2B.

7.3.2.5.1.1 Dancer A: Interactive Tango Experience via Video-Cued Recall

This section summarizes results from IPA analysis of Dancer A's description of his experience in the interactive tango system.

7.3.2.5.1.1.1 Dancer A: Study 1 Experience via Video-Cued Recall

Several themes emerge from Dancer A's account of his experience with the interactive tango system. First, he develops strategies for 1) determining system musical response and 2) moving to the resulting music. Initially, he tries to imagine tango music in his head that would result from his movements then observe if the current music is

matching. He soon abandons this strategy for the following strategies, which he relies on for the rest of the dance: 1) reconnecting/synchronizing more with his partner, 2) slowing and stopping to hear musical response, 3) Trying new tango moves to hear musical response, 4) relating the music to other musical genres and tango composers (e.g. Pugliese), 5) trying to hear how the music articulates the beat and moving to that rhythm.

His use of slowing down as a strategy evolves from moments of recognizing musical response to his movement when he is slowing down and stopping. He reports feeling more agency when he is moving slowly or stopping. He also reports relatively more positive affect in these moments.

During this session, Dancer A is engaged in the sometimes effortful process of finding, keeping and losing musical time. When he cannot hear the beat (eg. sounded onsets every quarter or half note)[145] or síncopa he often loses his sense of rhythm and it takes effort for him to move musically. He says at one point, "I heard that downbeat start coming and I was like, I started moving on the beat more and I was trying to figure that out, but then we lost it." When this articulation is present, he feels comfortable and is more likely to execute more complicated moves or experiment in other ways.

This process of losing, finding, and keeping the beat leads him to articulate how musical structure has been crucial to his previous experience dancing to fixed tango music. He notes that this framework allows more freedom and creativity in the movement. On the other hand, in the interactive tango system, those structures are not always there and further, he must spent effort building them. He thinks this is also a

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[145] Beats 1 & 3.

positive and interesting experience but he feels confused and adrift without the former, fixed structure.

During video-cued recall, he recognizes musical response to his movement that he did not notice during the dance. Since dancing absorbs much of his attention, as an observer he is able to pay more attention to action-reaction musical couplings. After watching the system, he processes the experience as interesting and positive.

7.3.2.5.1.1.2 Dancer A: Study 2A Experience via Video-Cued Recall

Dancer A's experience during Study 2A is unusually positive. He is dancing with a partner he knows very well and she reports being in a tango trance during much of the dance. He describes more instances of feeling musical agency and of making conscious decisions to vary the music.

He employs a reduced set of strategies from the first session of dancing to determine and test system response. He often slows down or stops to test system response. Slowing down often gives him time and attentional resources to listen to what is happening. He says, "I like towards the end here, I was slowing down to see how-- a lot more how it was responding and it helped me figure out-- That was nice." He perceives more musical agency when he is moving slowly, not only over musical response, but also over his own movements. He still tries new moves with the tango system, but these moves are related directly to musical mappings, such as trying boleos in different ways. In this study, Dancer A does not report losing the beat, but does note instances when the beat feels stronger or when the musical rhythm is aligning with him. He feels more comfort during those moments.

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He does not mention trying to become more in sync with his partner during this dance as a strategy. Perhaps he does use this as a strategy because they were already deeply connected during the entire dance and their comments during VCR also corroborate this conclusion. Both he and his partner note moments where it is apparent that they are particularly in sync. Further, at one moment, they both perform a kicking adorno at the same time and produce a harmonized musical ornament in the system. This musical result is almost impossible to achieve in the system as it requires a very high degree of synchrony.

The difference between experiencing the system and watching himself in the system is still pronounced. However, he notes that while he recognizes particular action-reaction couplings while watching his dancing, during the dance he just experiences the music as responding as it should in the dance. For instance, he notes that the system recognized some kicks/boleos as he was dancing, it felt like an organic response and not necessarily a trigger that he was intentionally invoking.

7.3.2.5.1.2 Dancer A: Musical Relationship

Dancer A's description of his musical relationship evolves during the time of the user studies. The themes of his first response relate to music as a structure or framework for movement. This answer may be prompted by his feelings of confusion when he could not detect the beat and by the effort required to build structures with the interactive tango system in Study 1. He describes music as 'a box' or a 'playground' that he dances within, but it also provides limits that he can push beyond. He says, "I like [tango music] because

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I [try] to push that box to its limits and poke at the edges. And look at all the space inside of it as well. And you know, sometimes I try to take a peek outside of it as well."

After dancing in Study 2A, his answer implies a much more dynamic view of music. He uses the metaphor of a book, saying, "if I were treating that book is a conversation, I could respond with my body – teach a little note. It's almost like a textbook, I'm just trying to look at the material see, what I have. Think of fun ways to respond to it or use it as I connect to my partner and dance with them." When his partner for Study 2A describes music as memory, he also agrees and adds that it is like time travel and that the music is strongly tied to Buenos Aires. In a way, music allows him to have empathy for people living at that time.

When asked about rhythmic arrival and musical strategies, he returns to music as a framework and structure. He also describes music in more embodied terms than previously, but this is likely because of the additional questions. For instance, sometimes he feels the end of phrases in his body and he feels rhythmic and sounding gestures in different places in his body.

The final time Dancer A describes his musical relationship he does not have a ready metaphor. He begins by mentioning interpretation but corrects himself. He begins to list his relations to music in the dance: 1) a framework for movement and connection and 2) an impetus for dancing in a particular way. He vacillates while describing the relationship, so the interviewer suggests that perhaps he is trying to say music is like another partner. He likes this idea and elaborates how he is a matchmaker between his partner and perhaps vice versa.

Again, when asked about rhythmic arrival and musical structures, he describes music in structural terms. He remarks that he now has an internal metronome in his head and realizes that even violin note onsets happen on the division of the beat. This statement implies that he did not have this sense before in conscious awareness. It is possible that his listening skills increased from Study 1 to Study 2A resulting in his more positive experience dancing in the system and also provides some explanation for why he was able to keep musical time no matter what state the system was in. In his final interview, he frames musical strategies in relatively more conceptual terms than embodied terms as opposed to when he answered the question directly after dancing in the interactive system in Study 2A. Thus, it is possible that dancing in the system prompted him to consider these musical strategies in a more embodied way.

7.3.2.5.1.3 Dancer A: Connection

Dancer A's description of connection experience remain relatively stable during the time of the study. He describes connection as intimate mutual sharing and notes that a feeling of safety for this intimacy to take place. He notes overthinking and distractions as the main two problems with maintaining/creating connection. He mentions music only once, during Study 1. He remarks that a musical connection with another partner generally leads to a deeper connection overall since he does not need to predict or plan what is happening in the next moment.

7.3.2.5.2 Dancer B

Dancer B is a male leader in his mid-30s with seven years of tango experience at the time of the first study (October 2015). He does not have any prior musical or instrumental training. He participated in all study phases and sessions. He also used the system twice in social situations in Spring 2016, once during a practica and once during wheelchair tango.

7.3.2.5.2.1 Dancer B: Interactive Tango Experience via Video-Cued Recall

This section summarizes results from IPA analysis of Dancer B's description of his experience in the interactive tango system.

7.3.2.5.2.1.1 Dancer B: Study 1 Experience via Video-Cued Recall

Meditation and "not thinking" reoccur as leitmotifs in Dancer B's accounts of tango dancing, including when he is using the interactive system. In the first session, he attempts to pay particular attention to musical response, sometimes feeling that he was overthinking in his efforts to understand the system. However, he still becomes immersed in moving and at times does not actively attend to musical listening. During this session, he does not report any particular strategies for determining musical response beyond his efforts to pay attention to what is happening in the music.

Interacting with the system reminds him that he lacks musical skills. He feels that he still does not understand tango musicality or the structural elements of music. He wonders what music dancers with musical experience would create. He thinks that dancing in the interactive tango system makes musicality easier, since the music follows his movements and thus, in a sense, relieves him of some responsibility. However, he

notes that while the music sounds very good sometimes, it can also sound 'off-key'. He reports that the second dance, happening after explanation of the system, sounds better than the previous.

During the second dance, he notes a one moment where he feels the music is clearly following the movement in a dramatic way. He and his partner are in a slow, low lunge and the music gradually fades out as they come to a stop. Then, the music comes back with a strong rhythm, and they resume dancing at quicker pace. When he hears the articulated beat, he feels the impetus to move.

During both dances in Study 1, Dancer B does not report a clear sense of musical agency. He registers musical responses to his movement while he is dancing, but he perceives more musical reactions in retrospect as an observer in VCR than in the moment.

7.3.2.5.2.1.2 Dancer B: Study 2A Experience via Video-Cued Recall

The conflict between tango as 'walking meditation' and learning the interactive tango system becomes more prevalent in this session. Many times when his partner or the interviewer notice a musical response, Dancer B reports that he was not conscious of the musical change or the specifics of what was happening in that moment. He says, "I'd probably have better feedback, if we danced and then I watched this and then we danced and then talked. Because I get lost in some of the movements sometimes."

During this session, he is still actively learning the system and he begins to envision creative potentials of the system. For instance, he realizes that he and his partner could create contrasting melody and accompaniment parts if they moved differently from

one another. He notices this while watching the video, since his partner is purposefully creating a busier melody via adornos, including kicks, while he is keeping the accompaniment rather slow[146]. He also listens for phrase endings, so that he creates interesting endings, as well as pauses during the dance, in movement and sound.

He is developing more strategies for musical interaction and ascertaining the system. His partner, Dancer C, is instrumental in this process, as she had already developed strategies in Study 1 and she also has more musical experience and skills. They discuss different ways of evoking different responses and try different tango moves such as volcadas (off-axis leans). They find that specific moves do not produce noticeably different responses. Another strategy they use is similar to Dancer A's strategy, which is dancing more slowly. Dancer B enjoys the slow movement/music in particular.

Again, he mentions that it is easier when the music follows him than vice versa: "If you're ---not following the music and the music is following you then I want to say that there is less pressure. It feels like there's less to worry about." When the follower notes that she understands the system much more now and that previously, she had mostly been engaged with figuring out what was happening, he agrees. However, he feels he is still learning.

7.3.2.5.2.1.3 Dancer B: Study 2B Experience via Video-Cued Recall

Dancer B enjoys the social situation more than using the system alone with his partner. Along with his partner, he comments that he enjoys not having the responsibility

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[146] This moment is also briefly addressed from Dancer C's perspective in section 7.3.4.5.3.1.3.

of musical agency for the whole time, but that he still has the chance to play with it. He enjoys the unpredictability of the music in this situation in comparison to normal milongas where the music is fixed. He believes that this lack of predictability puts less pressure on him to plan his musical response ahead, since it is impossible.

He notes that the music that other couples make sounds different from when he dances using the system. This realization reinforces the notion that he and his partner actually have musical agency when they are using the system. He also imagines dancing with a different partner while using the system, and he thinks that it would be different enough such that he might have relearn the system, or 're-pay attention' and calibrating to her.

He can hear when other dancers move faster or slower, but there is a limit to what features of movement he can perceive in the music. He does not experience any difficulties in dancing to other couple's music. When he is in the system, he is dancing to music generated by actions the instant or moments before. Thus, he perceives that doing the same thing whether he or someone else has agency: following the music. He is also very curious about how other dancers are moving to the music that he is creating while in the system, trying to catch glimpses of their response as he is dancing.

When he and his partner are using the system, Dancer B describes moments when he is deciding to create dynamic variation in the system. This session is the first time he reports this kind of direct indication of musical agency. For instance, he remarks about a particular moment: "I wanted her to wake up a little. [..] [I]t was the last minute choice, though. Because there's a lot that you can do with it if you want to go slow, because if

you're ever going slow you bring it way down in that one little movement and something interesting will happen, but if you go faster it'll keep up within the sound."

Again, he enjoys the system when he is moving slowly. He also reports that being able to change movement density is the best part of the system, since he can switch it up if he starts getting bored with what is happening.

When he is dancing, he is still paying particular attention to phrase and section changes. He and his partner, Dancer C, had spent some time in the workshop trying to hear the cadences, but it was very difficult for them. He is trying to predict the ends of phrases so that he can create pauses and stops that work more organically with the music. He now registers when phrases and sections change, but this realization tends to happen in hindsight. His predictions are not often correct. He meditates on how this skill could be effectively taught, wishing for a test or an exam.

In this session, he does not mention getting lost in his movement or forgetting to listen to the music. He does not specifically report missing musical response in the moment when the follower or the interviewer points it out.

7.3.2.5.2.2 Dancer B: Musical Relationship

When first asked about his musical relationship, Dancer B frames music as part of the general setting, saying, "Sometimes I kinda take the music for granted that it's just supposed to be there and it's just a tool to get the conversation started. Social lubricant." He notes that he "is not the best music ambassador." However, after hearing his partner's response, he clarified music as allowing him to not think because in the dance he does what the music is telling him to do and thus, doesn't have to worry.

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In Study 2A, he immediately compares his experience with fixed and interactive tango music. He describes fixed music as 'immovable', and agrees with his partner that he is learning how to hear music differently, in parts and dynamically, in order to interact with the system. He experiences rhythmic arrival with foot/floor contact, responding with this answer consistently across interview sessions. When asked about musical strategies, he mentions that one can have muscle memory of song rhythms after repeated listening. While he feels more freedom to move in less rhythmical sections of music, he still feels that he can be rhythmically off during these sections and that he can move in ways that don't work as well. A dancer can also dance in contrast to music. He notes that he responds in opposition to the rest of the dancers on the floor if they are all still during a still musical moment because 1) he likes to challenge other dancers by presenting an obstacle, and 2) it allows him to do his own thing.

In the final interview, he continues to emphasize the importance of not thinking. He reports that generally he still has a hard time 'picking out' musical patterns. So, he usually responds as he feels without trying to analyze the music.

However, he describes his relationship with music differently than in Study 1. He explains music as containing potentialities for ways to move and respond. He comments: "it's [music] a license to take on a new perspective." When asked about rhythmic arrival, this time he also reports an emotional component to being in or out of sync. He says, "That synchrony – [..] I think that's just an emotional system that you're just connecting. Rather than connecting with another person, or connecting with anything else, you're connecting with the music."

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7.3.2.5.2.3 Dancer B: Connection

Dancer B consistently frames connection in terms of meditation and not thinking consistently across all three studies, relating it to trance states in the first two studies. He sees connection as essential and structural to tango. That is, without connection you are just walking or doing something that is not tango. He usually experiences a good connection while dancing, only experiencing problems or breaks when things go very wrong. He does report different qualities and depths of connection when questioned further. He finds that overthinking and stressing are the problems that prevent connection saying, "[Connection is] actually the opposite of stress, it's the opposite of overthinking."

He experiences connection not only with his partner, but also with the rest of the dancers on the floor. In the last interview, he emphasizes the aspect of being part of a whole more strongly. He also mentions music while responding to a question about connection for the first time, saying: "That's not just you're [and your partner are] moving together, it's [that] you're moving with the other people in the room. And then there's the music there and you're really just working with the music."

7.3.2.5.3 Dancer C

Dancer C is a female follower in her mid-twenties with four and a half years of tango experience at the time of the first study (October 2015). She has played several instruments (i.e., piano, guitar, violin), but this is in the past, and she considers those experiences as failures[147]. Instead, she found the she preferred to engage with music via

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[147] For data analysis, she is considered a musician even if she does not claim the title as she has musical experience with several instruments and considers her dance training (e.g. tango, ballet, salsa) in terms of musical interaction.

dance where she was interacting her whole body instead of only her fingers. She participated in all phases of the study, including dancing twice with different partners during Study 1. During Study 2, she is less involved with the tango scene and she does not dance tango between these sessions.

7.3.2.5.3.1 Dancer C: Interactive Tango Experience via Video-Cued Recall

This section summarizes results from IPA analysis of Dancer C's description of his experience in the interactive tango system.

7.3.2.5.3.1.1 Dancer C: Study 1 First Experience via Video-Cued Recall

Her first time in the system, Dancer C concentrates on trying to ascertain system response, coming up with a number of hypotheses that are only partially correct. For instance, she guesses that lifting her leg changes the melodic character or produces an orchestration change. Again, this is not quite correct, but her foot onsets/peaks do cause to the next melodic fragment to trigger, sometimes resulting in such changes when a new phrase begins. Both she and her partner also note that they have trouble switching their mindsets from responding to the music to generating the music.

After the explanation, she develops strategies for exploring musical response. She directs her leader to start slowly and then they gradually increase speed, listening for how layers are added to the musical outcome. She says, "It felt like we were more in control because I think we started out slower so we had more of a baseline. Then once we sped up, we heard the other things turn on. So then, I think I had a better idea of what the baseline was and what the additional parts were." During the dance, she begins to feel a sense of musical agency. She uses adornos to play with note density, listening as it

becomes sparser or busier. She finds that it is harder to add energy to create higher movement energy states (e.g. bigger, busier music). While she feels agency over faster or slower sections, she has trouble producing staccato notes. Unlike Leader A or Leader B, she rarely notices musical reaction on the video that she did not realize in the moment.

When the session ends, she requests and schedules another session with the interactive tango system.

7.3.2.5.3.1.2 Dancer C: Study 1 Second Experience via Video-Cued Recall

Dancer C remarks that she is more aware of foot position. She is thinking of how location of the sensors and the motion capture method impacts musical response. While she understands the system, her leader does not, and she feels this during the dance. However, she uses adornos to effect musical change and gauge system response. She is aware in many moments of responding to changes in musical dynamics that are the results of their movement moments before. She feels she is dancing to previous movement. At the end of the dance, both dancers together expend effort to become still and stop musical response. However, Prototype #1 only ends if stillness occurs at the end of a phrase and they cannot detect the phrase ending. She says, "That's so, it looks like the, the frame was paused like we were standing so still. Like at first I thought we weren't standing still enough to stop it." Eventually, they just give up and declare themselves done.

During the VCR of the second dance after the leader receives the explanation, she reports that they both have a better idea of what is happening in the system. She also notices flaws in her movement technique during this dance, which she finds distressing.

At the start, she uses tapping adornos to determine when musical layers begin to build. She feels that the system responds to her movements, but expects that changes would be bigger than they are. At the end, they again attempt to stop the system organically, but fail. When asked about openness after VCR, she notes that because the system was dynamic, it felt more open and comments on her musical agency, "I knew I was affecting it so I could be like oh well you know I want it to be fast now so I will do a bunch of tapping or I don't want it to be fast so I will just kind of drag my feet you know."

7.3.2.5.3.1.3 Dancer C: Study 2A Experience via Video-Cued Recall

In Study 2A, Dancer C continues to use the musical strategies of using adornos to create dynamic variation in the music and starting slow then building layers, introducing the latter strategy to Dancer B. As she watches the video, she describes how she affects each musical change and remarks that the system feels more responsive than in the workshop. For instance, she describes creating smoothness in the music, "We were going for more legato with this, but then – okay, there were some quick little steps in there and stuff. We were satisfied with the legato." She recognizes when she is moving to music that has been created/affected by prior movement. She describes one moment, "You see, that was nice because I know those were created before it, but then I was going on the timing that they were telling you guys. That was a good thing." She still makes one illusory correlation, guessing that particular instruments are assigned to particular tango moves or musical roles (e.g. accompaniment).

At the moment of their occurrence, like Dancer A, she experiences boleo musical ornaments as simply a fitting musical response to her movement rather than being

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specifically triggered. She recognizes them when they are pointed out to her as she watches the video. She notes that different boleos generate different responses, as slow, smooth kicks do not trigger the boleo musical ornament. During this dance, she and her partner also try different types of tango moves, such as volcadas, to hear if it changes the system. The lack of a particular system response to these tango moves causes her to reflect on the nature of the sensors and brainstorm other sensors to use in the system.

She agrees with the leader's statement that the music following her movement is easier in some ways since she does not have to worry about keeping time or catching the song end in the same way. However, she and her partner are spending effort worrying about different things instead. For instance, they are involved in trying creating pauses exactly at phrase endings and are by and large, unsuccessful. Also, while Dancer B had been getting lost in the movement, she indicated that she had been very absorbed in creating musical structures and changes with her movement.

 After this dance ends, she remarks that she thinks she has a lot more control over musical outcomes than he does. She also notes that she does not know music theory and because of this, she found it hard to understand the system, saying, "I don't know anything about music theory, so it was confusing for me. But then, each time it's got more and more easy to use and clearer." The system has perhaps become more easy to use because her increased musical awareness.

7.3.2.5.3.1.4 Dancer C: Study 2B Experience via Video-Cued Recall

Dancer C reports that she enjoys interactive tango in the social situation more than dancing individually. She likes the additional energy of other people, and she

particularly appreciates that she can take turns with other dancers. More than once, she describes using the system as a responsibility and that she feels relieved that she does not have to always have musical agency and she can share that responsibility with other dancers. When she is using the system, she is always thinking about the next place that she needs to go with the music and how to create dynamic variation. She likes being able to have the interactive experience for a limited time, but also being able to take a break from it and hear what others are doing. She says, "It's so relieving not to be in control of the music. [laughs] It was like being off the hook. No, I think because I was worrying about, "Oh, am I making it like staccato – like legato enough?"

Like Dancer B, She is struck by how different other couples' music sounds from theirs. Listening to their music makes the experience feel more dynamic, as when she was dancing only with her partner, it started to feel like a "driving lesson." It is also gratifying to hear how different everyone sounds. She does not find it difficult to dance to other couples' music, though. She feels like she and her partner are really making an impact on the music.

She is sometimes aware of other couples' movements through the music they make. In general, she discerns whether they are moving fast or slow, and very occasionally she perceives varying articulations. At first, she reports watching other dancers when she is dancing without using the system, but later on, she also describes being absorbed in her partner and the music exclusively.

In this session, she also feels more comfortable with the system and that she really understands it. She no longer reports making movements to figure out or understand the system, but when she is using the system she describes various moments of effecting

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musical change. Again, she finds the system more responsive than before, saying, "[T]his time with this system, I felt like it was more sensitive so I felt like it really responded a lot and when I did all the little tiny figures [..] I could differ in here with the guitar [create a louder musical ornament via kick] and I could feel the music get faster." Occasionally, she wonders whether it is her or her leader who is affecting musical change since she sometimes finds it hard to parse different musical voices and parts.

During this session, she notes that she sometimes forgets to stay in the camera frame. She is generally aware of being videotaped, often thinking, "I better not fall", but she reports that very occasionally, she forgets this as well during this session. She notes more than once that she is keeping track of many things: her dancing, the musical output, and the other dancers. She cannot give constant attention to all these aspects and the activity is very absorbing.

7.3.2.5.3.2 Dancer C: Musical Relationship

Dancer C experiences music and connection to be intimately related. She says, "So that if you can respond to the music in the same way and start to initiate the same direction or sequence of movements then it's just so much more rewarding because you've both interpreted the music the same way. That, to me, is the point of dancing." She describes connection as paying attention to the same things in the music in multiple interviews, and also explains attuning to one's partner as a musical strategy.

During Study 1, she emphasizes what music makes her feel, both emotionally and through her body. As she is currently engaged in several dance practices, she reports prioritizing the "proprioceptive perspective." Her responses in later sessions continue to

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reinforce this point in different ways. For instance, she says, "It [music] controls your emotions. And influences your emotions and your energy levels." Along this same line of thinking, she describes music as being inspiring and able to provide catharsis, for instance, if she is dancing to Pugliese, who composes dramatic, dark tangos, after a bad day.

She identifies musical patterns as one of her musical strategies, particularly rhythms. Unlike other subjects, she is aware that she feels and responds to different divisions of the beat and this is part of the strategy[148]. She can also listen for sectional changes and changes in melodic material. However, she does not normally listen to music analytically and she does not know music theory. When asked about her musical relationship, she often processes her interactive tango experiences, comparing that experience with normal tango dancing. She describes having to hear different parts and instruments in the music and distinguish different moments, whereas she is used to experiencing music holistically. While using the system, she reports learning to listen differently. She also relates that while sometimes the music does respond the way that she intends in the interactive system, this feels similar to when she misremembers a musical phrase in fixed music.

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[148] For individual subjects, it is difficult to determine if the lack of acknowledgement of beat division in musical rhythm reflects a language barrier or an actual lack of musical perception. However, Dancer A's reported realization that melodic onsets occurred on beat divisions does imply that he, in particular, on some level did not recognize this musical feature before gaining more musical skills.

7.3.2.5.3.3 Dancer C: Connection

As stated above, Dancer C did not distinguish between connection and her musical relationship. This section expands upon Dancer C's connection experiences not directly related to music.

Dancer C also describes connection in terms of trance states, timelessness, and not thinking. She describes one notable experience when she felt so relaxed that she fell asleep as she was dancing, suddenly awakening on the other side of the room, still dancing. She also described feeling connected to dancers with technique so terrible that it was disruptive and painful (e.g. stepping on her feet). She felt deeply connected, in that she felt very immersed and aware of her partner but it was very unpleasant. However, she does not experience timelessness or euphoria during these types of dances. Additionally, she reports that an emotional connection can substitute for bad dance or music technique, as she enjoys dancing with her friends even if they have these problems.

7.3.3. Corpus Analysis of Interactive Tango Study User Data

This section presents the results obtained comparing word frequency profiles of interactive tango study interview transcripts.

7.3.3.1 Corpus Analysis of Video-Cued Recall

This section analyzes video-cued recall employing corpus analysis techniques such as comparing word frequencies across corpuses. First, this section compares Study 1 with Study 2, which reflects 1) different system prototypes, 2) the effect of workshop lessons and increasing experience in the system. Second, this section compares the

difference between Study 1 and Study2A with Study 2B, in which couples dance alone aside no other dancers and Study 2B, a social dance context.

7.3.3.1.1 Implications of Prototype Iteration and Workshops: Study 1 vs. Study 2

This section presents corpus analysis results obtained from comparing Study 1 and Study 2, which tested different prototypes. Additionally, all the dancers in Study 2 had an hour-long workshop before VCR and semi-structured interviews, so corpus discrepancies may also have implications about the effects of accumulating interactive tango experience.

7.3.3.1.1.1 Passive and Active Perceiving

The findings from comparing Study 1 and Study 2 corpuses imply that dancers experienced a shift in the perceptual locus of agency. In Study 1, dancers use the words 'sound'/'sounded' to refer to system response. Subjects more often describe system response in external terms, describing action-reaction couplings. In contrast, during Study 2, subjects insert themselves into this coupling by describing themselves as perceiving. They use the words 'hear' and 'see' (and their conjugations) to refer to sensing system response, suggesting that they are actively involved in perception. They move and then they 'hear' or they don't 'hear' something. They 'see' what the system does when they try something new. The interviewer rarely uses these words in questions and prompts, so the difference was unlikely due to changes in questioning. For instance, the interviewer refers to the 'sound' of the system only once during the entirety of Study 1.

The frequency of the word 'hear' is positively correlated with (1) dancer positive experience and (2) skills in using the interactive system in Study 2. Excluding the VCRs

of the two couples that continued to have problems using the system increases the

statistical significance of 'hear' frequency across the two studies substantially. This

difference is noted in the following table with 'Positive Study 2' referring to the accounts

of dancers with more positive, productive experiences in the system (5/8 VCRs in the

sample). The 'Positive vs. Negative Study 2' compares the frequency of the word 'hear'

among accounts of positive, productive experiences with accounts of more negative

experiences (3/8 sessions) in Study 2. Dancers also use the word 'listen' and conjugations

more often in Study 2, particularly in Study 2B, but this difference did not reach

statistical significance.

Table 5

Corpus Comparison Results for Sound, Hear, and See

Word	Appears more in:	Log-Likelihood	P-Value
sound/sounded	Study 1	29.97	$p < 0.0001$
hear	Study 2	5.87	$p < 0.05$
hear	Positive Study 2	10.31	$p < 0.01$
hear	Positive vs. Negative Study 2	17.99	$p < 0.0001$
see	Study 2	9.02	$p < 0.01$

7.3.3.1.1.1.1 Study 1: Dancers using 'sound'/'sounded' to describe system response

Oh, there was a cool part just a couple seconds ago, where we stopped and then we started and it sounded like it started to, like, you know, and I always go back to dun, dun, dun, and then follow into that.

I mean I guess now I see some slightly staccato movements but maybe we should have tried more staccato movements because I wanted the music to sound smoother versus staccato, but it didn't.

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You know one thing some of the stuff is forgiving if you mess up the footwork, it still has a nice sound to it sometimes.

Ok. Well, cause sometimes it sounds like it's two different, I mean, if it were a band, it would be more than one person performing, it's not like just one.

Because I just felt out of the blue I should pick it up and see how the system responds.

7.3.3.1.1.1.2 Study 2: Dancers using 'hear'/'see' to describe perceiving system response

So even though I wouldn't feel anything, I would keep going with it to try to hear it and see what it would catch.

I think we could hear the complexity increase.

Did you hear that -- you hear that? Yes, that was when -- and I was like -- but I heard it and I just started moving.

I really like the guitar. That was easy-- easier to hear where the sound is being produced from. It was a lot of fun and I really enjoyed it.

Because I'm like,"Oh, okay, I can make this movement and make that noise". But it's nice to hear what someone else does and you respond to them.

Then, stopping to see how it responds to the slowing down as well."

7.3.3.4.1.2 Learning System Response

The phrase 'figure out' is more common in Study 1 than Study 2, perhaps reflecting Study 1 design and suggesting that the workshops helped dancers use the system, as when they did VCR they seemed to be further along in understanding the system and had less to 'figure out'.

Table 6

Corpus Comparison Results for Figure Out

Word	Appears more in:	Log-Likelihood	P-Value
figure (out)	Study 1	10.17	$p < 0.001$

7.3.3.4.1.2.1 Dancers describing attempts to understand the system.

I'm just trying to figure out what's going on. So I'm just kinda doing moves I know. I'm like, okay, well does this fancy thing do anything?

Oh! I heard that downbeat start coming and I was like, I started moving on the beat more and I was trying to figure that out, but then we lost it.

Well, based on the video I first saw online, I was trying to figure out what would make it steady and what would make it staccato.

I was trying to figure out which sounds we were causing.

7.3.3.1.2 Implications of the Social Context: Study 2B vs. Study 1 and 2B

This section compares the corpora of user study sessions of individual dancers (i.e., Study 1 & Study 2B) against the social user study session (i.e., Study 2B). The social dance session was also the last session and thus participants, on average, had more interactive tango experience than in previous studies.

7.3.3.1.2.1 Difference: Music From Other Couples and Increased Agency

Dancers use the word 'different' and related words[149] much more often in Study 2B than the non-social studies. Further examination revealed two reasons for this discrepancy: 1) dancers were comparing how other dancers used the system, 2) dancers were more likely to describe how they and sometimes others were creating dynamic variation and changes in the music. Related to the latter, the word 'make' also occurs with more frequency in Study 2B, in descriptions of how dancers are 'making' the system do something and again, creating change in the music. However, subjects also use

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[149] Differ, difference(s), differently.

the phrase 'make sense', often asking if the interviewer understood what they were

saying – a use of the word unrelated to musical agency. Therefore, the significance of the

'make' word frequency across the corpuses was determined after subtracting that use of

the word from the totals.

Table 7

Corpus Comparison Results for Different and Make

Word	Appears more in:	Log-Likelihood	P-Value
different	Study 2B	33.74	$p < 0.0001$
make	Study 2B	6.18	$p < 0.05$

7.3.3.1.2.1 Dancers using 'different' to describe other couples' dancing and musical sounds

Okay, the music was very different when each different couple was controlling it so I like that there was a lot of variation because then the dancing felt different.

Most of his moments are together with the followers. He doesn't do much different from her.

It's just nifty, because you're used to have the sensors work in your way and then here work differently.

I think it was because you could tell each different couple, like the songs sounded very different.

7.3.3.1.2.2 Dancers using 'different' to describe intentional creation of dynamic variations in movement and music using the system

I was thinking just about what are the different variations I can bring about? Just on that.

Here, I was starting to think if I could listen and one part when that section stops, it would change into something different and ended up with that.

The pace works differently in that change here.

I hear it much more clearly now than I did then and that makes a lot more sense, because it did sound different when we were spaced further versus closer.

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Because the base music, I remember you said it's like one song, it's taking out of one melody of one song. I was trying to see what difference can we create out of that? Was now sort of familiar so I can sort of see—

But, I could differ in here with the guitar and I could feel the music get faster and I could hear it get faster

7.3.3.1.2.3 Dancers using 'make' to describe musical agency

Because I'm like, "Oh, okay, I can make this movement and make that noise." But it's nice to hear what someone else does and you respond to them.

Now you make it go crazy.

No, I think because I was worrying about, "Oh, am I making it like staccato, like alto enough?

It's like, "Oh I really am influencing the music and we're influencing differently than other people are." So it's like, "Oh, I really was making that and they really are making their own music."

7.3.3.1.2.2 Remembering Embodied Experience

'Remember' is used more frequently in Study 2B as in 'I remember thinking', addressing what they were feeling while dancing immediately during video-cued recall, as opposed to referring or comparing with other experiences. Before examining the context of the words, I hypothesized that the social situation prompted more self-reflection during dance. However, the words 'thinking'/'thought' did not vary in frequency across corpuses and after investigating the fuller context, it happens that 'remember' may appear more frequently in descriptions since dancers generally were engaged in more, not less, unreflective action, and thus, these results may rather imply that dancers had more embodied experience to recall. For instance, dancers mentioned

that they forgot about the cameras at moments or that they were wearing sensors and in general, a greater proportion of dancers reported being immersed.

Table 8

Corpus Comparison Results for Remember

Word	Appears more in:	Log-Likelihood	P-Value
remember	Study 2B	5.40	$p < 0.05$

7.3.3.1.2.3 Other Word Frequency Comparisons

Not surprisingly, during the VCR of the social dance, dancers used the word 'people' and referred to other dancers with more frequency. Dancers also referred back to previous interactive tango experiences more frequently in this study, using the word 'time(s)' with more frequency than in other study sessions.

Table 9

Corpus Comparison Results for People and Time

Word	Appears more in:	Log-Likelihood	P-Value
people	Study 2B	11.00	$p < 0.001$
time	Study 2B	10.85	$p < 0.001$

7.3.3.2 Differences in Connection Descriptions: Study 2B vs. Study 1

'Music' occurs more frequently in response to questions about connection meaning and experience in Study 2B. Does this imply the system had an affect on dancer experience of connection? From this data, it is possible but not certain that this word frequency suggests that the interactive system prompted subjects to consider connection more deeply in terms of music.

The couples that showed the most increase were the two pairings of musician/non-musician partners, in which both partners tended to mention and discuss the impact of music on connection more thoroughly in Study 2B even compared to their responses in Study 2A. Three dancers further emphasized and elaborated on music as being important while one dancer clarified that it came after physical connection and elaborated on its specific impact, subordinate to the connection to partner. The couple consisting only of non-musicians did not show an increased mentioning of music.

These results suggest that the system may have had an impact and further results from case study IPA analysis also support this conclusion. However, a long data corpus would be helpful in clarifying the influence of 1) prior musical training 2) the role and importance music already plays in subject's lives.

Table 10

Corpus Comparison Results for Music

Word	Appears more in:	Log-Likelihood	P-Value
music	Study 2B	11.00	p < 0.001

7.3.4.6 Drivers of Negative and Positive Experiences

This section describes the factors tending to produce more negative experiences during interactive tango, as well factors as influencing positive outcomes.

7.3.4.6.1 Negative Experiences

Generally, negative experiences appeared to arise from ego threats, expectation violations, and bad dancer connections. In Study 1, dancers were less invested in particular outcomes and did not necessarily process a lack of understanding the system as

failure. Thus, while they reported confusion, this confusion was less often associated with particular or firm negative feelings. On the other hand, dancers participating in a workshop session continuing to have problems understanding the system often became very frustrated. Sometimes they responded to lessons defensively, suggesting particular changes in the system or questioning the technology. In general, dancers with more negative experiences also felt a lack of musical agency.

One common thread of negative experience was an indication that they lacked musical experience in the accounts of musical relationships and strategies. For instance, dancers who described Argentine tango music as being particularly complex[150] tended to have more problems understanding the system. The musical strategy of memorizing tango songs in order to create movement response was also correlated with more negative experiences. The lack of a continuous articulated beat was experienced as disruptive for multiple dancers, but dancers with negative experiences had much stronger reactions to the absence. Even when this beat was articulated, these dancers sometimes had trouble hearing it if it was articulated with an instrument other than a staccato bandoneón or piano. Further, difficult musical listening tasks such as predicting phrase endings caused some frustration, even if minor, in dancers who otherwise had positive experiences.

Tango couples dancing together for the first time as they were learning interactive tango system also tended have negative experiences, even in Study 1. The process of calibrating to a new partner seemed to disrupt learning the system. For instance, one

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[150] Note that two dancers who experienced tango music as more complex did have a more positive experience. These dancers also reported having made significant progress understanding the music over the years and had been dancing tango for two to four times as long as the dancers reporting more negative experiences.

follower was excited to use the system during the workshop session, and constantly performed adornos and appeared to change weight without the lead. The leader, therefore, had a hard time connecting his movement to musical response during the session, and said that he felt he had no musical agency. During the second time in the system, they both reported a much stronger connection. However, neither had learned to create dynamic variation in the system. While the follower had created many different sounds in the system when acting on her own, the leader only employed slower, smooth movement and thus, the music did not deviate from sparse, smooth sounds using continuous movement. After, they described the sounds with displeasure as carousal music. Also, whereas the follower appeared very engaged and generally positive during the workshop session, she also became disaffected in her second experience.

Another complicating factor for this couple was that the leader was recovering from an injury and the experienced extremes of movement density were not correlated with system parameters, which were set using the experience of dancers without such impediments. In response to this situation, the prototype was adjusted to accommodate on the fly movement/music density range adjustments for next study, 2B. However, while the range of articulation (i.e. legato/staccato) could be adjusted on the fly, it was difficult to ascertain the need to do so in the middle of the videotaped session since this lack of musical variation had not occurred during the workshop lesson.

Other drivers of negative experience were related to the setting. In Study 1, many dancers had trouble with the floor, since it was not very smooth. This was a particular problem for older and injured dancers, and later sessions were largely moved to a dance

studio. Another factor was being videotaped. Some dancers disliked watching themselves on video and it was hard for some to refrain from self-criticism during VCR.

One striking feature of couples with less positive experience was that they were more concerned with dancing well and movement technique than dancers with more positive experiences. They more often mentioned whether they were executing a move correctly or not. Sometimes they would reassure each other about their tango skills.

Being a relative newcomer to tango (i.e., less than two years of tango experience) anecdotally seemed to exacerbate negative situations but did not emerge as a causal pattern in this study. For instance, one dancer had just taken a workshop on musicality and the teachers had given very specific directions for arriving on the beat. Since the step onsets did not always occur exactly when they had described, he was disoriented and began questioning system validity during the workshop session. [151]

The inability to understand system response and experience musical agency was directly related to frustration and negative experiences. However, the situational and individual causes for this inability were multiple, including lack of musical listening skills, adjusting to a new partner, and movement difficulties/injuries. [152]

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[151] His expectations were an outlier in the dataset, as no other dancer made these specific claims, even his partner.

[152] Note that the system has been modified so that dancers with different abilities may more easily effect noticeable musical change.

7.3.4.6.2 Positive Experiences

A number of factors influencing positive experience in the interactive system emerge from the user study data. Prior musical training, for instance, made a striking difference in dancer interactive tango outcomes. Trained and experienced musicians as a whole also tended to be more interested and engaged in the system. They were also faster to develop effective strategies for exploring system response. For instance, only one couple was able to generally understand system response and create intentional musical effects without an explanation. They were relatively new to Argentine tango but they were both multi-instrumentalists with years of experience in various other styles of dance. During the video-cued recall, the follower remarked to her partner, "I felt like I could tell what you wanted moods to sound like." Two dancers who reported playing an instrument (i.e., guitar) did not display this difference. Neither appeared to have formal training. It is possible that their musical experience had not given them the same skills as those with more experience and training.

Not surprisingly, more experience using the system tended to lead to better results and more positive affect. With each experience in the system, dancers tended to experience a steady increase in positive affect and feelings of agency. Some dancers reported the system being more responsive each time, even when the technology had not changed. Further, the dancers who watched the available explanatory videos about the interactive tango system[153] online before attending the workshop or experimental sessions also had more positive experiences and an easier time understanding the system, even though they were not musicians.

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[153] Only two of twenty subjects.

While dancers who had not danced together tended to have more negative experiences with the system, the opposite was true for couples with experience dancing with one another. For instance, the one couple reporting very clearly a transcendent experience using the system had a lot of experience dancing together and were very close. Additionally, having a tango partner who understood the system was also a driver of positive experience, no matter if this understanding was the result of prior musical training or interactive tango experience. Many had an equivalently positive experience as their more skilled partners.

7.3.5 Overall Study Themes

One immediate and consistent unexpected result was that unlike participants in interactive art installations, tango dancers only occasionally tested limits and extremes of the interactive system. Often they had to be specifically directed to try movement extremes even after being given an explanation of system movement-music mappings. After working with the system, dancers often moved slowly or attempted longer pauses, but very few dancers explored how pausing and stillness affected musical outcomes without an explanation of the system. Relatively more dancers experimented with fast movement, however definitions of 'fast' movement did not appear to be consistent across dancers.

Another theme that emerged was that subjects often noticed musical response to their movement whilst watching their VCR video that they did not experience in the moment. During the dance, the subjects are tracking many variables. The cognitive load of dancing tango may hinder engagement with the system. In the case studies, this pattern

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is more prevalent in the leaders than the follower and becomes less prevalent as the dancers gain more experience in the system. It is possible that the follower had more cognitive bandwidth allowing more musical attention because of her 1) role in the dance, and 2) musical skills and experience relative the leaders.

7.3.5.1 Study 1 Themes and Summary

Due to the format of the study session, many dancers spent considerable time trying to understand the system. Even after an explanation was given, dancers still spent the majority of the time attempting to elicit and determine musical response. Many dancers had trouble developing their own strategies for exploring system musical potentials and dynamically building musical structures.

A tension between responding and affecting music emerged. Dancers often reported that it was more difficult to add energy into the system to increase movement density and staccato articulation. This difficulty appeared to decrease perceptions of agency. Dancers described musical response as vacillating between 'music' and 'noise', also describing this phenomenon as changing between 'smooth', 'continuous' and 'choppy'. Rather than referring to articulation, in this instance subjects appeared to refer to melodic character. Dancers had trouble moving such that phrases consistently had a feeling of musical coherency.

Additionally, in Prototype #1, sound only stopped when dancers paused on a cadence, but many dancers could not hear the phrase ending. When they could not stop the music, dancers experienced a loss of agency.

7.3.5.1.1 Prototype Adjustments

After the user study, several adjustments to system response were made as a result of user feedback and incorporated into Prototype #2. First, system response to movement density and articulation was re-calibrated so that less movement energy was required to create more musical density and more staccato sounds. Feature and perceptual measure windows (i.e., movement density windows) were also made smaller in order to increase responsiveness. A feature was also added so that the response curve for articulation could be adjusted on the fly, to better match with the active dancers. Secondly, Prototype #2, the system stopped playing all music if the dancers remained still for four measures. Previously, music only stopped completely if dancers stopped moving at the end of a phrase, else it would not play the melody but continue playing accompaniment.

7.3.5.2 Study 2A Themes and Summary

The addition of the workshop substantially decreased dancer confusion and disorientation using the system and participants responses seemed less colored by the novelty of the experience. However, the spread of response was much wider than in Study 1. While most dancers were able to experience some degree of musical agency in the system, a few dancers did not. Individual dancers progressed their interactive tango skills at different rates, influenced by but not identical to their partner's progress.

Some respondents remarked that they enjoyed the musical response to giros and other turns, in particular. They could not articulate precisely why. It is likely that they were responding to the torso rotational timbral variation, which was an aspect of the system that was not specifically taught or explained to dancers during the workshop.

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In this study, subjects do not describe the music as choppy or discontinuous. The produced melodic lines tend to be more musically coherent than in System 1[154], but participants still sometimes produce disjointed melodic lines. [155]

The association between dancer loss of balance and musical result in this system increased feelings of agency when the dancer noticed the correspondence. Often, this was the result of the system recognizing a boleo as the dancer fell or recovered. The fact that the system responded in this way was received very positively, eliciting laughter both during the moment and in VCR.

7.3.5.3 Study 2B Themes and Summary

Participants reported enjoying the social session the most, with some being extremely enthusiastic. Dancers often heard others music and remembered what it is like to watch them dancing or to be their partner. However, one dancer with more trouble acknowledging system musical response rarely mentioned other dancers and their music unless prompted. Half of the dancers found it very difficult to tango to the music from other couples, even if they felt comfortable using the system. The other half did not have any problems, some noting that dancing to other dancers' music was easier or extremely similar to using the system themselves. For some dancers, hearing examples of different dancers using the system helped them understand system potentials. Dancers also reported the most musical agency in this session. [156] One couple mentioned that it was

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[154] No change had been made in the musical arrangement or technology for this matter.

[155] Anecdotally, according to my musical ear.

[156] When they were using the system.

strange dancing after their turn, as they still had the feeling that they were affecting the music in their body, but the music was not responding to them causing dissonance.

Anecdotally, the system appeared to foster a more supportive, communal environment, although the relatively intimate nature of the gathering (6 subjects) was also likely a factor. Additionally, almost all the dancers knew each other or were friends. After each dance, everyone applauded the couple using the system.

7.4. System Performance

This section presents results of the questionnaire given to participants regarding system performance during Study 2. Copies of the questionnaires are included in Appendix C. Dancers were asked to rate two system features on a scale of 0–10, 1) footstep response and 2) boleo detection. Only followers rated footstep response, since the system did not respond to leader foot onsets. While the intention of the first question was to measure user perception of onset/peak detection performance in relation to their experience in the system, it is unclear that all participants read the question as such. In general, responses to all questions appeared to correlate strongly positive/negative affect appearing in interviews, with the correlation of the first question being stronger. Individual dancer response was not always consistent between studies, even though the technology did not change. Dancers tended to rate the interactive tango system higher with more exposure. One dancer increased her rating to footstep response in the second study by three points. During VCR, many dancers indicated that they were not always cognizant of musical response, and this may have impacted their evaluation of the system.

The next two questions addressed the system response curve of movement density and articulation (i.e. staccato/legato). The rating system for these questions was different. Instead of rating 0–10, users were asked to place the ideal response at the center (5). Outcomes that leaned too much towards lower intensity outcomes (e.g. legato) were rated as less than 5, and outcomes that favored higher intensity outcomes resulted in ratings greater than 5 (e.g., staccato). In general, these responses were more consistent across studies, but still included contradictory responses. Additionally, some participants noted that their response to the question about articulation was regarding the default setting before adjustment.

The table below displays the results from the questionnaire for Study 2. The adjusted means and standard deviations refer to statistical measures of the dataset with outliers removed. Responses were considered outliers if they were 1) from dancers who had unusually negative experiences with the system[157], 2) a comment revealed the dancer did not understand the question, and 3) in one case, when a sensor was likely positioned incorrectly (observed via movement data).

Table 11

Footstep and Boleo Questionnaire Responses

Measure	Raw Scores	Adjusted Scores
Footstep Response	6.8	8.2
	(2.7)	(1.6)
Boleo Detection	6.4	7.3
	(2.4)	(1.8)

Note. Standard deviations appear in parentheses bellow means. The range for this scale was 0–10.

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[157] That is, dancers who reported rarely or never feeling any musical agency or understanding of system response.

Table 12

Movement Density and Articulation Questionnaire Responses

Measure	Raw Scores	Adjusted Scores
Movement Density	5.2	5.8
	(1.9)	(1.1)
Articulation	4.8	5.2
	(1.5)	(1.1)

Note. Standard deviations appear in parentheses bellow means. The range for this scale was 0–10, but centered on 5. Values above or below 5 indicate higher or lower energy states, respectively

Due to time constraints, a more objective performance analysis of system features has not been undertaken. However, the comparison between these two measures may help clarify the meaning of user responses. The adjusted means of footstep responses and boleo detection seem reasonable for current system performance. The use of acceleration peaks to measure onset detection generally works, but is an imperfect measure. Anecdotally, boleo recognition appeared to work very well some dancers and less so for others, and it could be that this is what the user data is reflecting that. A larger, more varied training dataset would be useful.

The ratings of perceptual measures generally show that means for the default settings of extremes were more or less correct, with the movement density means favoring denser musical outcomes too strongly. However, the unadjusted means show a large variation, which, together with the qualitative data analysis, do reflect real differences in perceptions of perceptual extremes in tango dance. These results suggest that there is not a real consensus on what is 'fast', 'slow', 'smooth' or 'rough' movement in the Phoenix area tango community or very likely, globally. Thus, allowing dynamic adjustment of perceptual ranges during deployment is a necessity for the system.

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7.5 Discussion

This section discusses user study results in relation to design decisions and research questions.

7.5.1 An Assessment of Design Decisions and Outcomes

The movement-music translations appeared intuitive to dancers in general and especially for dancers with musical training. For instance, dancers did not employ unnatural movements to drive system outcomes. When they danced in the system, they were definitely still tango dancing. But they did sometimes alter how they danced. Dancers tend to favor some tango figures over others and some included tango figures in interactive tango that they normally avoid. For instance, one dancer reported that he very rarely led boleos, but during the interactive tango, he did experiment with them to see what they would do. Additionally, while phrasing and creating specific rhythmic patterns via foot moments are common in dancer vocabulary, many dancers were not accustomed to creating/structuring dynamic variation in movement density or articulation. For instance, they rarely paused for any length of time during dance or varied speed during their first dance or even their second dance in Study 1. Dancers who became proficient using the system, however, often employed striking variations and IPA analysis of VCR sessions indicated that they were spending effort creating and thinking about these structures. This outcome perhaps reflects that in non-interactive tango situations, dancers tend to rely on music to create these kinds of structures, and thus they tend towards musical interpretation rather than collaboration. Before using the interactive tango

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system, many dancers did not necessarily have the skills to create larger time-based forms and structures in this way.

While the movement-music mappings appeared intuitive, dancers without musical training had trouble hearing or distinguishing musical elements, hindering use of the system. Even dancers with some musical experience had troubles distinguishing melody from accompaniment or instruments from one another. Continued use of the system often alleviated these problems, but the entry cost was very high for some dancers. Also, the system provides very few rhythmic or tempo indications of cadential figures[158], and so dancers had to rely on harmonic and melodic indications, rendering the task extremely difficult for those untrained in Western art music[159] or insufficient experience with Argentine tango music (i.e., many tango dancers).[160] Thus, varying system response to stillness based on phrase ending recognition was disruptive to agency to many dancers. For the last study, the length of time the accompaniment continued during stillness in the middle of a phrase was reduced to two measures. This change appeared to both provide contrast between pauses during phrase middle or end and allow dancers to feel that they could stop the system when they wanted.

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[158] One clue is that the fragment length is always smaller near the end of a phrase, but this is undetectable during sparse sections and likely difficult to use as a metric.

[159] Note that as Argentine tango music has been very influenced by Italian art song (See Chapter 3.2.1), phrase melodic and harmonic structures generally follow Western art music conventions.

[160] Although, it is possible that porteños would have less problems with this task, as research indicates that porteños report less problems with understanding Argentine tango music, in general, as they have had much more exposure (Merritt, 2012).

The interactive system did not appear to hinder or drastically alter many aspects of the social context of tango. However, a significant number of dancers found the interactive music of other couples difficult to engage with in their dancing. More experience with the interactive tango context may alleviate some of this discomfort. The nuevo aspects of the musical composition (e.g. freer use of accidentals and rhythm in ornamental figures and a weak phrase ending in Section B, modulating the musical key) may also have made the music more difficult to comprehend[161]. However, study results also suggest that the resulting music may need to articulate the beat more strongly during a greater percentage of the song, regardless of dancer movement/input. For beginning dancers and those with less musical skills, the absence of a very strongly articulated beat was extremely disruptive, sometimes seemingly causing distress.

7.5.2 Interactive Tango, Dancer Connection, and Musical Relationships

Results suggest that some dancers were able to hear aspects of their partner or other dancer movement and intention via the interactive system. In Study 2A, a few dancers mentioned hearing and getting additional information from their partner's movement. In one instance, for Dancer A and his partner, this correlated with a transcendent connection experience. In other instances, such as Study 2B, dancers reported surmising movement states of dancers using the system, but sometimes it was unclear whether these were purely intellectual conclusions and to what extent this was an embodied experience. Generally, dancers were easily able to hear musical density as the

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[161] Most dancers could not hear very strong cadences, either. Also, note that while the phrase ending was relatively very weak, tango song sections are very often in different keys such as the parallel major or minor.

movement velocity/acceleration of others, and some reported specifically hearing smooth movement. Results suggest that continued training might yield more embodied responses, possibly contributing at a deeper level to connection experiences.

Corpus comparison between the first and last interview transcripts implies that dancers considered the role of music more extensively in the final interview, after their interactive tango experience. While Dancer A did not consider music more deeply in his final response, Dancers B and C spent more time considering the role of music in connection. Dancer B's response during Study 1, for instance, does not mention music at all, whereas he describes music as being pivotal to connection in the final study. These results align with system aims of enriching connection experiences. Results also align with the aims of changing tango dancers from musical interpreters to collaborators. The IPA case study analysis of dancer accounts all imply a trajectory of increasing musical understanding and listening skills.

However, the results also suggest that subjects must have both musical agency and embodied understanding of the system in order to access sound as a conduit for connection. Subjects had varying levels of success achieving these preconditions. It is likely that dancers must move beyond the point of constant frustration to learn musical listening skills, if only to maintain motivation for continuing the process.

7.5.3 Priorities for Future Development

One of the striking results of this study was the vast spread of dancer response, correlated highly the development (or not) of interactive tango skill. For some, either listening for, or creating musical response was an extremely hard task. This indicates that

if the system could be altered to allow graduated levels of difficulty, more dancers may have more fun and less frustration. It is possible that learning the system could also be gamified in some way.

Dancer enthusiasm for and response to the social setting also suggests that interactive tango does not need to consist of large ensembles in order for dancers to experience sound as a conduit for connection. Several dancers remarked that they enjoyed taking turns in the system, having periods of musical responsibility and freedom. However, spreading the musical mappings across a larger number of dancers may lessen the responsibility for each individual dancer and decrease the cognitive load of musical interaction. Thus, testing and refining the two-couple system remains a high priority for system development. The arrangement of more songs in the system is also a high priority, as system cannot be used consistently in tango situations without a critical mass of contrasting songs.

7.6 Future Work

The results of this user study have been explorative, providing suggestions for what features and factors shape tango social interactive dance experience. Study results reflect that this space is highly multidimensional and a dancer's idiosyncratic momentary directed awareness of a set of factors in this space strongly impact dancer experience. More directed assessments would be valuable in the future, focusing on one or two interactive tango dance attributes in order to tease out these factors. These future studies could examine, for instance, what response curves of perceptual measures produce the strongest immediate feelings of agency? Are there techniques to personalize these

response curves or dynamically adapt to varying situations? Such work could have implications and value not only to interactive tango but also for the development of interactive multimedia systems for 1) the social or collaborative context, 2) developed for musical laypersons or amateurs, 3) the creation of more expressive performative systems, 4) developed for traditional genre-specific musical and dance traditions.

CHAPTER 8

CONCLUSIONS

New musical interfaces, particularly interactive dance systems, have commonly

been developed for spaces such as the stage, the art gallery, the experimental arts festival,

the noise scene, the DIY workshop. The intended users are either highly trained

dancers/musicians or in the case of installation work, the general public, expected to have

no training at all. The audience or gallery visitors often have a momentary or singular

experience with these systems, including in laptop orchestras in which mappings and

interfaces are generally specific to each individual work. Creators and performers take on

the main role in developing performance practices, often within experimental art and

music aesthetics. Interactive dance systems and new musical interfaces are not generally

developed for extended use and practice by amateurs.

Interactive Tango Milonga is an interactive dance intervention in a novel cultural

space, the social dance. Instead of remaining in the niche of experimental music and art,

the interactive tango system generates music and responds to movement in the specific

style of Argentine tango in its culturally appropriate setting. Participants are skilled

amateurs with highly varying levels of musical and dance ability. By moving, they are

contributing and taking part in the wider Argentine tango tradition and community.

Rather than existing outside this tradition and borrowing or appropriating musical and/or

movement elements for a stage work or art installation[162], interactive tango exists as part of the wider tradition, as an extension not unlike contact tango or tango queer.

This chapter summarizes the contributions and new questions arising from this reaching towards a new practice, addressing wider implications and applications. Then, looking forward, the next steps are addressed.

8.1 Contributions and Implications of Interactive Tango Practice

The main contributions of this work are: 1) the interactive tango system, 2) the theoretical framework for connection and its application as a design tool, and 3) the user study experiments, which elucidate critical issues and possibilities of intervening in a participatory music tradition.

During interactive tango system development, I have resolved challenges related to the motion capture of intertwining bodies and gait analysis as well as connection and alignment. I have developed strategies for resolving the disconnect in musical interface between how computing machines perceive the body/world and how we, as humans, perceive ourselves and the world. I have developed a real-time system for stylistic music arrangement and generation, responsive to perceptual input via dancer movement. These achievements pave the way for pedagogic system for training tango dancers to improve musicality and generally advance and be conscious of their technique.

This work is critical because while Argentine tango also exists as niche musical culture, it has crucial differences with common experimental music/art contexts. These

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[162] Of course, the interactive tango system has been used in performance and could easily be modified for an art installation for the general public. However, the impetus and design of this system has been for the social dance context.

differences become instructive when creating an interactive art intervention meant for lasting use and impact. For instance, this work necessitated designing for skilled amateur musicians and dancers, an audience pivotal to the wider adoption of new musical interfaces. To be adopted, these interfaces must become both feasible and relevant within the musical, cultural, and social context of the participants, not only as a novelty but also as part of on-going practice.

Some of these skilled amateurs do not have basic musical listening skills[163] that 1) musicians may take for granted and 2) are important in order to engage effectively with many musical styles. The work reveals that the learning curve and the point at which these amateurs experience frustration to be highly dependent on a confluence of causes (See Chapter 7.3.4.6). Results suggest that external factors such as social context, pedagogical approaches, and the means of dissemination should be considered as important as the design of the musical instrument or system. In a codified musical and movement context such as Argentine tango, participants may also have more preconceived idiosyncratic expectations about the manner and content of musical response than in more experimental art/music spaces. Participants may also have a greater tendency to anticipate easier mastery of system musical response since 1) they have related experiences and skills[164], and 2) they may not immediately perceive or recognize the system as requiring musical skill at all.

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[163] E.g., effortlessly distinguishing an instrumental melody in unfamiliar song or hearing/recognizing divisions of a beat

[164] Which, in reality, may translate into the intuitive intentional driving of musical response to varying degrees depending on participant and system design.

After only a few sessions with the interactive tango system, most dancers, even some beginning with rudimentary listening skills, were able to hear musical response and make purposeful musical decisions. The exploratory outcomes[165] generally imply a validation of the general design principles considerations derived from considering the situated tango dancing body for the skilled amateur use case. Results are an impetus for additional research, as further longitudinal and directed studies will aid in solidifying findings and in clarifying more specific strategies and principles.

Another finding is that disruption of these social spaces and expectations must be minimized, as the very novelty of a new interface is already disturbing on-going practice and creating more variables for participants to track during the already absorbing activities. This finding may be more relevant to activities such as social dance, but more generally, setting and context are still critical to users' tendencies to be in flow or experience transcendent states such as trance. For instance, the more ecologically valid setting of the social session led more dancers to report being immersed than dancing alone.[166] Balancing opposing requirements for musical coherence and agency is also a critical problem for the collaborative space. Different modes of performance, allowing graduated difficulty, may be a solution to allow more skilled users more involvement while keeping entry cost low for others and mitigating possible musical incoherence in social situations.

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[165] As trained musicians found the system relatively intuitive and dancers lacking these skills were able to attain new understanding of musical structures and ways of listening via interaction with the system.

[166] Many dancers also commented specifically that they felt more at ease at the dance studio than the classroom. And dancers in the classroom were often thrown out of their experience by the relative roughness of the floor.

The infiltration of participatory music contexts with digital musical instruments, such as the interactive tango system, not only leads to greater social impact and pool of users, it also introduces new modes of artistic critical response to societal structures. For instance, the interactive tango system increases follower agency and responsibility relative to the patriarchal context of traditional Argentine tango. The interactive tango system also allows for significantly greater connectivity between unpartnered dancers on the floor via sound, emphasizing interdependent 'networks of mutuality'. [167] While leaders are always involved with other dancers via navigation, the interactive system provides a much easier way for followers, in particular, to connect with the other dancers. Instead of being presented with symbolic representations and rarified situations eliciting questions and critical response, by dancing in a continuing tango practice, participants are enacting and coping with structural change and disruption in traditional structures.

8.2 Interactive Tango: Looking Forward

The interactive system currently exists as a self-contained system including expensive propriety sensors and a private codebase. In order for dancers to interact with the system, the developer, myself, must be present for deployment. [168] In order to facilitate new, on-going practices, the system must move towards greater accessibility and availability. For instance, creating a reduced version of the system for use with one smartphone would allow much greater distribution. On-going workshops teaching interactive technique and partnerships with tango organizers will also be important going

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[167] Phrasing borrowed from Gibson (2006).

[168] Or an experienced proxy.

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forward. Fuller system versions could also be distributed to interested organizers, which would allow users without smartphones or specialized equipment access to the system. Additionally, the development of an API[169] or utility software for the arrangement of tango songs for the interactive dance system could encourage community involvement and increase the variety of music available for the system. The API could also allow the system to be used for other styles of music and in unexpected ways. Previous chapters have articulated specific priorities for system implementation and outcomes as well. [170]

The work outlined in this thesis may be seen as one small step towards the instigation of a new, evolving social practice. The aim of this work is to eventually transform interactive tango into a subculture facilitated by not only my work but also that of competing and complementary interactive tango systems, techniques, and dancers. During my research, I have found participatory music to be a rich context for artistic work with potentials for greater impact and raising new questions. It is my hope that this work opens doors for other interactive art interventions into social, participatory traditions.

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[169] Application programming interface.

[170] See Chapter 6, Chapter 7.5.3, and Chapter 7.6 for more details.

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APPENDIX A

LETTER OF IRB APPROVAL

APPROVAL: EXPEDITED REVIEW

Garth Paine
Arts, Media and Engineering, School of
480/965-9438
Garth.Paine@asu.edu

Dear Garth Paine:

On 12/20/2013 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	An Investigation into Embodied Agency and Connection to Music, Partner, and Community in Interactive Argentine Tango Social Dance
Investigator:	Garth Paine
IRB ID:	STUDY00000296
Category of review:	(7)(b) Social science methods, (7)(a) Behavioral research
Funding:	Name: Fulbright Foundation;
Grant Title:	
Grant ID:	
Documents Reviewed:	• Interactive Milonga Consent Form, Category: Consent Form; • Protocol for Interactive Milonga Tango Study, Category: IRB Protocol; • Interactive Milonga Questionnaire, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Interactive Milonga Interview Questions, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Email from Argentina Fulbright Coordinator Verifying No Additional Clearance, Category: Other (to reflect anything not captured above); • Fulbright Acceptance Letter, Category: Other (to reflect anything not captured above);

The IRB approved the protocol from 12/20/2013 to 12/19/2014 inclusive. Three weeks before 12/19/2014 you are to submit a completed "FORM: Continuing Review (HRP-212)" and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 12/19/2014 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Courtney Brown
        Courtney Brown

APPENDIX B

INTERACTIVE TANGO DANCE STUDY INTERVIEW QUESTIONS

Study 1:

Open-Ended Questions asked during the Video-Cued Recall:

1. Please tell me what you were feeling when dancing here.
What did it feel like dancing in the Interactive Tango Milonga?
2. Did the music respond to your dancing?
3. What was your relationship to your partner during the experience?

Questions asked after Video–Recall Session

1. At any point did you have a feeling of being open during the dance?
   a. can you describe these moments?
   b. conversely, was there a point where you felt particularly closed? When?
2. Was there a point when you felt particularly heavy or dramatic during the dance?
   a. can you describe these moments?
   b. conversely, was there a point when you felt a lightness in the dance?
3. Were there moments of high intensity? can you describe these moments?
   b. What about moments of softness and low intensity?
4. As a tango dancer, please describe what your relationship is to the music.
5. As a tango dancer, please describe what 'connection' means to you.
6. Can you recall a time recently when you felt that you were extremely connected to both the music and your partner when you were dancing tango?
   a. When and where was it?
   b. Do you remember what you were wearing?
   c. With whom were you dancing? (No names, please ID via relationship to you)
   d. What was it like to dance with him/her?
7. Tell me about the experience—what happened when you were extremely connected while dancing the Argentine Tango?

Study 2:

Open-Ended Questions asked during the Video-Cued Recall:

1. Please tell me what you were feeling when dancing here.
What did it feel like dancing in the Interactive Tango Milonga?
2. Did the music respond to your dancing?
3. What was your relationship to your partner during the experience?

Questions asked after Video–Recall Session

1. As a tango dancer, please describe what your relationship is to the music.
   a. What does 'dancing on or off the beat' mean to you? How do you know that

you have you arrived on the beat? With what body parts?
- b. Do you have any strategies that you have learned for interacting with music / musicality? What are they?

2. As a tango dancer, please describe what 'connection' means to you.

3. Can you recall a time recently when you felt that you were extremely connected to both the music and your partner when you were dancing tango?
- a. When and where was it?
- b. Do you remember what you were wearing?
- c. With whom were you dancing? (No names, please ID via relationship to you)
- d. What was it like to dance with him/her?

4. What qualities, events, or events that have caused difficulties in achieving connection?
- a. Can you feel extremely connected to another dancer with flawed technique? What aspects cause disruption?

APPENDIX C

INTERACTIVE TANGO STUDY QUESTIONNAIRE

1. What is your age?
2. What is your gender?
3a. Are you usually a follower or a leader?
3b. If you are primarily a follower or a leader, do you sometimes switch roles?
3c. If you switch roles, how often do you dance the role? Please answer in terms of percentages. (ie, 50% means you dance equally in both roles.
3d. During your most recent experience Interactive tango milonga, how often were you in each role?
4. How long have you been dancing the Argentine tango?
5. At what skill level do you consider yourself?
    a. Absolute beginner (this was my first experience dancing)
    b. Beginner
    c. Advanced Beginner
    d. Intermediate
    e. Advanced Intermediate
    f. Advanced
    e. Professional
6. How experienced are in electronic arts and computer-based music?
    a. Absolute beginner (this was my first experience in electronic arts)
    b. Beginner
    c. Advanced Beginner
    d. Intermediate
    e. Advanced Intermediate
    f. Advanced
    e. Professional (I create or teach electronic music or art for a living)
7. What is your experience using the interactive tango system?
    a. This was my first time
    b. I have danced in this system 2-4 times
    c. I have danced in this system 5-10 times
    d. I have danced in this system 10-20 times
    e. I have danced in this system over 20 times

Questions added for Study 2:

8. If a follower, how was system response to your footsteps?
(0 – system did not seem to respond or response was unclear, 10 – very responsive)

0 1   2   3   4   5   6   7   8   9   10 NA

9. Comments, if any, on system to response to steps

10. If relevant, how was system recognition/response of circling and/or calecita moves during your dance?

(0 – system did not seem to recognize the move or response was unclear, 10 – very responsive)

0   1   2   3   4   5   6   7   8   9   10   NA

11. Comments, if any, on system to response to circling/calecita

12. If relevant, how was system recognition/response to boleos/kicks during your dance?

 (0 – system did not seem to recognize the move or response was unclear, 10 – very responsive)

0   1   2   3   4   5   6   7   8   9   10   NA

13. Comments, if any, on system to response to kicks/boleos

14. When you moved smoothly, or legato vs jerkily or staccato, how was the response of the system?

(0 – music too staccato/jerky, 5 - music about right, 10 - music too smooth/legato)

0   1   2   3   4   5   6   7   8   9   10

15. Comments, if any, on system to response to jerky/smooth movement

16. When you made more movements, as opposed to fewer, did the the system respond with more or few notes and musical lines in accordance to how your perceptions of your own movements were busy or sparse?
(0 – music too sparse, not enough response to movements, 5 - music about right, 10 - music too busy, with too many notes)

0   1   2   3   4   5   6   7   8   9   10

17. Comments, if any, on system to response to movement amount/density