‘Ah Ha’ Moments: Novice Choreographers Using Defamiliarization in Digital Choreographic Technologies

by

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Abstract

Choreography is a complex compositional and embodied creative process that often relies on ‘co-imaging’ between choreographer and dancer, and more recently between choreographer and technology as a strategy in generating new movement ideas. Adding technology into the choreographic process is a unique challenge because choreographers generate, augment and assess movement through and on their bodies. Technology has historically been used as a tool to augment creative opportunities in choreographic process; often these varied choreographic support tools are designed to function as a ‘blank slate’ for choreography. However, these choreographic tools do not necessarily contribute to the design of creative ideas. My research investigates the experience of novice choreographer’s ‘ah ha’ moments in their creative process by addressing a gap that exists within current digital choreographic creativity support tools. This gap is the ability to co-imagine novel movement choices between choreographer and technological support system. ‘Ah ha’ moments refer to moments in creative choreographic process that present new insight, understanding or choices and that bridge connections for a choreographer, contributing to a new awareness that results in novel movement material, or novel approaches to structuring movement: reflection of an iterative process. Co-Imagination is the process of imagining the creative possibilities interactively together, yet with unequal creative control. In the research presented in this thesis, I have explored the concept of applying generative algorithms in the creation of movement catalysts that can propose novel choices to the choreographer. I have designed, implemented and evaluated these generative choreographic procedures (which I have titled ‘Cochoreo’) to the existing choreographic support tool ‘idanceForms’ (idF). Novice choreographers were asked to design short choreographies using idF over a week. Data was collected through observation and focus group discussions and analyzed through grounded-theory inspired thematic methods. The contribution of this work situates the design and practice of interactive choreographic systems within creativity theory to explore future design of iterative and provocative technology for supporting movement, creativity and co-imagination.

Keywords: Choreographic Process; Sketching; Defamiliarization; Genetic Algorithm; Embodied Experience; Creativity
Dedication

I dedicate this dissertation to my husband, Dr. Greg Corness, without whom the depth of inquiry and experimentation in choreographic tools would not exist. His endless support, constant questioning and willingness to rapidly prototype and ‘try it out’ continues to persuade me that this work is engaging and important to the field. This work is also immensely supported by our daughter Tarn, who compels me to work diligently while staying grounded around times of play, exploration and learning.
Acknowledgements

Firstly I would like to acknowledge the strong and steadfast support of my senior supervisor, Dr. Thecla Schiphorst. She believed that I had a vision worth investigating through research and practice, and fiercely protected my position a number of times.

Secondly is my supervisor Dr. Philippe Pasquier, who has always been a grounded source of perspective with quick feedback, often laced with humor. fearlessness of guiding a dancer into programming and AI.

The idanceForms team has been a large source of inspiration and quick application of design ideas. I appreciate the support and guidance provided to include Cochoreo in the idanceForms platform. This includes Tom Calvert, Herbert Tsang, Jordon Philips, Norm Jaffe, Karen Cochrane and Sunny Zhang.

My husband Dr. Greg Corness has been an amazing support system as well as provocateur, constantly challenging an idea to help me refine or communicate its value.

Tarn for her joyful playfulness and experimentation to learn about her own approach to movement choices while discovering her surroundings.

My post-doc and graduate student support base including Shannon Cuykendall and proPhhecy Sun challenged and developed my ideas and helped me to stay focused. Dr. Sarah Fdili Alaoui helped to guide the structure of my ideas and elaboration of their value. Her support enabled clarity in the construction of many papers.

My family’s support of my wanderings down unknown paths with unknown results.

The Arts Technology family for their belief in my abilities and encouragement to balance a new faculty position with a new baby and finalizing a dissertation. And the communities of contemporary choreography and interactive technologies for creating a playground of interdisciplinary exploration.
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## List of Acronyms

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<th>Term</th>
<th>Initial components of the term</th>
</tr>
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<tbody>
<tr>
<td>idF</td>
<td>idanceForms Software</td>
</tr>
<tr>
<td>PaR</td>
<td>Practice as Research</td>
</tr>
<tr>
<td>GA</td>
<td>Genetic Algorithm</td>
</tr>
<tr>
<td>HCI</td>
<td>Human-Computer Interaction</td>
</tr>
<tr>
<td>CST</td>
<td>Creativity Support Tool</td>
</tr>
</tbody>
</table>
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Choreographic Process</strong></td>
<td>The process of composing and crafting movement material.</td>
</tr>
<tr>
<td><strong>Co-Imagining</strong></td>
<td>A participant interacting with the creative development aspects of contemporary choreography without necessarily being a co-author. An alternative term to ‘collaboration’ and its connotations.</td>
</tr>
<tr>
<td><strong>Problem Solving</strong></td>
<td>The process of identifying a complex issue and exploring options for successfully maneuvering it.</td>
</tr>
<tr>
<td><strong>Defamiliarization</strong></td>
<td>An approach to making the familiar unfamiliar, to bring new awareness to an experience.</td>
</tr>
<tr>
<td><strong>Scaffold</strong></td>
<td>To support a process by providing hints or useful knowledge to help a choreographer achieve a creative solution.</td>
</tr>
<tr>
<td><strong>Agency</strong></td>
<td>The level of control and action available to have an effect.</td>
</tr>
<tr>
<td><strong>Human Computer Interaction (HCI)</strong></td>
<td>The domain of humans interacting with technology, focusing on the procedure, process and experience of interaction.</td>
</tr>
<tr>
<td><strong>Genetic Algorithm</strong></td>
<td>An algorithm for generating potential solutions to a problem by providing goal states.</td>
</tr>
<tr>
<td><strong>Phenomenology and Phenomenological Interviewing Methods</strong></td>
<td>A philosophy of how we create experience, adapted to a methodology for investigating experience</td>
</tr>
<tr>
<td><strong>Practice as Research</strong></td>
<td>A methodology for investigating a development or experiential process through the actions of doing the project.</td>
</tr>
</tbody>
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Introductory Image

Figure 1. ShiverSlouch Iterative Design Process for Interactive Choreographic Support Tool
Preface

This dissertation has resulted in and drawn from prior publications in which the author was a first or joint first author. In this preface I articulate how these publications have supported the exploratory process of the author in her research, and highlight each publication’s contribution to the research including collaborative team projects in which the author led in a key role as the research designer and evaluator. Within this thesis, all prior publications are indicated in the footnote of the section header. The appendix of this document contains permissions from all authors involved in relevant publications. The remainder of this Preface articulates how my research trajectory is evidenced by a series of publications, but more importantly, how these publications support the narrative of my research trajectory.

My research has explored the experience of choreography utilizing ‘co-imaginative’ systems expressed through a series of iterative system developments. In my prior publications of this research, I begin with a published literature review, in which I investigate the domain of Human Computer Interaction focusing on systems that apply strategies of ‘defamiliarization’ in user’s creative decision-making processes. This research has been previously published with Dr. Thecla Schiphorst (as second author), who supported the concept development and mentored the editing process of the publication. In another publication, I co-investigated systems for assisting choreographic process and published this work as a joint author with Dr. Sarah Fdili Alaoui, with the mentorship of Dr. Thecla Schiphorst. My role as an author in this publication was focused on providing a literature review and analysis of the historical perspective on assistive choreographic systems. Dr. Fdili Alaoui organized this content into the overall argument of the publication.


Early on in my MSc. research at the School of Interactive Arts and Technology (SIAT) at SFU, and beginning with a system which I titled “Scuddle”, I explored and designed a computational choreographic system, and developing a genetic algorithm that generated static stick figure poses to be used as ‘movement catalysts’. This research inquiry set the foundation for articulating a specific set of constraints that could guide choreographers in investigating novel movement. This research has been previously published with Dr. Thecla Schiphorst and Dr. Philippe Pasquier. Dr. Schiphorst supported a critique of the connection between the long held historical context of procedural choreographic techniques and the computational and procedural use of random processes in genetic algorithms. Dr. Pasquier, a computer scientist with a research focus on artificial intelligence and machine learning, supported the development and testing of the genetic algorithm and the technical writing that supported its explication. This publication won a Best Student Paper Award from the Cognitive Science Society.


The second iteration of this research explored how such a system could receive input from a choreographer creating interaction between choreographer and system. In this iteration, the author combined Scuddle, a Kinect camera and the desktop version of DanceForms to create a lo-fi prototype that imagined what the criteria and affordances of an interactive choreographic process might contain. This work has been previously published with Dr. Thecla Schiphorst and Dr. Steve DiPaola. Dr. Schiphorst mentored the conceptual framework, inquiry and writing process while Dr. DiPaola mentored the creativity system iteration and iterative concept development.


The third iteration of the ‘co-imagining’ concept that I focus on within my research, was initiated when I joined the design team for idanceForms, a mobile iPad version of the DanceForms software. I contributed to this design team in a number of ways: 1) I provided design input and functioned as the key researcher who led evaluation studies for the idanceForms app. In addition, I was tasked to lead the testing and evaluation of emerging design features of idanceForms, to develop innovative features based upon my research in ‘movement catalysts’, and to evaluate the choreographers and dancer’s user experience of the idanceForms software by studying a variety of choreographers and dancers through three diverse pilot studies. The publications that resulted in these studies included:


The most recent iteration of the co-imagining concept was realised when “Cochoreo” a generative algorithm to generate novel movement catalysts based upon my original ‘Scuddle’ architecture feature was implemented within the idanceForms software application. I designed Cochoreo as a generative choreographic strategy that could suggest ‘unusual’ movement poses that could serve as ‘movement catalysts’ that may dehabituate movement choices. Cochoreo is based on the Scuddle generative algorithm fitness function. However, Cochoreo also present original approaches to usability in idanceForms which include the use of the iPhone or iPad camera in capturing or creating inspiration for input to Cochoreo movement generation, 3D movement generation options, and user control over the parameters of how a ‘movement catalyst’ pose is generated.
Chapter 1. Designing Approaches to ‘Ah Ha’ Experiences for Novice Choreographers that Leverage Embodied Technology

In creating a dance we often do not have a fixed problem space, a clearly defined goal state, or a discrete set of defined transformations we would like to employ in order to reach our goal. It is exactly because of the nature of creativity that design can be seen as an ill-structured problem. In artistic composition, creative solution is part of the goal. (T. Schiphorst, Calvert, Lee, Welman, & Gaudet, 1990)

![Figure 2. Flow of Exploration in Interactive, Choreographic Support Tools](image)

Choreography is an iterative and interactive creative process (Sawyer & DeZutter, 2009), in which choreographers create, explore and evaluate movement by moving. Movement develops from a choreographer’s interactions with their own felt experience, within their immediate environment. Choreographers explore movement as source material that is generated, tested and evaluated specifically through their bodies and the bodies of their dancers. These ‘back and forth’ interactions support the generation of
movement material, the iterative development of material according to a creative goal and
the crafting of movement phrases into a completed work.

‘Ah ha’ moments are an important part of creative process because they indicate
moments of ‘making sense’ or understanding in an exploratory experience. While ‘ah ha’
moments often refer to a common understanding of a ‘eureka’ moment or brilliant moment
of full understanding or discovery, literature in creativity theory describes a more nuanced
version of ‘ah ha’ that indicates a moment of realization or bridging understanding, stating
that ‘eureka’ moments are not realistic occurrences (Runco, 2007). Shneiderman states
that ‘While the Aha! moments of discovery and innovation are very personal, the
processes that lead to them are often highly collaborative (Shneiderman, 2007). I explore
how ‘ah ha’ moments in choreography develop through these interactive moments when
a movement decision fits the situation, supporting the development of movement material
as well as awareness of the creative process.

Sawyer, a professor in creativity theory and performance, goes so far as to argue
that no creative work is constructed solo, but that creativity can only stem from
collaboration in practice (2009). Sawyer’s definition of collaboration is that every past
interaction with the world and shifting experience of the creator is relied upon in creative
process to contribute to the generation and augmentation of material, and that creativity
cannot be generated in a vacuum. This interaction between one’s self in their current
creative process and all their prior experiences is often referred to as habit. A
choreographer is constantly relying on these prior experiences, knowledge and
techniques to support their current creative process. However, these prior experiences
can also get in the way, and new procedures need to be engaged to create new
experiences. Popat, a professor in choreography and digital contexts, noted that a
suspension of judgement and space for playful interaction is necessary in her work in
collaboration between robots and choreographers (Popat & Palmer, 2005).

After a public lecture and 5 day workshop, Andre Lepecki, a performance theorist
and professor, was interviewed about his recent use of the word ‘co-imagining’ to describe
his interaction with the creative development aspects of contemporary choreography
without necessarily being a co-author (Cunteanu, 2016). This definition indicates that co-imagining could refer to an unequal balance of creative control. While a single choreographer often holds the majority of creative control when constructing a piece, they take inspiration from many places and people. This inspiration can almost be considered collaborative at times, when the choreographer is highly responsive to the imaginative influence of others and is enabled to explore outside of their habitual choices.

The term ‘collaboration’ is often referred to as a process of equal contribution towards a goal, free flow of information and shared vision resulting in equal ownership (Aragon & Williams, 2011). This process of equal contribution and equal balance of creative control is often used in choreography. However the interactions that lead to creative insight and discovery are dynamic and not always able to be attributed to specific instances or authors, as Sawyer discovered in his studies on creativity in improvisational theatre performances (Sawyer, 2007). I use the term ‘co-imagining’ because it is free of the strict connotations of ‘collaboration’ and supports the concept of unequal balance of creative control. The domain of computer-supported computational work (CSCW) emphasizes collaboration as a supporting tool, exploring computation as a method for supporting social interaction between human users. Whereas the term ‘co-imagining’ allows creative ideas to come from sporadic, lightweight interactions between artists who both contribute concepts that augment material and are not necessarily ‘owned’ or of equal weight.

Co-imagination is an important perspective to include in the domain of choreography because choreographers are often exploring ideas with and through other people and experiences, though they continue to be the main controllers of the content. From my review of theory in creativity and choreography and my personal experience as a choreographer and dancer, I view the successful interactions of ‘co-imagining’ as often provoking ‘ah ha’ moments in choreographers. I am interested in how the back-and-forth, interactive aspects of this co-imaginative process can be leveraged in technology design to support the emergence of ‘ah ha’ moments in choreographic process through generating, augmenting and supporting movement composition.
Choreographers have historically used numerous procedural and algorithmic approaches to enhance creative compositional strategies, yet very few of these strategies exist in current choreographic support tools (Fdilia Alaoui, Carlson, & Schiphorst, 2014). Merce Cunningham used Chance Procedures as a method to implement randomization into his choreographic process. He continued to use chance procedures when he began working with LifeForms, in order to randomly select a limb and create a movement, a timing or a spatial pattern. The process of Cunningham learning and using LifeForms in a compositional manner was documented and described by Dr. Thecla Schiphorst thoroughly throughout her master’s thesis (Schiphorst, 1993). The randomization was controlled by Cunningham while being inspired by and implemented in the system, which did not have any creative control in the process. The following quote illustrates the process of working with Chance Procedures and the difficulty in translating the procedure of the composition onto a performative body:

I’ve spoken often about the solo that I did years ago. It was called ‘Untitled Solo’. It was one of the first chance pieces. I separated the body into the legs and the arms and the torso and the head, and worked out movements for each of those elements, and then, by chance means again, worked out whether the legs were used by themselves doing a given movement, or, if at the same time, part of the body or the head and/or the arm come in. It went from, say, doing one thing with your legs, to suddenly doing four things, each different, one with the arms and with the body and the head and so on. [It was] Terribly difficult to do. Incredibly, it was impossible.... I would do a little bit of the dance, then sit down exhausted. Finally after about the eighth time, I was sitting down, done in, and David [Tudor, who was playing piano accompaniment for the dance] looked at me from the piano and said, “well, this is clearly impossible, but we’re going ahead and doing it anyway. [laughter] So we did. (Siegal, 1990).

While the process of enacting these compositional choices on a body was physically very difficult, it separated compositional choices from movement that ‘felt good’ or was tied to personal habit. This brought a new approach to choreographic procedures that generated new creativity in the field of modern dance. It is from these historical developments that inspiration is drawn for the design of technological systems to support creativity in choreography.
There are two approaches to technological systems designed for creativity: computational creativity (autonomous) and creativity support tools (assistive). While there are many examples of both approaches to creativity systems in fields such as music and design, there are very few in choreography. The domain of computational creativity, or metacreation, explores how computers can be autonomously creative. This means that a system generates and evaluates its own creative content without human intervention. Well-known autonomously creative systems include Aaron, the autonomous painting system by (McCorduck, 1990) and David Cope’s work in autonomous music generation in styles that mimic composers such as Bach (Cope, 1996). The second domain of Creativity Support Tools (CSTs) designs systems that support human user’s existing creative processes (Shneiderman, 2007). This means that a system provides a blank slate and often appropriates physical tools to digital versions for a user to create their own visions with. Traditional CSTs include systems such as Adobe Photoshop, which provides the user with any tools they might need to support their creative plans or the Choreographer’s Notebook, an annotation tool for choreographers to record a rehearsal and make notes and visual sketches to document which changes they will make in the next rehearsal (Singh, Latulipe, Carroll, & Lottridge, 2011). Current choreographic tools mainly fall into the Creativity Support Tool category, with very few systems generating any content. However, each of these domains tend to be one-sided (agency, or control, of the process is held by either the creator or the system) and minimally interactive. These conditions do not support the nature of co-imagination, which is iterative and highly interactive with active participation from both sides. I am interested in how a system can be an active part of choreographic interaction: by having features that are autonomously creative as well as being able to support the user’s existing creative process (See Figure 3).
My research explores how to provoke ‘ah ha’ moments in novice choreographer’s interactive compositional process with technology. This requires understanding the deeper interactions of choreographic co-imagination and how to support a choreographer in their experiential and kinesthetic process. I strive to design experiences with tools for people who consistently think ‘outside the box’. These are artists and creative movement specialists who develop ideas iteratively through their embodied, kinesthetic experience: working hands-on, in situ and reflectively to explore novel ideas. The embodied process of improvisation and trial-and-error is rapidly executed in a studio in real-time. Choreographers practice, develop, assess, evaluate and iterate new movement phrases through the bodies of the dancers participating in the choreographic process (Blom, 1982). Leveraging some resemblance to the practice-based aspects of choreography is important to system design for creative movement.

To investigate methods for augmenting aspects of co-imagination in choreographic systems I approach the choreographic process with technology from a defamiliarization perspective. Defamiliarization is a process of disorienting the creator, audience or user within a specific scenario in order to dramatically shift their perspective. This process of changing perspective through specific disorientation often enables the choreographer to distance themselves from their habits, and reliance on prior experiences, in order to create new experiences. I interviewed Dr. Schiphorst about Cunningham’s use of Chance Procedures and work with LifeForms to understand his use of defamiliarization in compositional methods (Schiphorst, 2016).
...he’s describing mechanisms for, or maybe I would say functions or procedures, that one can use to shake up or destabilize the way in which one understands the movement possibilities. So he was always interested in that process of destabilizing or defamiliarizing the movement possibilities. Not only the movement choices by themselves but also how he viewed them, how he could reflect upon those to free his imagination so that he could see them differently. I don’t think he was ever thinking that one thing would be the same as another [chance procedures vs. LifeForms], but that’s why he used these simultaneously. For example, Beach Birds was a dance for stage in which he used LifeForms but it was also a dance for camera in which he used the camera and of course the IChing in the construction of these, so he became polyphonic in these layers of defamiliarization.

However, Cunningham’s approach to Chance Procedures and LifeForms as methods of defamiliarization were used in order to see movement opportunities differently. Cunningham was interested in the compositional methods of randomization, not necessarily to break personal movement habits or to develop an un-embodied method of choreography. The focus on randomization and on a set Chance Procedure of the IChing created new and novel compositional scores, but did not address a level of personal meaning-making that would be innovative to a specific person’s habits. Therefore there was a different type of ‘ah ha’ moments had that were about creating new dances, but without a reflection on a typical personal process. Through this process I decided that the personal level of meaning in defamiliarization was important and could be designed for, by making specific design choices in a choreographic support tool.

I implemented this personal meaning approach by designing the generative feature Cochoreo, and implementing it into idanceForms with the development team. Cochoreo was specifically designed to provoke unique movement choices aside from prior experience by utilizing paired-constraint theory (Stokes, 2006). Paired-constraint theory states that creativity can be guided by inhibiting specific parameters (such as an identifiable habit) and provoking other specific parameters (such as an opportunity for new movement). Inhibiting specific parameters of a choreographer’s process is often a process of defamiliarization, because a regularly used tool is not available in their process and the choreographer needs to make new compositional decisions. In the design of Cochoreo I specifically inhibit movement features that lend themselves to codified techniques: positions that are stable, symmetrical with fully extended limbs, which provides a situation
of defamiliarization. This design choice catalyzes movement opportunities that are unstable, asymmetrical and with varied joint positions to reveal new approaches to generating movement material.

This research has iteratively designed choreographic experiences with software, resulting in a study with novice choreographers. This study investigated how novice choreographers could develop novel movement phrases, co-imaginatively, while using Cochoreo. The studio test of this final system has been conducted over 3 separate studies by inviting student choreographers to compose with the choreographic editing system over a period of one week. This time frame was restricted due to the time resources available by the participants. Study 1 consisted of 2 sessions in a week while studies 2 and 3 consisted of 6 sessions in a week. While the timeframe of the study was limited, it enabled a consistent number of participants. Data from the studio tests was gathered through focus groups and observational data. Focus groups were loosely guided to support choreographer’s articulation of their compositional experience, leveraging phenomenological interviewing methods to support verbal description. Observation data was gathered by using the researcher’s expertise in somatic practices such as Alexander Technique and Laban Movement Analysis (Jones, 1997)(Studd & Cox, 2013). Data was analyzed using a multi-level grounded theory approach to thematic analysis to construct a template of choreographer’s assessment of creativity, agency and support through the choreographic process in co-imagination with the idanceForms software.

The focus of these studies was to explore how co-imagining could be leveraged through the design of a choreographic support tool to provoke ‘ah ha’ moments. This research investigates kinesthetic movement knowledge, creative cognition and technology design through the disciplines of Dance and Choreography, Somatic Techniques, Cognitive Science, Psychology, Human Computer Interaction and Artificial Intelligence.

Limitations of this research topic also double as benefits and includes the idiosyncratic nature of creative process and the complexity of movement information and lack of existing taxonomies to articulate this information fully. While all creative processes
are individual to the practitioner, all processes follow a regular course of development that can be leveraged, however loosely in design. This complexity of movement information also affects the ability to directly model movement information in technology due to the mathematical and computational energy required to manage data with advanced analysis methods (such as machine learning techniques). However, the richness of movement information is highly important because it holds many subtle and often-overlooked qualities that we as humans rely on for communication, social cues and guiding attention. The implementation of this research can be beneficial in the specific contexts of creativity support tools for choreography and creative movement but also in the broader contexts of HCI, robotics, cognitive science and design for furthering development of whole-body interaction technologies, believable virtual characters, physical computing and design for aesthetic experience.

### 1.1. Dissertation Outline

- Chapter 1: Designing Approaches to ‘Ah Ha’ Experiences for Novice Choreographers that Leverage Embodied Technology
- Chapter 2: Addressing the Gap in Designing Creativity Tools for Choreographic Systems
- Chapter 3: Iteration and Evaluation of Interactive, Embodied Choreographic Design
- Chapter 4: idanceForms and Cochoreo: A Choreographic Support Tool for Sketching Creative Process
- Chapter 5: Evaluating Interactive Choreographic Creativity in the Field
- Chapter 6: Interpretation and Assessment of Novice Choreographic Process
Chapter 7: Development of a Model for Interactive System Design in Choreographic Process

Figure 4. Organization of Dissertation Argument Highlighting Chapter 1

1.2. The Context of the Research

There are strong overlaps between the experiences of movement, decision-making and creativity that can provide unique opportunities for designing technology (Candy, 2007; Jones, 1997; Kirsh, 2009, 2010; T Schiphorst, 2008; Studd & Cox, 2013). The process of designing choreographic-support tools invites exploration into habitual and novel processes, the use of constraints in creativity and the knowledge and experimentation in choreographic domains. This work can extend knowledge about modeling movement information in technology, designing for creative process and in turn will support research in the role of interaction and co-imagination in choreographic process.

However, what parameters can be used and how interaction is designed are critical choices to implement these new design principals in ways that support choreographer experience. Existing systems that explore the collaborative realm of creativity between artist and system include the music system Voyager, Parametric Design for architecture
and a system for graphic design titled Evolver. George Lewis’ Voyager system is used for improvising music with a live performer (Lewis, 1999) by analyzing patterns of the performer’s music and responding with stochastically similar musical gestures. Rob Woodbury’s work in Parametric Design enables user manipulation of existing architectural structures to generate new creative options (Woodbury, 2010). DiPaola et al. designed a system as a graphic design tool that supports exploratory searches through its generative suggestions and provides history-keeping options to bookmark interesting combinations for later use (DiPaola, McCaig, Carlson, Salevati, & Sorenson, 2013). The use of a genetic algorithm and decision to support the more labor-intensive and intuitively-based portion of the design process created a tool that suggests co-imagination in the process without fully attempting to re-create collaboration.

While DiPaola’s system worked well in a discipline based in a visual, screen based medium, there are many new challenges arising in the design of technology for gesture, full body movement and practice-based endeavours. As a basis for a comparable system for choreography, I used the system idanceForms extensively in my research, as it is a historical and foundational system for assisting choreography with technology. Because I have been a part of the design team focused on the choreographic experience, I have evaluated the experience with multiple levels of participant expertise. This process has also given me insight and engagement with the design of various parameters, features and their interfaces. This design process, paired with my explorations in defamiliarization and the embodied, kinesthetic design of parameters for creative movement choices supported my development of CoChoreo as a generative feature in idanceForms to embody the creativity support space between idanceForms as an assistive tool and a co-imagining idea generator.

To approach the issues of movement complexity and the richness of choreographic experiences, I used defamiliarization in my design strategy to support the exploration of ‘ah ha’ moments. Defamiliarization has been a successful technique for provoking creativity and new perspectives, which is mainly used in art and literature domains. By applying defamiliarization in the design of interactive technology for choreographic process, I can engage with the choreographer’s immediate experience of
their own choreographic process. By designing Cochoreo, a generative function in the sketching-based choreographic tool idanceForms, choreographers can interactively creative movement material. Defamiliarization supports the design approach that uses ‘catalysts’ for movement to make suggestions to the choreographer, which they can collaborate with through various sketching tools in the software. To test this hypothesis, the study will explore the core question:

1.3. Research Question

How does a novice choreographer’s experience of defamiliarization with a co-imagining choreographic-support tool effect the development of ‘ah ha’ moments?

Through investigating this core question, the research will advance knowledge needed to enhance interactive design of choreographic experiences with technology by:

- Identifying components of novice choreographer’s interactive and co-imaginative creative process
- Identifying and implementing specific characteristics of how technology engages performer creativity
- Identifying and analyzing the effect of co-imaginative features in a creativity support tool for choreographic experience
- Exploring when and how ‘ah ha’ moments were experienced in the choreographic process
- Engaging focus groups to gather choreographic suggestions for how they might experience movement using this tool
These activities support the investigation of the core question by articulating choreographic devices used in co-imagination and in creating an environment in which to study the choreographic experience.

This work is explored through a series of Practice-As-Research projects that are iteratively evaluated through a study to contribute to the design of the following project. The culmination of this work is in the design and implementation of the Cochoreo feature in the idanceForms software, which we evaluate in the final study. I have been involved in the development of idanceForms for four years, mainly in an evaluation role though I contributed to discussions in the design process. Through my interactions with the development of idanceForms and my work exploring defamiliarization and movement design parameters for creativity I designed Cochoreo, a generative feature that was implemented in idanceForms to generate novel movement catalysts within the movement sketching platform. The combination of a creativity-support tool such as idanceForms and a generative tool such as Cochoreo can iteratively support the notion of ‘co-imagining’ when choreographing interactively with technology.
Figure 5. Order of Studies Performed to Explore Co-imagining in Choreographic Creativity
Chapter 2. Addressing the Gap in Designing Creativity Tools for Choreographic Systems

‘If technologies can be used to create a space for the experience of self-awareness, thereby providing a rich interplay between movement and sensory expression, then our technologies can support self-cultivation through the development of our skills of experience.’ (Schiphorst, 2011, pg.159)

Figure 6. Comparing Research and Applications

This chapter explores various research approaches to creative process by defining creativity and articulating defamiliarization as a technique for accessing creative solutions in unusual contexts. Assessing approaches to creative process are important to inform design for engaging creative experiences in choreography. My approach was to highlight

1 This chapter draws from these previously published works:


the focus of a choreographer's interactive experience and how to engage with it, rather than performing a survey of typical choreographic strategies.

I surveyed the use of defamiliarization techniques in HCI and analyzed themes that contributed to creative solutions. I then surveyed creativity support tools specifically designed for choreography using the same system as defamiliarization in HCI and articulated the findings of the analysis and its potential applications in technology design. Choreography is the core domain of exploration in this research, highlighting the unique and specific qualities of movement, decision-making and choreographic design.

Contemporary choreography is the art of crafting movement, developed through a long history of techniques (Adshead, 2000; Blom, 1982; Humphrey, 2003). Like other compositional processes, choreography is a complex creative process that explores a variety of formal procedures that can result in unique artistic creations (Butterworth & Wildschut, 2009). Choreographers have been fascinated with the creative possibilities enabled by the use of technology in the compositional process. The creators of 9 Evenings was a collaboration between engineers at Bell Laboratories and contemporary artists in 1966. Many choreographers were involved including Steve Paxton who created a large inflatable structure for audiences to meander through and Yvonne Ranier who guided dancers through a series of choreographic tasks over walkie-talkie. Merce Cunningham worked with the software DanceForms in collaboration with Thecla Schiphorst for multiple pieces to explore the use of software animation in designing choreography. Troika Ranch collaborates with Mark Coniglio, creator of interactive performance software Isadora to create interactive dance works. Both the Australian company Chunky Move and Austrian company Palindrome worked with designer Frieder Weiss to create a variety of beautiful interactive visuals and sound for performance works. The use of digital technologies and software programs challenges choreographers to perceive their creative problem space anew through new constraints alongside new possibilities.

There are strong overlaps between the processes of movement, decision-making and creativity that can provide unique opportunities for designing technology (Candy, 2007; Carlson, Schiphorst, & Pasquier, 2011; Carroll, Lottridge, Latulipe, Singh, & Word,
2012; DiPaola et al., 2013). Currently within choreography, computers are often used as CSTs to design the presentation of performance (compelling graphics used as set, lighting or costume pieces, sound scores). While the limitations of using technology as such will impact choreographic decisions, choreographers often respond to these outside limitations with reinforced use of their own movement habits and styles. I am interested in how computers can be engaged within the creative choreographic process to impact habits and style, to shift attention to particular aspects of experience and suggest new choreographic choices.

Defamiliarization, or 'making strange', is a pragmatic tactic used to design for indirectly interacting with a user cognitively. By making the familiar unfamiliar in order to bring new awareness to known practices, user’s choices are destabilized while simultaneously engaging agency to re-orient their experience. This form of 'disorientation' incites the user to assert their agency within a creative scenario (Boden, 2003). Asserting agency utilizes users’ own reflections, analysis and assessments of a given situation in order to engage in the task at hand.

This research explores how a technological system can be an active part of choreographic co-imagination: by having features that are autonomously creative as well as being able to support the user’s existing creative process. I define the term ‘co-imagination’ from Andre Lepecki in the context of how choreographers create work through their distributed interactions with other dancers, choreographers or artists (Cunteanu, 2016). ‘Co-imagination’ infers a two-way interaction that requires at least two active, participating agents whose decisions dynamically affect the other. However, co-imagination does not require equal balance of creative control or authorship. I am leveraging the situation created by this form of interaction to enhance creativity. The commonality of co-imagination as a way of provoking creativity has been acknowledged through my expert knowledge of choreographic practice and is applied in creativity support tools to further research how creativity can be provoked and engaged with through technological tools.
My research explores interactive choreographic methods to use as features for bridging autonomously creative systems and creativity support tools to design systems that interact with creative choreographic processes in deeper co-imagination manners. This chapter investigates the current state of design in interactive choreographic tools by articulating creativity theory and how it supports artistic tools such as defamiliarization in HCI, and then applies these concepts to evaluate existing creativity support tools for choreography.

2.1. Creativity Theory and Applications in Creativity Support Tools

Boden describes creative choices as often falling in one of two categories: exploratory or transformational (Boden, 2003). Exploratory creativity is a creative result of exploring of all available ideas within existing parameters (or constraints) that result in a selection from within those parameters. This is often viewed as ‘little C’ creativity by Kozbelt et al (Kaufman & Sternberg, 2010), creativity that is close to one’s habitual choices and therefore more predictable. Transformational Creativity is a creative result that generates ideas well outside of existing parameters, and is likely to be more unpredictable based on one’s habitual choices. Most choreographers tend to regularly participate in ‘exploratory creativity’, daily testing their knowledge of their practice and attempting to surprise themselves. How these small surprises accumulate and are crafted into completed works can sometimes produce ‘transformational creativity’ output. Mark Runco, a psychologist who researches creativity, states that literature in creativity theory describes a more nuanced version of ‘ah ha’ that indicates a moment of realization or bridging understanding, stating that ‘eureka’ moments are not realistic occurrences (Runco, 2007). It could be stated then that exploratory, or ‘little C’ creativity results in small ‘ah ha’ moments for an individual. This would be supported by a quote from Aragon and Williams paper:

“Contrary to the popular belief of the “aha” moment of insight, recent work has indicated that creativity is often a series of incremental steps to discovery” (Aragon & Williams, 2011)
Within choreography the process of exploratory creativity could be the small discoveries that one makes when physically exploring new opportunities for movement in the studio. These ‘new opportunities’ can be miniscule, discovered by accident, through interaction with others or an environmental change (such as working on a different floor texture). Depending on the choreographer’s attention to these small discoveries as ‘ah ha’ moments, they can transform their approach to movement, to structuring movement and to choreography. The following quote is from Merce Cunningham describing his use of Chance Procedures in choreography:

Using chance to choreograph opens up the possibilities. It allows me to reach beyond the logical and into the unexpected. When you come upon a situation which your own experience would attempt to deal with one way, it closes the door to infinite other possibilities. Chance provides options which, under ordinary situations, I never would have thought of doing. I had to decide to follow the random method no matter where it led. To do that I had to give up two ideas: that I didn’t like it, and that it was not possible. (Cunningham, 1955)

‘Exploratory creativity’ is a process of situated cognition that is illustrated in the field of design by Cross (Cross, 2011). Cross notes that design strategies apparent in all case studies include: ‘1) taking a broad ‘systems approach’ to the problem, rather than accepting narrow problem criteria; 2) ‘framing’ the problem in a distinctive and sometimes rather personal way; and 3) designing from ‘first principles’ (or the mechanics/affordances of the task)(pg. 75). Choreography can implement these design strategies as well, by 1) re-contextualizing their creative idea. By 2) changing the framing of their movement parameters. By 3) focusing on the mechanics of movement or travelling through space. These strategies are regularly implemented by choreographers as a way to manage the creative process and guide attention in a way that supports exploratory creativity and incremental steps as ‘ah ha’ moments.

Gabora’s research in creativity explores the ability to shift one’s attention between broad, associative thought and detailed, analytical thought (DiPaola & Gabora, 2007). The ability to shift to an associative mode of thought enables a subject to use the distributedness of their cognition, leveraging the affordances of the perspective to adapt how they address the more detailed, analytical mode of thought. This process constantly shifts the
perception of a ‘fittest’ option while increasing the diversity of possibilities as new ideas are developed and decreasing diversity of possibilities as all agents take on the fittest actions. Gabora notes that creative individuals are able to find the ‘fittest option’ by gathering information through quick shifts between associative and analytical thought, which is then organized into flat hierarchies for retrieval, enabling broader connections to be made than the average individual (Gabora, 2007).

An example of this ‘quick shift’ procedure can be found in cognitive science. Kirsh performed a study exploring creativity in choreography, and found that one method choreographers often used to explore an idea in ways that could provoke more novel creative solutions was to shift modalities. Choreographers started exploring an idea in movement with their legs, then transformed it to movement with their arms, then shifted it audibly and then back to their legs (Kirsh, 2011a). These tools for provoking creative thought are frequent in artistic domains and support active construction of a creative environment, and creative constraints. Yet, these tools are rarely leveraged in technology design for creativity support tools. This can also be said of problem-solving in general, as also noted by Kirsh:

‘Problem-solving is an interactive process in which subjects perceive, change and create the cues, constraints, affordances and larger scale structures in the environment, such as diagrams, forms, scaffolds, and artifact ecologies that they work with as they make their way toward a solution.’ (Kirsh, 2009), pg. 290

Kirsh has researched choreographic process by closely observing and discussing the making of a large group work by Wayne McGregor (Kirsh, 2011a). His findings show that choreographers develop a movement ‘idea’ and then have dancers ‘riff’ on it to develop a diverse adaptation of the original idea to collaboratively explore movement concepts. He has also explored how dancers ‘mark’ movement ideas, by performing it half physically and half mentally, in order to better learn movement sequences using embodied forms of cognition (Kirsh, 2011b). Sawyer and DeZutter investigated improvised theater performance to track how a performance emerged collaboratively (Sawyer & DeZutter, 2009). They found that as the dependency of each participant’s decisions relied on previous actions, it became harder to predict an individual participant’s decisions based on their usual individual traits. The emergent creativity developed from skills and
personalities in situ, as well as the actors working with the affordances of the social scenario.

The interaction component of creativity theory is not often leveraged in the design of Creativity Support Tools. The use of technology in creative practices is often framed from the point of view of a tool that facilitates a user’s creativity, resulting in the more static aspects of memory storage and retrieval. Creativity Support Tools (CSTs) are often presented as systems that provide functional support to user creative process, such as the ability to edit video (i.e. using Final Cut Pro or iMovie), visualize data (Spotfire, JMP) or share photos (Flickr and Facebook) (Shneiderman, 2007). CSTs that do focus on collaboration are often designed to facilitate task-oriented human user interaction, without adding intelligent features that adapt creative-cognition theory (Coughlan & Johnson, 2009). As such they lack features that could interject new perspectives into creative process or recommend constraint-based opportunities for creative exploration. Augmenting CSTs with adaptive creative-cognition features requires the design of a set of features that can support system collaboration in an intelligent autonomous system. While the domain of computational creativity explores generative systems to produce creative results autonomously, there has been far less research into how systems can behave as a creative agent in a collaborative process with a human user (DiPaola et al., 2013). To enable such autonomous creativity the system must illustrate agency as a unique entity, with the ability to listen and respond with a set of beliefs, intentions and desires in situ. The system must also enable iterative development and extensive history-keeping. While the designer cannot directly control a user's creative cognitive process, they can create tools to indirectly affect the way decisions are made to result in new perspectives to a creative problem.

Designing for more nuanced collaborative tools that support user experience relies on critical choices around what parameters can be used, how interaction is crafted and how the user is cognitively engaged. DiPaola et al. explored collaborative creative tools by designing a system as a graphic design support tool. This system, titled Evolver, generates design combinations based on the user’s seed material using parameters of color, shape, repetition, symmetry and rotation. This system supports exploratory
searches through its generative suggestions and provides history-keeping options to bookmark interesting combinations for later use (DiPaola et al., 2013). The use of a genetic algorithm and decision to support the more labor intensive and intuitively-based portion of the design process created a tool that suggests collaboration in the process without fully attempting to re-create collaboration. Improvisational music systems such as Lewis’ Voyager and Weinberg and Driscoll’s Haile robot have been designed to interact with musicians as players rather than instruments (Lewis, 1999; Weinberg & Driscoll, 2007). However, they focus on performing compositional decisions in the moment, rather than exploring and structuring a work as a whole. While these systems were successful in well-understood disciplines in visual and audio mediums, there are many new challenges arising in the design of technology for gesture, full body movement and practice-based endeavours. I am interested in designing systems that provoke collaborative practices with choreographers through design of existing technology for capturing movement, artificial intelligence techniques for generating movement suggestions and defamiliarization tactics that suggest symbiotic iteration between a user and a system.

2.2. Defamiliarization as a Tool for Engaging Creative Agency

One frequent problem in a creative practitioner’s life is to maintain the continuous ability to be creative. It is easy to become stagnant amidst known results and practiced techniques. The ability to think creatively often requires specific practices to shift one’s focus to somewhere new and novel. In my proposed model I intersect research in how creative process is physically enacted by a practitioner with existing research in creativity theory that defines what happens cognitively in creative process. The practitioner is familiar with developing their own techniques for imposing constraints, developing awareness, and creating new patterns. Exploring creative decisions in any discipline frequently relies on using constraints: strategic, sometimes self-imposed parameters, to inhibit habitual responses and generate novel, but controlled, responses. According to Patricia Stokes, a psychologist and artist, the type of constraints utilized in creative decision-making affects the types of solutions generated. The chosen constraint defines
the search space, defining the potential solutions available at that time. Stokes suggests that creative constraints have to work in pairs (the first to inhibit habit, the second to induce new creative choice). In order to restructure an existing problem space; routine or habitual results need to be restrained while new and ‘creative’ results need to be provoked. Artists often create their own constraints to explore new possibilities for change, such as Monet’s repeated paintings of the same row of poplar trees 24 times with the goal of discovering new ways of seeing the same trees.

Artistic techniques used to provoke creativity are illusive because they search for solutions to ill-defined problems (problems without a desired goal and therefore context and task delineation). However, scope is created through domain-based skills and context of the problem as noted by Gallagher that ill-defined problems are only solved by making up the framing for the problem (and therefore the problem itself) as it is being worked on (Gallagher, 2008). One technique for generating creativity in practice is defamiliarization. Defamiliarization is an interventionist term used to produce an intervention or ‘distancing affect’, originally coined as a literary device by Victor Shklovsky in 1917 (Crawford, 1984). Other terms used synonymously include ostranenie (making strange) and verfremdungseffekt (alienation as coined by the theatrical director, Bertolt Brecht (Thomson & Sacks, 2006). Defamiliarization is a pragmatic tactic for making the familiar unfamiliar, disconnecting the user from familiar experiences thereby requiring them to problem-solve in an unfamiliar environment (Crawford, 1984). This form of ‘disorientation’ incites the user to assert their agency within a creative scenario (Poirier & Pringle, 2012). Asserting agency utilizes users’ own reflections, analysis and assessments of a given situation in order to engage in the task at hand.

2.2.1. Analytical Lenses

In this work, I look at the literature in HCI and choreographic technology to extract salient components that can be used to design towards supporting creativity and partnering with choreography. One of the contributions of this work is to provide the analytical tools to extract parameters as design criteria that can interact in dialogue with a user’s creative cognitive process. I focus on literature using defamiliarization, ambiguity or
making-strange techniques for interacting with habitual user responses within the context of collaborative creativity. This literature explores opportunities to bring attention to the immediate experience of the user in interaction with a system. I analyzed themes in the literature through three stages:

1) The designer’s end goal and focus of the projects.

2) The interaction of the user and the system: type and level of agency.

3) The reoccurring characteristics and connections throughout the projects.

2.2.2. The Designer’s End Goals: Analysis Stage One

The first categorization is made through the lens of defamiliarization to sort projects by:

a) Task completion: task-oriented projects based on their focus on clear goals.

b) The enhancement of play, creativity, enchantment and meaning: projects focused on the engagement with the user through interaction

c) The re-labeling or transfer techniques: projects using novel affordances to constrain the interaction.

2.2.3. The Type and Level of User Agency: Analysis Stage Two

The second stage of the analysis identifies design choices towards user’s iterative interaction with a system. Agency refers to the amount of potential ability to act held by the user. This includes options in two areas: type of user agency and the level of agency required. The type of user agency is articulated as the conscious choice to either restrain the user’s agency by disorienting them, provoke their agency by scaffolding their
experience or both simultaneously. The level of agency required for interaction is articulated as a continuum of narrow to wide. A narrow level of agency means that the user has some potential ability to act, but it is heavily guided without many options. A medium level of agency means that the user has more potential ability to act, though it is still guided in some way. A wide level of agency means that the user has lots of potential abilities to act, which is either open or with minimal guidance. An interaction that is strictly task-oriented is narrow, one that guides direction for exploration is medium and one that is totally open for the user's creative choices is wide.

2.2.4. Reoccurring Characteristics and Connections: Analysis Stage Three

Using stages one and two of the literature analysis, I identified common components between project focus, type and level of user agency (for example, Playful: novel, engaging, high user agency, medium level). I determined that every focus could be analyzed for degree of novelty, user agency and level of system guidance. To test these elements I translated the ratings on each paper on 3 levels: high, medium or low novelty; high, medium or low agency; and high, medium or low guidance. I mapped these ratings and identified their locations as quadrants for similar components (see Figure 6). I named these Open-Play, Creativity, Disorientation and Closed-Exploration. Because every system included in the review had a high novelty rating, I removed this rating from these figures to simplify the illustrations.
Disorientation has low user agency, low system guidance yet high novelty. This creates an unfamiliar environment in which the user has minimal ability to affect, which could be a situation where the user’s typical actions for that situation are inhibited and hence they are unable to move forward on their own. The process of exploration focuses on in-the-moment experience.

Closed-Exploration also has low user agency but high system guidance and high novelty. In this way the user’s typical actions are inhibited, but there is guidance towards new actions that gives the user a space to move away from and towards. This process of exploration is more task-based with a clear objective and purpose.

Open-Play has high user agency, low system guidance and high novelty. The user’s actions are provoked through their own engagement, though often without any
outside guidance to challenge their engagement. This process is more exploratory in relation to a task because the user is exploring novel ways to continually engage in it.

Creativity has high user agency, high novelty and high system guidance. This element allows inhibiting typical user actions while guiding them towards new, novel actions while the user stays in control and engaged. It can create a very fruitful environment but providing very new options that the user can choose between. This process is a mix of exploring options in situ as well as having goals to work towards so that there is iterative development.

2.3. Analyzing Defamiliarization Techniques in Human Computer Interaction

A number of different approaches have been taken to design interaction that prompts users to be more creative in the field of Human-Computer Interaction. Many of these approaches disorient a user’s familiar creative process in order to create new opportunities for creativity. While the concepts of defamiliarization and ambiguity have been used in human computer interaction by prominent researchers, the implementation of these techniques are still under used and rarely applied into creativity support tools. There are many benefits to further exploring these categories in system design to engage the user’s creative agency and develop deeper modes of interaction for collaborative practice.

This section analyzes literature in HCI and Creativity to extract parameters as design criteria that can interact in dialogue with a user’s creative cognitive process. I have reviewed and analyzed 28 papers using defamiliarization, ambiguity or making-strange techniques for interacting with habitual user responses within the context of collaborative creativity. This literature explores opportunities to bring attention to the immediate experience of the user in interaction with a system. I analyzed themes in the literature through three stages: 1) the focus of the projects, 2) the interaction of the user and the system in the projects and 3) reoccurring characteristics and connections throughout the projects.
### Figure 8. Tables that Identifies Defamiliarization Concepts by End Goals, Type of Agency and Level of Agency

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<th>Designer/End Goals</th>
<th>Type of Agency</th>
<th>Level of Agency</th>
<th>Task Oriented</th>
<th>Creativity</th>
<th>Play/chant</th>
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<th>Re-labeling</th>
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### 2.3.1. Descriptions of Reviewed Papers

Aoki and Woodruff explored methods for controlling user responsiveness in task-based environments such as leasing mobile phone contact information (Aoki & Woodruff, 2005). Halloran et al explored methods of helping museum curators to re-connect their prior knowledge and habits with new possibilities through designing exhibit tours (Halloran et al., 2006). Goncher explores the options for designing for creativity with engineering students (Goncher, 2009). Noguchi and Coughlan and Johnson both designed constraints to guide creative process in music and visual art (Coughlan & Johnson, 2009; Noguchi, 1999). Poirier and Pringle held a workshop to explore, define and discuss evaluation methods for defamiliarization in design with members of the HCI community who
contributed their implementation experiences (Poirier & Pringle, 2012). Yu and Nickerson examined the overlap in analogous thinking as a method for creative problem-solving in concept map creation (L. Yu & Nickerson, 2011).

Creativity, play and enchantment is explored by using defamiliarization to push users towards disorienting experiences with unique constraints as the following examples illustrate: Benford et al. play with concepts of discomfort and vulnerability in audience engagement (Benford et al., 2005). Corness et al. disoriented viewer’s sensations to better understand how audiences perceive performers’ actions in a creative context (Greg Corness, Carlson, & Schiphorst, 2011). Gaver et al. explores methods to provoke user interpretation through exploring imagination in unaccustomed roles (Gaver, Beaver, & Benford, 2003). Sengers et al. focuses on on-going construction of experience through open-ended interaction with dynamic feedback to develop engaging affective experiences (Sengers, Boehner, Mateas, & Gay, 2008). Constraints can be designed using aesthetic elements that use whole self experiences to provoke perception, play and innovation such as with Bardzell and Bardzell, Biskjaer et al., Bronet and Schumacher, Candy, Carlson et al., Johnson-Laird and Peterson et al. (Bardzell & Bardzell, 2008; Biskjaer, Dalsgaard, & Halskov, 2010; Bronet & Schumacher, 1999; Candy, 2007; Carlson, Schiphorst, & Pasquier, 2011; Petersen, Iversen, Krogh, & Ludvigsen, 2004; Sternberg, 1988). Defamiliarization and play may be useful in creating playful interactions with everyday technologies, such as kitchen appliances (Bell, Blythe, & Sengers, 2005). Design for empathy or enchantment can be better understood through experiences of disorientation and user agency to re-engage in the experience (McCarthy, Wright, Wallace, & Dearden, 2006; Wright & McCarthy, 2008).

Additional defamiliarization techniques include methods of transferring, re-labeling or re-mapping parameters from one object to another. By shifting the affordances of one medium to another the user’s perception of both objects is disoriented, changing the perception of the affordances. Djajadiningrat et al. describes a project that identifies affordances and re-maps them to another medium, while exploring affordances of cultural perceptions (Djajadiningrat, Matthews, & Stienstra, 2007). Ljungblad and Homquist observe exotic reptiles and re-map relevant qualities to robots to provide insight for
potential roles of autonomous robots (Ljungblad & Holmquist, 2007). Kirsh explores re-mapping between sensory modalities to test the cognitive processes of choreographers and the process of designing and composing movement while Loke inhibits habitual movement generation techniques to better understand methods for movement design that can be applied to technology interaction (Kirsh, 2011a; Loke & Robertson, 2008).

2.3.2. The Designer’s End Goals: Analysis Stage One

In analyzing the literature, papers are grouped by project categorizations (first analysis stage), and indicated by kind of interaction using identifiers (second stage)(See Table 1). The first stage of analysis identifies papers that use defamiliarization to manage various interactive situations.

One situation I identified is when the designer is mainly focused on the end goals or ‘task completion’. These are projects that often have a clear end goal which look at how a user completes a task in an ambiguous context. This shifts the user’s focus during interaction towards the result, with less focus on the process and immediate experience. Many of these projects are creativity-related that provide a specific goal or task to the user (Aoki & Woodruff, 2005; Halloran et al., 2006; Goncher, 2009; Coughlan & Johnson, 2009; Noguchi, 1999; Poirier & Pringle, 2012; Yu & Nickerson, 2011). Some projects even offer instructions on how to achieve the goal (indicating a well-defined problem space (Boden, 2003)).

Another situation I identified is when the designer has no clear tasks or goals, but focuses on the process of exploration. Creativity, play and enchantment is explored by using defamiliarization to push users towards disorienting experiences with unique constraints (Benford et al., 2013; Gaver, Beaver, & Benford, 2003; Sengers, Boehner, Mateas, & Gay, 2008; Bardzell & Bardzell, 2008; Biskjaer, Dalsgaard, & Halskov, 2010; Bronet & Schumacher, 1999; Candy, 2007; Carlson, Schiphorst, & Pasquier, 2011; Petersen, Iversen, Krogh, & Ludvigsen, 2004). Some projects intentionally disorient the user in order to push them to explore new places, such as redesigning domestic technology to gameify chores or to purposely disorient an audience member’s typical
sensory input in order for the audience to re-evaluate how they experience a performance (Bell, Blythe, & Sengers, 2005; Corness, Carlson, & Schiphorst, 2011). Design for empathy or enchantment can be better understood through experiences of disorientation and user agency to re-engage in the experience (McCarthy & Wright, 2004; McCarthy, Wright, Wallace, & Dearden, 2006).

Other situations used additional defamiliarization techniques, which include methods of transferring, re-labeling or re-mapping parameters from one object to another. By shifting the affordances of one medium to another the user’s perception of both objects is disoriented, changing the perception of the affordances (Kirsh, 2011; Ljungblad & Holmquist, 2007; Loke & Robertson, 2007). Djajadiningrat et al. describes a project that identifies affordances and re-maps them to another medium, such as mapping the affordances of shooting a gun to an office calendar, while exploring affordances of cultural perceptions (Djajadiningrat, Matthews, & Stienstra, 2007).

### 2.3.3. The Type and Level of User Agency: Analysis Stage Two

The second stage of analysis identifies papers based on the type and level of user agency in interaction with the system. I identify the type of agency as having a system that disorients or scaffolds a user’s interaction. Disorienting systems take away parts of the experience in order to put users in an unfamiliar place to act from (Aoki & Woodruff, 2005; Corness, Carlson & Schiphorst, 2011; Loke & Robertson, 2007; Petersen, Iversen, Krogh & Ludvigsen, 2004; Poirier & Pringle, 2012). Scaffolding systems add to or support the user’s existing experience in order to help users explore new options (Bell, Blythe & Sengers, 2005; Biskjaer, Dalsgaard & Halskov, 2010; Gaver, Beaver & Benford, 2003; Kirsh, 2011; Ljungblad & Holmquist, 2007; Sengers, Boehner, Mateas & Gay, 2008; Yu & Nickerson, 2011). Some systems use a combination of disorientation and scaffolding to disorient a portion of the user’s experience while scaffolding another (Bardzell & Bardzell, 2008; Benford et al, 2013; Bronet & Schumacher, 1999; Candy, 2007; Carlson, Schiphorst & Pasquier, 2011; Djajadiningrat, Matthews & Stienstra, 2007; Halloran et al, 2006;
McCarthy & Wright, 2004; McCarthy, Wright, Wallace, & Dearden, 2006; Noguchi, 1999). One example of this is Coughlan and Johnson constraining the options a user has to design a digital musical instrument, but providing help on how to play the new instrument (2009).

I identify the level of user agency as the amount of interaction a user can have on a system. Systems that had a narrow level of agency often provided users with very specific options to choose from (Aoki & Woodruff, 2005; Djajadiningrat et al., 2007; Ljungblad & Holmquist, 2007). Systems that had a medium level of agency gave some options but also had options for the user to create (Bardzell & Bardzell, 2008; Biskjæer, Dalsgaard, & Halskov, 2010; Carlson, Schiphorst, & Pasquier, 2011; Coughlan & Johnson, 2009; Goncher, 2009; Halloran et al., 2006; L. Yu & Nickerson, 2011). Systems that had a wide level of agency often did not provide the user with any choices and they had full control of how the system was explored (Benford et al., 2005; Bronet & Schumacher, 1999; Candy, 2007; Corness, Carlson, & Schiphorst, 2011; Gaver, Beaver, & Benford, 2003; Kirsh, 2011; Loke & Robertson, 2007; McCarthy & Wright, 2004; McCarthy et al., 2006; Poirier & Pringle, 2012; Sengers, Boehner, Mateas, & Gay, 2008).

In projects with narrow focus the user was constrained to using the most readily available options to complete the task. Medium focus using guided exploration allowed the user to be more creatively engaged, while still having support from the system. Wide focus directed all choices to the user without any focus on system-directed task orientation. How these choices are designed in system interaction affect the creative choices a user makes. The third stage of analysis explores these numbers in more detail.
In order to better understand how these components relate back to the papers, I analyze one paper in the categories of Disorientation, Open-Play, Closed-Exploration and Creativity. In the Disorientation quadrant Corness et al. describe a performance-research project to disorient the audience’s typical method of sensing a dance performance behind them by separating their visual, auditory and kinaesthetic senses through a mediated environment (Corness et al., 2011). Within the environment the user is unable to control their typical perceptual process of the situation, resulting in low user agency. The mediated environment also does not provide any guidance to the user, though it is a highly novel scenario. The combination of these elements resulted in a highly disorienting experience for the audience member while providing insight on how audiences construct a relationship to a performer through their experience.
In the Open-Play quadrant, Gaver et al. describe three options for designing for ambiguity: enhancing, creating and provoking (Gaver et al., 2003). Enhancing Ambiguity uses imprecise representations to emphasize uncertainty. This includes over-interpreting data to encourage speculation (but draw attention to possible truths rather than non-truths). It may expose inconsistencies to create a space of interpretation and cast doubts on sources to provoke independent assessment. Supporting Ambiguity develops unusual contexts to inhibit user preconceptions such as blocking expected functionality to comment on familiar products. Provoking Ambiguity offers unfamiliar roles to create a novel situation with a goal in place, to encourage the user’s imagination without a clear direction towards achievement. These options rely on high user agency to make sense of the low system guidance.

In the Closed-Exploration quadrant, Djajadiningrat et al. uses a variety of examples as ‘re-labeling’ to select a novel, meaning-laden object or character to overlay a functional tool (Djajadiningrat et al., 2007). For example, one project identifies the affordances of a pistol and re-maps them to a calendar program, enabling a new playful manner of engaging with everyday scheduling. This process inhibits the user’s traditional expectations and affordances of the calendar function while provoking new novel experiences through the pistol affordances. While re-labeling does not allow for the open-endedness of other methods of defamiliarization, it re-contextualizes possible options which requires the user to re-consider the decisions at hand. This experience could be quite disorienting to an unprepared user (when the expected affordances are not present). This work supports user engagement and quality of experience in interaction, which is highly important in creative process. There is low user agency because the user does not have to create the scenario in which to use the tool, but are engaged in a highly novel situation interacting with a highly designed system that guides their experience through the meaning-laden choices.

In the Creativity quadrant, Coughlan and Johnson describe a system for designing computational instruments and composing music by collaboratively designing constraints (Coughlan & Johnson, 2009). This study tracked the development of instruments and identified the importance of iterative design between tangible and conceptual ideals. This
system of actively exploring constraints found a balance between inhibiting the user’s familiar musical options while provoking new ones. There was high user agency, high system guidance (through the collaborative constraint-design effort) and high novelty in the situation. Users explored the wide available options, but also had clear artistic goals to reach for.

Categories of creativity, open-play, closed-exploration and disorientation can help to define modes of creativity support in interaction design. The interaction of these categories determines the user’s engagement with creativity support tools as a challenging and supportive partner in exploration and decision-making. While the concepts of defamiliarization and ambiguity have been used in human computer interaction and many other disciplines by prominent researchers, the implementation of these techniques are still under used and rarely applied in digital contexts. There are many benefits to further exploring these categories in future system design to engage the user’s creative agency and develop deeper modes of interaction for collaborative practice (Fdili Alaoui, Carlson, & Schiphorst, 2014).

2.4. Combining Defamiliarization with Choreography Assisting Systems

I am interested in how digital tools can be designed to support choreographic creative processes. In order to implement techniques that engage the agency of choreographers, I illustrate the existing systems that support choreographic process. Our current analysis extends our previous contribution (Fdili Alaoui, Carlson, & Schiphorst, 2014) that described existing systems that have been developed to digitally reflect on movement material, to generate choreographic material, to provide real-time interaction with movement material, and to annotate movement material. In analyzing this literature, papers are grouped by project categorizations (first analysis stage), and indicated by kind of interaction using identifiers (second stage)(See Table 2). The first stage of analysis identifies papers that use defamiliarization to manage various interactive situations. I analyze the papers for the same topics in the above section on defamiliarization in HCI. By using the categories developed from the reviewed literature in HCI and
defamiliarization I can analyze the background of Choreographic Support Tools. In doing so I aim at extending my previous work by articulating the focus of a variety of systems and what they bring to choreographic experience, how intelligent techniques contribute to the choreographic process and where intelligent, interactive systems can evolve in the future.

Dance is often described as an ephemeral art form, in constant shift, leaving no remaining tangible traces. This ephemeral nature of dance creates part of its aesthetic value as a form based in memory and situated cognition, though becomes a challenge in its codification, documentation and communication. The application of a codification strategy and method to communicate formal aspects of movement data to computation continues to be an unsolved research problem, though the application of existing movement frameworks such as Laban Movement Analysis is providing a useful tool (Studd & Cox, 2013). While there are many codified movement techniques and compositional strategies available, each individual choreographer necessarily tailors a work through their embodied experience and situated actions, which is not based on an established vocabulary and structural process that can be easily replicated for digital means.

Choreography can be defined syntactically as a sequential combination of human movements that makes an aesthetic progression over time. However, choreography is a constantly shifting attitude towards the exploration of body, mind, relationships and culture that distracts from any codified syntax of movement. The lens that recognizes choreography as a complex cognitive process may suggest that any true formalization techniques are impossible, or will reduce the effortful and performative aspects that are at the heart of the creative process. I aim to identify salient aspects that can be codified and manipulated computationally, while leaving opportunities for creative interpretation. The perceived benefits of this work include creating a shared understanding of choreographic strategies and bringing awareness to how choreographic strategies are used, enabling more options and control to choreographers in their creative process. DeLahunta questions current choreographic practice as “perhaps our practices are outdated or can be improved. How can we doubt our own processes and question our own methods?” as a way to question our current beliefs of choreography, and to pursue new investigations.
around our understanding of movement (deLahunta, Barnard, & McGregor, 2009, pg. 136).

I have explored how a combination of defamiliarization techniques and particular formalized choreographic parameters can be designed in a creativity-support tool to facilitate an interactive choreographic process. Technology brings new opportunities for codification and clarification in complex processes. Candy states that the computer’s capacity to facilitate a more precise specification of the constraints which artists work within make technology an attractive medium to explore (Candy, 2007), allowing the user to understand and articulate a larger palette of methods that support both movement perception and interpretation. The articulation of movement description and choreographic techniques brings awareness to current parameters, which support agency and creative choice in implementation strategies.

2.4.1. Software for Assisting Choreography

De Keersmaeker states that “what is missing is an interface between mute videos and practical connaissance, or experiential knowledge, that would allow dance to be more than a ‘wheel that turns on itself” (De Keersmaeker & Cvejic, 2012). Choreographers have been fascinated with the creative possibilities enabled by the use of technology in the compositional process. The use of digital technologies and software programs challenges choreographers to perceive their creative problem space anew through new limitations alongside new possibilities. For example, Jowitt, an established dance critic in New York City, describes Cunningham’s use of chance procedures even within his use of the software LifeForms to undermine his own creative control:

Just as Merce originally used chance to thwart his own physical habits, he uses it now to undermine the control of he-who-wields-the-mouse: he’ll often toss coins to decide what limb the LifeForms figure will move next and in what direction. (Jowitt, 1992)

Reflective Tools

I describe three systems that apply various approaches to visualizing movement or structures: two of these systems reflect on shapes and structures of movement to
enhance an audience’s viewing skill set in the moment and one system abstracts performance and structural aspects of choreography to illustrate change over time in a single perspective. While the content of these systems are similar, they depict movement information to provide different perspectives and uses.

**Reflecting movement**

The Improvisation Technologies CD-ROM is a system that aims at pedagogically presenting compositional techniques used by the choreographer William Forsythe to craft movement. The CD-ROM provides video tutorials where the spatial component of movement is graphically augmented with geometric overlays that constitute the basics of Forsythe’s approach to movement in relationship to space. Following the CD-ROM of Forsythe, the dance company Emio Greco|PC (EG|PC) published a book and DVD-ROM entitled ‘Capturing Intention’ that reflects upon movement qualities crafted in the Double Skin / Double Mind (DS/DM) workshop that constitute the basis of the movement vocabulary of the company. The book and DVD was developed in the context of a large research partnership initiated by the company EG|PC for the purpose of documenting their choreographic dance process and practice. They used the company’s descriptions, Laban and Benesh notation, demonstrative video clips and sound as potential mean of transmission of their expressive material (DeLahunta, 2002). Thereafter, the company continued with a second project called Inside Movement Knowledge. In this project, disciplines such as linguistics, motion capture, and movement-based interaction were involved to reflect on the movement vocabulary of DS/DM workshop with their specific tools (Bermudez et al., 2011). The project resulted in various studies, documentation, notation, glossary and a movement-based interactive sonic and visual installation.

**Reflecting Structures**

The choreographic work ‘One Flat Thing Reproduced’ by William Forsythe has been studied by researchers from Ohio State University (Palazzi et al., 2009). They developed the website Synchronous Object to reflect upon the sequencing procedure of the piece by augmenting the videos through post-production techniques to visualize the initiations and cueing interactions between performers. Following the Synchronous
Objects prototype, MotionBank project linked the Ohio State University researchers, William Forsythe and additional choreographers. This heightened audience attention to choreographic structures through graphical visualization by creating scores that reflect on the compositional data.

With the aim of reflecting on the choreographic structures in dance performance, I developed an offline system called ActionPlot that codifies and plots expert viewer information from the viewer’s first-person experience (Carlson, Schiphorst, & Shaw, 2011). ActionPlot illustrates three levels of choreographic data; viewing dance for detailed movement information (Body), for structural or performative information (Space) or for interpretation or meaning (Effort). Choreographic data is plotted by the number of performers, the performer’s attention and intention to move, the amount of energy exerted, the movement and effort phrasing, and the balance of the movement within the body. This data is mapped to glyphs including lines, circles and boxes broken into quadrants representing areas of the body in movement.

**Generative Tools**

In this section I define the term Generative Tools broadly, as tools that generate movement material either autonomously (through using an existing corpus of data) or manually (as a tool that facilitates a human choreographer’s creation of material). The following sections explore systems that focus on generative aspects of movement that support choreographic composition for humans and computation.

**Generation by Movement Simulation**

Among the more renowned contemporary compositional tools for choreography is DanceForms (historically also referred to as LifeForms and Compose). Danceforms is a compositional tool and software system that uses graphical animation for generating simulated dance movement based on user input or library selection. Libraries have been developed from motion capture data, key-frame animation, and movement vocabularies such as Cecchetti ballet and Cunningham Choreographic Technique (Tom W. Calvert, Bruderlin, Mah, Schiphorst, &Welman, 1993; T. W. Calvert, Welman, Gaudet, Schiphorst,
& Lee, 1991). The system focuses on three components of movement as formalized in LMA: space, sequencing and body-posture. The space perspective allows the choreographer to design movement pathways and spatial patterns. The sequencing perspective allows the choreographer to design sequences and movement phrasing in a timeline. The body-posture perspective allows the choreographer to design body positions using detailed joint manipulation or choose codified positions from movement libraries. DanceForms, aside from the provided libraries, relies on the user’s selection of movement postures in order to aid the production of dance sequences, similar to the choreographic process that is necessary for a dancer in the studio (T. Schiphorst et al., 1990). Merce Cunningham used DanceForms to generate movement on avatars, transposing the movement decisions onto live dancers. Cunningham exploited the use of error and “glitch” interaction to produce highly improbable and unlikely movement scenarios, supporting his strategy of uncovering unexpected movement choices that he could explore in the studio. This experimental process allowed Cunningham to explore movement options that he may not have otherwise considered, further facilitating his strategy of using chance operations to open up new ways of viewing movement possibilities.

**Generation of Movement Sequences**

Yu and Johnson’s system generates autonomous movement sequences through the use of a Swarm technique (T. Yu & Johnson, 2003) within DanceForms on the project titled Tour, Jete, Pirouette. This project used the existing libraries of movement within DanceForms to autonomously generate sequences from a series of individual movements onto a group of dance avatars. Sequences were developed by comparing and selecting qualities of individual movements yet did not account for transitions from one movement to the next. Due to DanceForm’s interpolation algorithms, the sequences would look as though they flowed smoothly.

A similar approach with a more sophisticated system generating plausible transitions between movement is that of Web3D Composer. It creates sequences of ballet movements based on a predefined library of movement material as a tutoring tool for ballet students (Soga, Umino, Yasuda, & Yokoi, 2006, 2007). The system allows the choreographer to select movements from a pool of possibilities, which shift based on
structural ballet syntax using markovian probability systems. The beginning and ending positions of each movement are catalogued so that the system can choose a sequence based on transition possibilities for the human dancer as well as for syntactic structures.

**Generation of Procedural Rules**

CorX facilitates dance improvisation by generating rules through textual instructions about pathway, speed, spatial direction and body action (jump, skip, bend) (Bradford & Côté-Laurence, 1995). The instructions are used to change the immediate action of the performer and bring their awareness to a spatial change in the moment. The system uses an If/Then syntax as a conditional statement with a shifting action to change performer’s movements. For example, if speed is fast then make speed slow. All possible rules are pre-designed and the user selects conditional statements. Action statements are assigned probabilities based on their frequency of use and are system selected to pair with conditional statements.

Similarly, the DaNcing system generates sets of rules resulting with sequences of dance steps, represented as ASCII symbols superimposed upon a bird’s eye view of the stage. The system uses a series of music related parameters, stage use rules, and a predefined library of traditional movements to generate syntactically correct Waltz choreography using a Genetic Algorithm (Nakazawa & Paezold-Ruehl, 2009). The dance form itself is initially quite restricted and relies heavily upon the rule system.

**Generation by Mutation**

Another approach to generative systems is to use genetic algorithms to generate new material by mutating existing material. This challenges the choreographer by causing their usual creative process to become 'unusual' in order to allow them to reframe their approach to designing movement. This can also be referred to as “Defamiliarization” as described in the section above or “Making Strange”, a choreographic strategy described by Lian Loke (Loke & Robertson, 2007). For example, The Dancing Genome Project developed a genetic programming model to explore adaptations of movement sequences for performance (Lapointe, 2005; Lapointe & Époque, 2005). The movement material was
gathered through motion capture data extracted from a dancer performing a movement sequence in a studio. The motion capture data was used as input to the genetic programming model to shift the sequence of dance movements, creating a mutated sequence. The final mutated sequence is performed by virtual avatars alongside the original sequence performed by live dancers to create a mixed-reality duet.

Another example of the use of a Genetic Algorithm is The Scuddle system. It generates movement catalysts for creative decision-making in contemporary choreography (Carlson, Schiphorst, & Pasquier, 2011). The use of movement catalysts allows choreographers to distance themselves from habits, making their usual creative process strange and unfamiliar to reframe the approach to designing creative movement. The Scuddle system uses low resolution of movement data to allow for the choreographer’s creative freedom while utilizing a heuristic-based fitness function to generate catalysts focused on body posture, height of execution and qualities of movement when performed. Body posture was evaluated based on asymmetry, instability and complexity while Effort Factors were evaluated for complex combinations of Fighting and Indulging Effort Factors in LMA.

**Generation by Style Incorporation**

Generative systems for movement investigated the incorporation of Style element into existing pre-recorded movements to create, modify, and transform the movement material. For example, Brand and Hertzmann developed a system called Style Machine that generates stylistic motion by using unsupervised learning techniques based on Stylistic Hidden Markov Model (SHMM) (Brand & Hertzmann, 2000). This model learns patterns from a highly varied set of movement sequences recorded from motion capture data. The model then manipulates movement by identifying structure, style and accidental properties and applying style qualities to movement (such as modern dance style in ballet movements).

Similarly, the SmartBody project models style components from movement qualities layered upon functional movement vocabularies to imbue movement with meaning, personality or affect for gaming environments. For instance: Bound extension in
the sagittal plane layered upon a walk will generate a sneaky walk (Shapiro, Cao, & Faloutsos, 2006). The authors use Independent Component Analysis, an unsupervised learning technique to separate motion capture data into style variables and functional movement variables. Thus style components can be reapplied, enabling the user to explicitly re-adapt existing movement by selecting the style’s quality.

**Interactive Tools**

Interactive tools allow dancers to interact with a digital media that responds in real-time to their performance. The digital media can be designed for assisting choreography by facilitating improvisation or exploration of the creative process through behaving as the dancer’s virtual partner. The crucial point here is how the link between the dancer’s movement and the digital response is designed. In other words, within interactive tools the mappings between input and output modalities are crucial for generating expressive cause-effect relationships that allow for a rich exploration of movement.

The Viewpoints AI project looked to the Viewpoints compositional framework to create a real-time interactive system exploring dance improvisation strategies. The system used kinect data and the SOAR reasoning framework to create a repository of short and long-term memory of the choreographer’s movements that select and apply different response modes and improvisational strategies. The reasoning framework can respond by: doing nothing, mimicking the user’s movement, transforming the user’s movement and then performing it, repeating a movement it has learned during its lifetime of experience, or executing various kinds of interaction patterns (Jacob Mikhail, Zook Alexander, & Magerko Brian, 2013). Using this same Viewpoints framework, Corness et al designed the Ariel system that provides musical responses for movement improvisation. This system explores performer’s embodied knowledge in traditional sense-respond models of interaction to find new opportunities for engaging the performer in interactive systems. The resulting flute music also contained a breath that indicated the flutist’s performance qualities, enabling the performer to anticipate the flutist’s musical gestures and resulting in more coordinated and sympathetic performance improvisations (Corness, 2013).
Finally, McKinney et al. designed and implemented a 3.5m tall robot spider as a dance improvisation partner by exploring themes of composition, embodiment and play (Wallis, Popat, McKinney, Bryden, & Hogg, 2010). The robot is suspended from the air and is controlled using information gathered from multiple sensory inputs. The robot follows three interaction scenarios: mimic/follow, oppose, and innovate/random. There are currently no learning algorithms. This research addresses habit through exploring the dancer’s own habitual patterns, where the robot reflects these movement preferences back to the dancers in its own movement. The robot’s movement focuses on the Effort qualities as formalized in LMA.

**Annotative Tools**

Annotating dance movement or structure during the rehearsal has a strong potential for assisting choreographic reflection. It allows choreographers to analyze, edit, play, and re-frame material in order to prototype it and craft it incrementally during the choreographic process. For example, the Choreographer’s Notebook is a web-based annotation tool for choreographic process (Carroll et al., 2012; Singh et al., 2011) that operates as a creativity support tool for documenting, annotating, reviewing and editing choreography. Dancers can rehearse their parts in real-time and film themselves, then compare their performance to the video in the annotation tool. The choreographers also used the tool to provide detailed feedback on the performance for coaching purposes.

Finally, the project Transmedia Knowledge Base for contemporary dance project is designed to facilitate multi-modal forms of annotation of the movement and the compositional process on video of contemporary dance (Cabral, Valente, Aragão, Fernandes, & Correia, 2012; Fernandes & Jürgens, 2013). The tool includes three components: verbal annotations synched with videos, the creation Tool as a digital notebook for real-time video annotation, and a web-based collaborative archive for contemporary dance. Their systems plays a role in note taking, sketching and visualizing compositional elements without actively engaging in the creative process. While the tool can be used within the process to re-frame a creative problem or see a work from a different perspective, it also has strategies for learning and analyzing movement. This creation tool has been designed with and for the choreographer Rui Horta, to assist during
the compositional process. The methodology for dance annotation using linguistic approaches has been used for a microscopical documentation of the repertoire of Rui Horta and EG | PC (Fernandes, 2013) as well as the glossary of DS/DM.

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Figure 10. Papers that Reference Defamiliarization Concepts Organized by End Goals, Type of Agency and Level of Agency in Choreographic Systems Literature

2.4.2. The Designer’s End Goals: Analysis Stage One

These systems illustrate where the designer is focused on the end task. These projects have obvious instructions for how to use the systems and clear goals to achieve the tasks. Systems in this category of task completion include the DanceForms project to animate dance sequences or Choreographer’s Notebook to annotate video for more interactive note-taking in choreographic process. (Brand & Hertzmann, 2000; Tom W. Calvert, Bruderlin, Mah, Schiphorst, & Welman, 1993; T. W. Calvert, Welman, Gaudet, Schiphorst, & Lee, 1991; Fernandes, 2013; Nakazawa & Paezold-Ruehl, 2009; Shapiro,
The situation of creativity, play and enchantment is explored by using defamiliarization to push users towards disorienting experiences with unique constraints. These systems have less obvious instructions or end goals, where the user’s interpretation of the situation is highly important (Bayliss, McKinney, Popat, & Wallis, 2007; Carlson, Schiphorst, & Pasquier, 2011; Carlson, Schiphorst, & Shaw, 2011; Jacob, Zook, & Magerko, 2013; Silang Maranan et al., 2014; Subyen, Maranan, Schiphorst, Pasquier, & Bartram, 2011; Wallis, Popat, McKinney, Bryden, & Hogg, 2010). Examples include the CorX system which generates instructions for dancers to move spatially as they improvise or the Dancing Genome Project which uses an interactive fitness function to manipulate a dance sequence for use in performance (Bradford & Côté-Laurence, 1995; Lapointe, 2005; Lapointe & Époque, 2005).

The situation of transferring, re-labeling or re-mapping parameters from one object to another is also used in these choreographic systems. There is often a system with clear goals, yet is not interactive so that it is up to the user to interpret how to use the system (Palazzi et al., 2009; William Forsythe, 2010). Examples of such systems include Forsythe’s Improvisational Technologies, which displays the spatial pathways of his movements, as rendered graphics in video that are not interactive (2010). This system is used for educational purposes or to provide improvisational inspiration for professional dancers, and requires the dancer’s interpretation of information to use.

### 2.4.3. The Type and Levels of User Agency: Analysis Stage Two

The second stage of analysis identifies papers based on the type and level of user agency in interaction with the system. I identify the type of agency as having a system that disorients or scaffolds a user’s interaction. Disorienting systems take away parts of the experience in order to put users in an unfamiliar place to act from (Bradford & Côté-Laurence, 1995; Brand & Hertzmann, 2000; Nakazawa & Paezold-Ruehl, 2009; Shapiro et al., 2006; Wallis, Popat, McKinney, Bryden, & Hogg, 2010b; T. Yu & Johnson, 2003).
Scaffolding systems add to or support the user’s existing experience in order to help users explore new options (Fernandes, 2013; Lapointe, 2005; Lapointe & Époque, 2005; Palazzi et al., 2009; Singh et al., 2011; Soga et al., 2006; William Forsythe, 2010). Some systems use a combination of disorientation and scaffolding to disorient a portion of the user’s experience while scaffolding another (Calvert et al., 1991; Carlson, Schiphorst, & Pasquier, 2011; Carlson, Schiphorst, & Shaw, 2011; Jacob et al., 2013; Subyen et al., 2011). One example of this is Coughlan and Johnson constraining the options a user has to design a digital musical instrument, but providing help on how to play the new instrument (2009).

Systems that had a narrow level of agency often provided users with very specific options to choose from (Brand & Hertzmann, 2000; Carlson, Schiphorst, & Shaw, 2011; Nakazawa & Paezold-Ruehl, 2009; Palazzi et al., 2009; Shapiro et al., 2006; William Forsythe, 2010; T. Yu & Johnson, 2003). Systems that had a medium level of agency gave some options but also had options for the user to create (Jacob Mikhail et al., 2013; Lapointe, 2005; Lapointe & Époque, 2005; Soga et al., 2006; Subyen et al., 2011; Wallis et al., 2010a). Systems that had a wide level of agency often did not provide the user with any choices and they had full control of how the system was explored (Bradford & Côté-Laurence, 1995; T. W. Calvert et al., 1991; Carlson, Schiphorst, & Pasquier, 2011; Fernandes, 2013; Singh et al., 2011).

2.4.4. **Reoccurring Characteristics and Connections: Analysis Stage Three**

I analyze each paper from our previous study (Fdili Alaoui, Carlson, & Schiphorst, 2014) in each of the categories of Disorientation, Open-Play, Closed-Exploration and Creativity. In the Disorientation quadrant, Forsythe created ‘Improvisational Technologies’ that illustrates techniques for generating and exploring movement in improvisation, highlighted by digital traces of spatial pathways (Forsythe, 2010). While this system creates new opportunities for the user to explore, there is no direct interaction with the system. The system itself has no interaction either, essentially being a video of unique
movement options. The combination of these elements creates an inspiring direction for users though does not guide or engage in the user’s specific process in any way.

Figure 11. Analysis of Choreography Literature for Defamiliarization (Removing Novelty Rating)

In the Open-Play quadrant, DanceForms is a support tool for designing choreography (Calvert et al., 1993). It is animation based, enabling the user to create movements by either selecting existing options from a library or designing movements themselves by manipulating an avatar. This creates a high level of agency for the user, relying on their input to create any content. However the system does not guide the available options in any way, beyond the inherent limitations of the desktop-based system.

In the Closed-Exploration quadrant, Web3D Composer uses markovian techniques to re-order segments of motion capture data mapped to an avatar for teaching ballet choreography (Soga et al., 2006). The user can select a starting movement and options of what is possible to come next are reformulated, constraining the movement options available to the syntactically-correct options. Because the user’s options are so
constrained while the system can control what the guided scenarios are, this system falls in the Closed-Exploration category.

In the Creativity quadrant is Viewpoints AI, a system developed by Jacobs and Magerko using the SOAR cognitive framework to capture and manipulate improvised movement based on Viewpoints (Jacob et al., 2013). The user can perform any movement in front of a Kinect camera, allowing high user agency. The system then generates a unique mode of playing back the movement after being manipulated, by repeating the movement, transforming it, reversing it, etc. This procedure is performed by the system’s choice, creating a high system agency in combination with the user’s agency.

2.5. Discussion and Conclusion

Creative problem solving for choreography requires the ability to shift between different modes of thought. Gabora discusses the need for attention to freely shift between broad, associative thought and narrow, analytical thought to explore an idea creatively. While there is a domain full of Creativity Support Tools, it is noted that most systems operate as a ‘blank slate’ (Shneiderman, 2007), and do not aid the user in their creative process. This requires the user to rely solely on their own ability to shift between associative and analytical thought. While this is a typical model for software assisting human activity, I am interested in how choreographic systems can support the user’s creative process by provoking them to think differently in interaction with the system. I am specifically interested in how to design systems for supporting choreography, as movement is a unique art form that is under-utilized in technology design.

While movement data and choreographic cognitive processes are complex, and difficult to formalize computationally, I can design systems that provoke users into interaction by designing for creative process. Many projects have explored defamiliarization techniques in their system design to provoke user engagement (by providing ‘loose’ or ‘unclear’ options) however these have not been applied to movement. These defamiliarization projects in the domain of HCI explore the relationship between user and system interaction, designing to engage the users cognitively in the system,
beyond completing goal-oriented tasks. I analyzed these systems for qualities of creativity and agency to deconstruct salient qualities for application in choreographic tools.

I have identified components of user agency, system guidance and novelty as important elements in creative system design. Our investigation of the literature through these analytical components presents us with four quadrants as four categories of creative systems. These four categories articulate different approaches to creative process that are valuable as guidelines that differentiate interactive systems. I named those categories: Disorientation, Open-Play, Closed-Exploration, and Creativity. Disorientation has low user agency, low system guidance creating an unfamiliar environment in which the user has minimal ability to affect. Closed-Exploration has low user agency but high system guidance and high novelty. In this way the user’s actions are inhibited, but there is guidance towards new actions to move away from and towards. Open-Play has high user agency, low system guidance and high novelty. The user’s actions are more exploratory without any outside guidance to challenge their engagement. Creativity has high user agency, high novelty and high system guidance. It allows to inhibit typical user actions while guiding them towards new, novel actions while the user stays in control and engaged. It can create a very fruitful environment but providing very new options that the user can choose between. This process is a mix of exploring options in situ as well as having goals to work towards so that there is iterative development.

These categories provide guidelines that can be used to support the development of certain attributes for creative systems. I applied these categories to understand the current state in HCI. Moreover, to explore the area of choreographic software and potential gaps for interactive design opportunities I also analyzed the field of choreographic software. I found that while some systems can be considered to fall in the ‘Disorientation’ or ‘Creativity’ quadrants, many systems function as either Open-Play or Closed-Exploration systems. These systems focus more on either user agency (as a traditional creativity-support tool) or on system agency (as purely generative tools with minimal interaction). There continues to be a large gap in ‘Creativity’ systems that actively promote
interaction between high user and system agency to be able to iteratively develop choreographic ideas.

This work demonstrates that designing a technology that utilizes a database of content, the topic of Closed-Exploration is useful to guide decisions that can provoke creative decision-making. In a choreographic system this could create a series of ‘known’ options, yet the combination of known options is what makes creative solutions. For a scenario that requires a user to develop completely new ideas that are independent of any guidance, a Disorientation perspective is useful. In a choreographic tool this might constrain all familiar options for generating movement, creating a highly unusual scenario to develop movement material from. To develop more collaborative systems that support iterative development, a Creativity perspective would provoke both new ideas as well as scaffold ideas into new areas. A choreographic tool might be versatile enough to shift back and forth easily, as Gabora’s description of creativity, constraining some options and scaffolding others to allow iterative development between choreographer and system.

In conclusion, systems supporting choreography need to provoke collaborative practices with choreographers through technology for capturing movement, artificial intelligence techniques for generating movement suggestions and defamiliarization tactics that suggest symbiotic iteration between a user and a system. In defamiliarizing users, computers need to be engaged in the choreographic process to shift habits, styles and experiences and suggest new choreographic choices. This work posits such a vision as the future directions of intelligent systems for supporting and partnering with choreography.

This dissertation explores the implementation of these ‘Creativity” interactive design strategies in Cochoe, a generative feature in the creativity support tool titled ‘idanceForms’ (Carlson, Schiphorst, et al., 2015; Carlson, Tsang, Phillips, Schiphorst, & Calvert, 2015). idanceForms is an iPad-based choreographic application based on the DanceForms animation system that enables a user to design movement based on skeleton editing or Camera Keyframing (more details in Chapter 4: System Design).
designed a feature titled 'Cochoreo' that uses a genetic algorithm to evolve user-created content into new content. idanceForms continues to function as a creativity-support tool by facilitating file saving and memory keeping to view various iterations of the process.
Chapter 3. Iteration and Evaluation of Interactive, Embodied Choreographic Design²

‘Creative thought is actually distinguished by the fact that it proceeds by leaps, by means of a sudden disorientation which obliges it to reorganize itself in new ways, abandoning its well-ordered shell. It is thought in life, not rectilinear, nor univocal.’ (Barba, 1995, pg. 88)

Figure 12. Apply to Design Process of Building for Experience

This research explores the collaborative, lived experiences of choreographers working with creativity support tools. Chapters One and Two have detailed the research

²² This chapter draws from these previously published works:


context and existing work in designing support tools for Human Computer Interaction and Choreography. This chapter on Methodology begins by highlighting salient concepts on researching experience to support the investigation of creativity and how to evaluate its effectiveness when implemented in digital choreographic tools. I then present the evolution of my research in choreographic creativity through explorations and pilot studies to arrive at the final system design and studies in iterative choreographic process.

3.1. Researching Choreographic Experiences

![Typical Creative Design Process](Newman, 2009)

Each choreographer has a unique experience of their creative process (see Figure 13). Therefore, it is important that the research methodology is qualitative, constructing an environment that supports exploration and individual descriptions of experience. In this dissertation, data on the choreographer’s creative experience is collected through a combination of practice-as-research, observation and focus group methods. Practice as research is the method used in the first two pilot studies, exploring the iterative design of choreographic tools. Observation is performed by an expert choreographer and somatics practitioner to gather non-verbal information about choreographer’s actions in the research environment. Focus Groups are used as a method for collecting verbal data from choreographers about their creative experience. This research is also influenced strongly by a history of phenomenological methods, a technique for accessing experiential data
(often non-verbal) from human participants through re-living the experience and using sensory memories as trigger points. The following paragraphs detail methods for accessing experiential data:

3.1.1. Practice-as-Research

Practice-as-research as a methodology is an ongoing topic of discussion around what research is and how it can be practiced in art. Christopher Frayling discusses practice-as-research in three forms: (1) Research for the practice of art (i.e. dramaturgy), (2) Research on the practice of art (i.e. theory) and (3) Research in or through the practice of art (i.e. Reflection-in-action (Schon, 2000) or forms of evaluating art) (Creswell, 2006; Frayling, 1993; Ludivine, Jones, Kershaw, & Piccini, 2009; Borgdorff, 2007)).

- Research for art (1) examines the topic being explored in the practice, for developing the practice. An example in choreographic practice is the process of researching a historical period or inspirational idea.

- Research on art (2) is the reflection on a work or practice as relating to a theoretical framework. Choreographic practice is researching on art when exploring the relationship of a movement framework such as Laban Movement Analysis on compositional techniques (Studd & Cox, 2013).

- Research in or through art (3) refers to the investigation of thoughts or actions in the process, either as immediate reflection (reflection-in-action) or reflection shortly after action (in journaling or documentation) (Frayling, 1993; Borgdorff, 2007).

Practice-as-research is often a solo process, however it doesn’t have to be. Performing practice-as-research with a larger group of people often requires additional methodological resources such as greater articulation of data collection. I used the Practice-as-research approach throughout my entire design process, from the development of the research question through to the final study. This approach is defined by my personal exploration of choreographic process, the observation of the choreographic process of colleagues and study participants and the research of prominent choreographer’s creative processes, touching on all three perspectives to Practice-as-research throughout.
3.1.2. Observation

In dance and movement studies, observation is developed as an embodied process within the training and deepening of the physical and theoretical movement knowledge. Somatic practices refer to the practice of the "living, aware body". They are body-based practices that relate to one’s own personal perspective and develop an embodied awareness of the bodily sensation and capacity as experienced and regulated from within. A major skill developed in Somatics practices is an acute movement observation, an ability to shape inner and outer attention, and a capacity to synthesize the observed movement patterns in the body. HCI researchers have developed methodologies inspired by the field of dance because it emphasizes the role of practicing and mastering observation as part of building a strong practical and theoretical knowledge for performing and crafting movement (Fdili Alaoui, et al., 2015; Fdili Alaoui, et al., 2015). Schiphorst argues for the necessity of developing somatic connoisseurship in the design for movement experience (Schiphorst, 2011). Moen et al has found that developing movement literacy, as in somatic practices or movement studies, is central in shaping observation when designing for movement and movement experience (Moen, 2007). I used observation on multiple levels throughout my design process. I observed choreographers working throughout the process, I took video of my own choreographic process and observed it, and I observed study participants in the various studies performed throughout this design process. I am specifically trained in Alexander Technique and Laban Movement Analysis which provide tools for micro and macro perspectives to movement experience.

3.1.3. Focus Groups

While focus groups are sometimes viewed as large group interviews, they have the power to access experiential data from many perspectives (Kamberelis & Dimitriadis, 2005). The group setting enables study participants to support what another is saying, to articulate both explicit and implicit experiences, and to create deeper reflections through the combination of experiences. Kamberelis and Dimitriadis directly discuss the ‘performative turn’, of the difficulties and implications of researching performance topics
through focus groups. They note that verbal data is not ‘all’ the information being conveyed in a performance context, but that the way it is conveyed and in what social situation, creating certain relationships between the group illustrates many additional levels of information. Therefore performance contexts need to be assessed for the data being fluid and holding additional meaning beyond just the words. This is where observational techniques become important to support the physical development and interactions between participants. Focus groups allow the researcher to ‘disappear’, enabling the participants to be in control of how they convey their experience, and can reveal group dynamics. Focus groups create a space to explore the ‘complexities, nuances and contradictions with respect to whatever is being studied’ (Kamberelis & Dimitriadis, 2005, pg. 40).

Focus group discussions were performed in two pilot studies and the final study to explore the dynamics of choreographing with an interactive creativity support tool. Focus groups were loosely directed to facilitate the choreographer’s critical articulation of their process, actions taken and decisions along the way (Kamberelis, 2005; Kamberelis & Dimitriadis, 2005). Focus groups relied heavily on phenomenological interviewing techniques in order to support choreographer’s verbal articulation by facilitating their recollection of experience by using sensory triggers to ‘re-live’ their experience (Petitmengin, 2006).

3.1.4. Phenomenological Interviews

Phenomenological methods are techniques that describe the process of ‘becoming aware’, a set of procedures for shifting or deepening attention towards an experience, as outlined in Cognitive Science literature by Varela, Depraz and Vermersch (Depraz, Varela, & Vermersch, 2003). This work has been explored rigorously and articulated in detail by cognitive scientists including Francisco Varela, Natalie Depraz, Pierre Vermesch, Evan Thompson, Eleanor Rosch and Claire Petitmengin (Depraz et al., 2003; Petitmengin-Peugeot, 1999; Thompson, 2007; Varela, 1993). These techniques incorporate specific procedures that guide attention, and are similar to and often referenced in the practice of somatics. The practice of guiding attention in order to focus more clearly on cognitive
activity or intuitive decisions often results in heightened awareness of the process being attended to. Heidegger explains this process as taking something that is ready-to-hand (functioning without the need for your conscious attention), and breaking this tacit and unconscious relationship to make it present-at-hand (not functioning adequately and therefore requiring your attention in order to ameliorate the breakage) (Heidegger, 2008).

When framing the use of a tool like a hammer, the process of shifting awareness to the tool is seamlessly unified with the goal of hammering a nail. It is not intentionally directed toward the tool itself but to the goal. Because it is tacit the connection with the tool may seem unintentional. However, in somatics practice, and particularly in the introduction of choreographic support tools, this process becomes intentional, uncovering familiar creative processes that have been hidden beneath the threshold of awareness requires a ‘breakage’ in order to enable new choices and actions. By bringing attention to a specific process, such as the choreographic design process, while using defamiliarization techniques the researcher can create a situation in which the participant is sensorily present, with heightened attention to their decision-making process. Once the participant has experienced this presence they can more easily ‘re-live’ this experience when prompted with sensory cues, and more easily demonstrate or verbally articulate their experience.

3.2. Exploratory Research and Pilot Studies

Working with LifeForms suggests possibilities of working with time and space that I had never thought of before” (Pierce, 1991) ... “Things can happen that you think are impossible, but if you try them out, they lead you to something else. And it’s all in space, not time, you’re looking visually and putting things in space.” (Dunning, 1991) Combined in (Schiphorst, 1992).

The next sections articulate multiple in-situ investigations towards designing a system that supports iterative choreographic creativity. These investigations stem from inspiration by Cunningham’s methods in chance procedures and history of working with LifeForms (see above quote organized by Schiphorst). Cunningham’s approach to choreography as a set of procedures than change our perception of movement supports the development of new, creative movement options that was celebrated as some of the most influential choreography in history.
The first exploration focuses on defamiliarizing a choreographer’s habitual process for creating movement material in the Scuddle system that I designed, built and ran a focus group study on. The second exploration created a lo-fi prototype of an iterative choreographic tool titled ShiverSlouch in a first-person experience that I designed, implemented and ran a first-person study on. The third exploration is a pilot study that I designed and performed with professional dancers, and the fourth exploration is a pilot study that I designed and performed with youth dancers both with the idanceForms system. These explorations have been an important process in understanding embodied experience and its relationship to creativity, steps in the iterative practice and tools that provoke or inhibit creativity.

Choreography is based in the movement material that is used as content. The manipulation of this content is procedural: very process oriented, due to its first-person experiential nature. Movement experience is iterated over time, which evolutionizes movement techniques that transform choreographic compositional processes. This process is also seen in music, where 12 tone technique was designed to constrain composition to a specific musical vocabulary that changed compositional processes (Brindle, 1968). Hence my explorations in developing a movement vocabulary and choreographic process have been iteratively entwined in the following explorations.

3.2.1. Prior Design and Scuddle³

I have always been interested in the potential of fully computer generated, contemporary choreographies. Through my university dance experience while I was also taking courses in Computing Science, I was aware of my habitual movement patterns and wanted to gain the control to change them at will. However, I did not want to change them in order to move in a more technically ‘correct’ way. I wanted to move in a highly original

way, that could lead to novel choreographies and a uniquely creative yet functionally desirable, style. The process of changing habits and learning to move in a particular way does not come easily. Many body-based practices that explore dehabitation techniques take years of full-time study to master. For example, Alexander Technique teacher training takes 3 years of full time practice, or 1600 hours. A common aphorism among dance professionals is the statement that “it takes 10 years to make a dancer.” This shared common domain knowledge alludes to the length of study required to master the knowledge and practice of movement and to develop sufficient and versatile embodied knowledge to become a dancer (Blom, 1982). The process of altering movement patterns developed over years of practice is not simple to identify, consistent among various styles of dancers or easily taught.

During the research that developed in my master’s thesis, I began to concurrently study computational techniques available within Computer Science, and specifically a branch of Artificial Intelligence, which provided ideas for potential approaches to finding movement solutions. I was interested in solutions that could alter my physical habits, with the goal of creating novel movement. I became interested in using computer programs that would generate unusual movements on 2D avatars or stick figures with realistic anatomical limitations in order to use these movements to choreograph dances. A hypothetical system could create a catalogue of every possible joint movement 5 degrees apart and algorithmically combine individual joint locations into a whole body position. Body positions could then be algorithmically sequenced into movement phrases that could be used compositionally and that the live physical dancer could learn. One problem with this hypothetical system is how to define a way to evaluate positions when aesthetic preferences vary so widely. Though the bigger issue is that the positions are not movements, it is not a sequence of positions that will create a dance. The transitions between the positions are what make up movement, and are often more interesting than the positions themselves. (However is it the complexity of movement data in transitions that make them so difficult to work with computationally, such as the problems in capturing ‘Effort Quality’ that the movingstories research partnership is working on) (Bradley, 2008; Laban, 1976, 1974).
This initial idea for computer-generated choreography prompted a preliminary programming sketch. However, as a first draft, instead of creating a catalogue, positions were randomly generated without including anatomical limitations. While this sketch still created positions, they were unique in a way that suggested movement. When exploring the resulting positions in the studio I discovered unusual movements as transitions that I would never have explored on my body (in my personal movement preferences) otherwise. I also found that I relied strongly upon my habitual learned tendencies for survival (for example to move without getting hurt), as a mechanism by which to realistically explore the images that appeared nearly impossible to execute. It was during this stage that I was able to recognize certain habits more strongly than others and could begin to describe the experience verbally. As this was an intriguing process that met my goals of invoking highly original movement, while uncovering habits and decision-making processes that enables me to understand my choreographic process and develop new strategies for movement, I began to revise the system to explore additional movement qualities.
As the first iteration of the system contained only body positions, I still had a lot of freedom to rely on my movement habits. The second iteration of the system added Laban Effort Qualities and Height (the level the movement is performed at) to further constrain movement possibilities (Bartenieff, Hackney, Jones, Zile, & Wolz, 1984; Bartenieff & Lewis, 1980; Hackney, 1998; Studd & Cox, 2013). These additions required me to dynamically move through the provided body position, transforming the position into movement. However, only certain movement catalysts challenged me to move past my habits, while other catalysts enabled me to easily transform the movement into my typical movement patterns. I began exploring novel movement but still relied on my habitual survival skills to an extent that did not only keep me ‘physically’ safe but also was keeping me ‘creatively’ safe. There was more design work that was required in order to analyse what kinds of movement catalysts were more effective in generating novel movement, and what kind of algorithmic model I could use to generate these qualities in movement catalysts.
Figure 15. Author Exploring Scuddle Catalyst

The final version of Scuddle for my master’s research needed to dramatically shift my habitual movement choices. To do this I built a Genetic Algorithm to generate ‘preferred’ catalysts, weighting and selecting desirable elements to further constrain positions, height, body symmetry and Effort Qualities. The selected catalysts became very difficult to physically explore but created very interesting, highly novel and unusual movements. Though movements may feel foreign, trained dancers often continue to execute difficult movement with ease, which can appear to the observer as aesthetically reasonable decisions to select and execute (for instance ballet movements may look light and easy but are very difficult for a body to perform taking years of physical training to execute correctly). To the dancer, there is a lot of time spent solving both kinaesthetic and conceptual problems. The process of kinaesthetically performing Scuddle movement catalysts heightened the choreographer’s awareness of the problem-solving process, and enabled verbal articulation and discussion.

Scuddle Pilot Study

The final version of Scuddle attempted to disrupt habits while still facilitating the entwinement of movement material with the compositional process. The system uses specifically developed ‘incomplete movement data’ as position suggestions with Laban Effort Quality suggestions. The incompleteness of data facilitates ‘open’ exploration, enabling multiple solutions to be generated from an ‘incomplete’ movement catalyst.
A pilot study was performed with 7 choreographers using participant-observation methods followed by open-ended interviews. Five choreographers were given the system on a laptop to generate their set of movement catalysts and two were given printed copies of a generated set. Choreographers using laptops were given instructions to generate catalysts and all participants were asked to explore the movement catalysts on themselves. After time was spent exploring and reflecting on movement, they were asked to pair up and take the roles of dancer and choreographer.

The study found five main results when choreographers used Scuddle: 1. The process of using Scuddle prompted comparison to their usual creative process (5 choreographers), 2. There was a heightened awareness of personal habits when a habit was explicitly addressed by Scuddle (5), 3. Choreographers tended to re-examine their approach to structuring movement when using Scuddle (4), 4. Movement was initiated in non-habitual and creative ways (7), 5. The experience could be articulated verbally to facilitate further study into creative cognition (4).

Choreographers felt that working with the movement catalysts was very different from their typical processes. Statements that movement is often generated from a concept, through improvisation, to make creative decisions based on what feels 'right' or 'interesting' internally were made by 5 choreographers. Participant 2 stated 'I usually start with a concept but this time I started with pure movement and I still made the movement meaningful to me.' Participant 5 discussed ‘a heavy reliance on the body’s survival skills’ that took time to explore before reflection could occur. This was noticed by 3 others, though was dependent on how exuberant the choreographer was in execution. Choreographers found a heightened awareness of particular habits when the system directly addressed them, especially in relation to body symmetry and balance. For example, participant 3 stating that the system ‘forces me to think of my arms at all times, which I never do’ and participant 2 ‘it is weird for my body but actually feels really interesting - it makes me be really asymmetrical’. Participant 1 found ‘with the legs I wanted to revert back to what I was comfortable with, but the arms I could really do something interesting with’.
Decisions to structure movement based on the catalysts varied and required a re-examination of their personal approach. Participants 3, 4, 5 and 6 read the components from top to bottom in order of height, body position, effort qualities and attempted execution in that order. However, participant 1 selected height and the effort qualities first, and attempted to fit the position into these components second. When confused by a movement catalyst she changed her perspective to a bird’s eye view, stating that ‘it was most important to find out what I think this is and then shift it to or adjust it for my body’. Participant 1 and 2 both tended to attach different effort qualities to different parts of the body, for example Time as Sustained to the legs with Weight as Strong to the arms. Participant 4 would focus on Weight and Time when executing a movement catalyst and assumed that Space and Flow would emerge automatically. Participant 2 looked for the similarities and differences between two catalysts and attempted to execute them consecutively.

All choreographers initiated movement in non-habitual and creative ways. Participant 3 stated that ‘It pulls me out of my body at first, but it doesn’t feel bad.’ Participant 2 stated ‘This is not a narrative but makes me connect the dots in an interesting way.’ Participant 6 stated that Scuddle ‘gives you these very specific guidelines, but being creative people we interpret them in our own way. It’s a very valuable tool and gives an interesting angle to work from.’ Participant 1 thought Scuddle would be useful ‘to get out of a rut or the habits you go back to.’ Participant 4 felt ‘disjointed now physically but I am interested and would want to explore more artistically.’ Choreographers found they could better articulate their experience verbally with the technical perspective of Scuddle. Participant 3 said ‘yes, this helps me to verbalize my decisions’ and participant 2 stated ‘I am talking about it more technically as opposed to making decisions that feel right’.

**Conclusion and Future Work**

The objective of this study was to examine how a system that generates movement catalysts challenged choreographers in making creative movement choices. The results illustrate that the use of Scuddle prompted: comparison to choreographer’s usual creative process, heightened awareness of personal habits when explicitly addressed by Scuddle, choreographers to re-examine their approach to structuring movement, non-habitual and
creative movement choices and an experience that could be articulated verbally with the added technical perspective. From these initial results, it was deduced that Scuddle is guiding the choreographer to explore creative movement while supporting articulation of creative decisions. This analytical approach to developing creative movement material separates the decision making process into concrete events that can be identified and verbalized. The articulation of events are able to facilitate a deeper exploration into the creative decision making process. Future work was indicated to examine how to develop a system that could function iteratively, with more support for embodied interaction.

3.2.2. ShiverSlouch: Practice as Research Prototype

![Initial Interactive Prototype with a Kinect Camera and DanceForms](image)

Figure 16. Initial Interactive Prototype with a Kinect Camera and DanceForms

After the Scuddle work I was fascinated with how to make the Scuddle process more interactive and iterative. The Scuddle system generated 6 catalysts as static images

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to be explored as movement material for the choreographer. To take this further, I devised a critical inquiry by developing a choreography in the studio, titled ShiverSlouch, with the aid of a ‘Wizard of Oz’ exploration of the interaction between a simulated software tool and a choreographer. Critical inquiry comes from Human Computer Interaction and uses ethnographic methods to collect data in the field, or in situ (Holtzblatt & Beyer, n.d.). Data was collected about how a subject (the author) interacts with a system within their normal environment.

I composed a ShiverSlouch for a solo performer based on an iterative development process using 3 computational systems in the studio (See Figure 15). This process was documented with video and journal reflections in every stage. The first system is titled Scuddle, to initiate and develop a movement vocabulary (Carlson, Schiphorst, & Pasquier, 2011). The second system is Integrate, to capture movement data with a Kinect camera and translate the data to bvh format (Gaskell, n.d.). The third system is DanceForms, an animation platform specifically designed for choreography, which I used to play back and manipulate movement files (Calvert et al., 1991). Choreography is often composed in 3 stages: generating movement material, sequencing and developing movement material and structuring movement compositionally. For this study I identified the interactions used and mapped them to the part of the process being explored (Figure 16). This section articulates what was explored in each stage, how technical limitations influenced the process and how the choreographer’s choices influenced the process.
The goal of this type of compositional process was A) to create a choreography (requiring attention to the choreographic task, not distractions in technology limitations) and B) to identify methods for designing technological support or mediation to engage in the choreographic process. Within this compositional process we were focused on creative and novel movement choices that develop into full compositions. As seen in the above table, the process began by using the Scuddle system to generate movement catalysts, which the choreographer used to create a movement vocabulary (1). The choreographer sequenced movements into phrases herself (2), then used a Kinect camera to capture the phrases (3). The movement files of phrases were imported into DanceForms, and manipulated by adjusting pelvis and limb positions over groups of frames (4). The choreographer then re-learned the new movement phase from the avatar in DanceForms, interpreting the new information (5)(See Figure 15). This exploration between choreographer and mediating technology is performed iteratively to develop movement material (6). Three parameters were imposed by the choreographer as having manageable options for ‘chunking’ movement information: types of movements (gestural, angular movements, slouched torso), sizes of movement (small, medium, large) and spatial trajectory options (in place, linear, curved)(7). The choreographer then used the parameters to structure sequences spatially and temporally to construct the choreographic
progression, by drawing a map on paper (after exploring pathway creation in DanceForms)(8). Finally, the choreographer documented each stage of the process while journaling about her thoughts in each stage.

**Reflections in Composition: Choreographic Process**

During the choreographic process I found it easy to develop initial movement 'ideas' from the Scuddle system that were continually re-integrated into the final composition. Because capturing the movement was using the Kinect, the focus while developing movement was on the technology rather than on our explorations. I found that improvising, capturing, manipulating and re-learning our movement was mediating the movement a lot from its original state. The technology did include intelligent interventions to translate my own movement habits when re-learning the movement. The 'information' that was re-presented to me lost performance quality because it was expressivity filtered 'down' through noise from the camera capture which eliminated individual nuances or complexity in movements themselves. This was a useful step to understand how defamiliarization is a tool for simulating system agency in interaction.

This 'lossy' result of movement information meant that I was required to re-interpret the animated movement rather than re-learn the movement phrases from video. This process became difficult and time consuming without providing additional compositional benefits. Once I had developed sections of movement I noticed the need for high-level compositional tools to structure it. Beyond exploring motion I did not have a metaphorical theme to help guide choreographic decisions. While DanceForms enabled playback and detailed editing it does not yet incorporate high level structural features that can be applied to choreographic explorations. I designed a linear structure with pen and paper that I could be used to manipulate the animation in DanceForms. Ultimately, I focused on the experience of performing the movement and sketched out salient features using contextual inquiry, which provided a much more dense and nuanced map of potential choreographic structure. This map provided many elements to work with because I could easily notate spatial location, speed, transition movements and dynamics in a way that I could remember. My experiential explorations illustrated the need for shifting modalities (between detail and higher level choreographic context) and using abstraction
to move between detailed features such as limb positions and higher level concepts of phrasing, spatial trajectories and structure.

![Choreographic Design Map of Spatial Pathways](image)

**Figure 18. Choreographic Design Map of Spatial Pathways**

**Technology-Oriented Decisions: Limitations and Creative Opportunities**

The inherent limitations of the existing feature sets effected both the realistic applications to choreography as well as manipulating the available creative search spaces. Choreography has traditionally found opportunities to be creatively opportunistic when working with the inherent limitations of the technology by focusing the movement vocabulary, structure and content on solving the new constraints that technology brings to a creative process. The Scuddle system brought a focus to generating unique movements through physical exploration of complex inspirations, however it does not support idea development or iteration. This supported initial movement ideas but did not facilitate interactive dialogue.
Capturing movement with the Kinect made the instantiation of movement in DanceForms a much easier and familiar embodied process than clicking with a computer mouse. However this development alone warrants higher-level controls for manipulating and transforming movement phrases. The automatic capture feature to start capturing with the correct pose was efficient, but needed to be edited out in the animation process. There was a high level of noise in the Kinect data that often presented very jittery data. There was also a narrow spectrum of capture opportunities for a dancer. The available floor space for capture is small (oriented towards gamers fixated on a screen), the camera still needs to see recognizable limbs even with the depth camera (limbs are easily lost and replaced as standing still), sudden changes of movement or tempo are often lost. Many movements were not able to be captured including curved spine, swinging limbs, legs extended above 90 degrees and any sense of weighted-ness in the movement. This lack of specificity in the movement data constrained the opportunities for manipulating choreographic process computationally. The choreographer made choices towards basic, more easily recognized movements, attempted to move more slowly, not perform work on
the ground which had the effect of reducing complexity and novelty. The most prominent creative understanding in the process with the Kinect was that it brings a strong focus to the body's positions, rather than orientation, spatial relationships and quality or expressivity of movement. There are many qualities that lend themselves towards defamiliarization practices, augmenting the original movement in unique positions and jittery interpolations.

DanceForms brings a strong focus on the details of movement data that allow the user to be very specific with every joint movement in each or any specific frame, however there are no options for higher-level manipulation. Once I captured my movement into DanceForms I could not find any simple ways to manipulate the whole body or multiple movements, so I copied and pasted sections of movement to edit the sequences or adjusted single limbs. Spatial pathways could be manipulated most easily, but were difficult to select and move as spatial trajectories. The ability to playback manipulated avatars enabled the choreographer to re-learn and re-interpret the movement in ways that could not have been afforded without the technology. However the re-interpretation was affected by noise in the original captured data and the strong focus and need for detail in the editing interface. In the end of this process I found that I was continuing to focus on individual movements or very short sequences through the Kinect and DanceForms interaction that were not supporting exploration or development on longer compilations of movement data. Future developments that focus on high level compositional functions would be useful to manoeuvre in embodied exploration with less articulation of details.

I often find that technology is useful for creating a more objective perspective in which to explore movement, away from the guiding physical sensations of the body's position in relation to itself. However, this requires bringing attention to more subtle or compositional aspects of movement that current systems do. While one solution is to wait for technology to 'catch up' and be able to sense and manipulate a higher and more refined resolution of human movement information, I am more interested in current design opportunities that leverage embodied creativity from a perspective of bringing technological innovation. Existing practices in defamiliarization, cognition and creativity
theory can be used to engage in creative collaboration. I outline my findings in reflections on the remainder of our discussion on creative choreographic process.

**ShiverSlouch Conclusions and Future Work**

This pilot study explored opportunities for designing new feature sets for collaborative creativity into tools used for choreographic process. I developed a contextual inquiry to address this question using three existing systems to inspire, mediate and support choreographic development. Through this iterative process I suggest a variety of opportunities for further investigation. Functional software developments for choreographic systems could focus on furthering current feature sets in body position and movement data. The addition of physics engines to DanceForms would provide new opportunities for exploring qualitative aspects of functional movement. Generative and learning techniques to develop greater autonomous creativity would provide agency in the DanceForms system (or newly designed system), such as using style machines to extract stylistic data from existing movement and manipulating it to become new movement (Brand & Hertzmann, 2000), integrating Scuddle to generate unique positions for interpolated movement (Carlson, Schiphorst, & Pasquier, 2011) or using unsupervised algorithms for large datasets such as deep-learning (Coates, Lee, & Ng, 2011).

Alongside the greater creative autonomy of an interactive system, new collaborative systems would benefit from enhanced functional history-keeping and accessibility. Maintaining connections with the history of the creative process enables users to reflect on prior actions and decisions while reverting to prior options if desired. This transparency of the history of choices also supports new creative developments that use and build upon prior actions without losing the central focus. Designing for easy access to history and parallel working processes would also be a useful and important feature when supporting the non-linear and iterative creative process.

Additional methods for manipulating movement data in collaborative systems would be highly useful to support cognitive perspectives of movement and compositional processes. Shifting modalities has also been found to be an important component of choreographic cognition, as studied by David Kirsh (Kirsh, 2011b). Choreographers often
highlight a particular movement feature and develop a creative idea by re-mapping this feature to another part of the body. For example, highlighting the movement of the arm in both position, trajectory and quality and re-mapping it to movement of the hips. This re-mapping strategy could also be more abstract, such as taking the timing of a movement through space and performing the timing by simply walking in time.

Designing a ‘modality’ system that could be shifted between different data sets would need to consist of parameterizing movement data to enable the user’s focus on a specific quality of subtle movement data. Movement parameters could consist of the body part, body position, spatial trajectory, tempo, level of body (on floor, middle, jumping), movement qualities, exertion levels, etc. Patterns in the specific quality of data could then be extracted, abstracted and applied to other another quality of data, hence shifting the same data between modalities. An example of this would be the re-mapping of movement data (such as trajectory and acceleration) from a leg to a subject's head. Various modalities that would be useful in choreography include:

- Qualities of expressive movement such as Effort Qualities from the Laban Movement Analysis framework. Effort Qualities are deconstructed into elements of time, flow, weight and space and combine to create effort actions such as punch, press, dab, flick, wring, float, slash and glide. (Laban, 1974)

- Qualities of tempo and rhythm that would enable the manipulation of an individual and sequence of movements beginning, middle and ending.

- Spatial intention that affects how a subject engages with themselves, their environment, other subjects or objects. This is often depicted as intending to interact through distances, such as presenting oneself strongly to a distant subject or exploring ideas of movements internally.

- Explorations of weighted-ness that provide visuals and control over the subject's center of gravity, ability to perform certain movements and resistance or giving in to gravitational forces.
One aspect of shifting modalities aside from the data itself, is the abstracted representation. The visual presentation of information affects how the choreographer kinaesthetically interprets it. Shifting modalities is a form of changing how movement information is represented, creating new search spaces for creative exploration. While the data could be abstracted by its modality, the level of specificity is also an important factor. The main motivation for a choreographer to use technology is to be able to observe structural choices, creating a more objective stance in which to perceive movement information that can augment the choreographer's own kinesthetic feedback. Presenting information as a 3D avatar with facial features is very different from a stick figure, different from a point cloud or unique form or spatial or geometric temporal or analytics representation. Technology is able to highlight specific features separate from the rest of the movement data, which we cannot do on a person. Being able to highlight the exertion of a choreographer over time or the movement quality of an arm compared to a leg is highly useful information in choreography and many non-creative movement domains.

Future work was indicated to explore how to implement some of the features articulated in this pilot study in the DanceForms platform. The movingstories partnership inside DanceForms team planned to design a context-specific, adaptable interface for DanceForms that enables high-level editing features for choreography on an iPad device. By leveraging opportunities for mobile platforms we can move a bit closer to embodied interaction in situ, bridging with new opportunities for personal meaning-making between movement and technology. The team planned to design editing features based on both the low-level animation keyframe functions as well as higher level features where movement data can be adapted using a combination of modality and abstraction levels. This work is happening concurrently with the movingstories Research Partnership (www.movingstories.ca) in researching methods for capturing, manipulating and representing movement data from a somatic perspective to broaden our understanding of movement in language and computation.
3.2.3.  idanceForms Design Process

The next iteration of this research explored the integration of new choreographic features in a mobile application. idanceForms was designed as an iPad application that offers a unique approach to creative sketching of movement, and as an extension of the original DanceForms software. The idanceForms team consists of Thecla Schiphorst, Tom Calvert, Herbert Tsang, Jordon Philips, Norm Jaffe, Karen Cochrane, Yaying Zhang and Kristin Carlson. My role in collaborative team was mainly in evaluation to ensure the design is supporting the movement experience, though I was involved in system design and interface design choices. As a facet of the movingstories research partnership, idanceForms allows choreographers to compose sequences of movement using their own personal movement choices. Choreographers investigate and improvise movement through the framing of the mobile tablet's camera in order to select animation keyframes of still forms that they combine to create sequences of movement, holding unique meaning to the creator.

idanceForms has been designed by utilizing the craft knowledge held by the idanceForms and movingstories research team, in co-imagination with professional choreographers and the literature of the choreographic process (Benford et al., 2013). Craft knowledge is defined by Benford as experiential knowledge acquired over many years and is used by the idanceForms team to acknowledge the deep expertise held by choreographers. This history and tacit experience of choreography provides frameworks and strategies for sketching, sequencing and reflecting on movement to make personal meaning from movement material both experientially and analytically. Frameworks and strategies include Laban Movement Analysis, Viewpoints and techniques developed in disciplines such as Ballet, Modern and Improvisation (Blom, 1982; Bogart & Landau, 2004; Humphrey, 2003; Studd & Cox, 2013). These specific techniques for generating and assessing creative movement can be leveraged in technology design to support composition through new lenses, creating a tremendous amount of potential for creativity in choreography (Carlson, Schiphorst, & Pasquier, 2011).

Advances in mobile devices are enabling exploration of touch and qualities of motion in situ that can create new spaces for creative exploration (Schiphorst, 2011). This
can greatly change the opportunities for movement and technology. In an choreographer's practice, prior options for authoring movement in DanceForms or other systems required them to leave the studio, or to have a full desktop station in the studio. The separation between experientially exploring movement and analytically navigating software was difficult to bridge before mobile devices. The portability of current mobile technology with the power for natural touch interfaces, embedded sensors and cameras creates a unique tool that is easily accessible while in motion and in the moment. These new developments provide a plethora of opportunities to explore how technology can extend the existing practices of artists such as choreographers, animators, and special effect artist in order to augment their creative and compositional experiences with movement.

3.2.4. idanceForms Study: Professionals In the Field

I designed and ran a study with the support of the movingstories idanceForms team as a workshop titled 'Mobile Computing as a Lens for Choreographic Perspective: Embodied, Experiential, Expressive'. Five female choreographers participated in the 90-minute workshop, held as part of an academic dance conference. The workshop was designed around the concept of innovation: based on the cutting-edge history of contemporary dance, which rapidly evolved over the last century by continuously challenging the most recent development. We performed a loosely directed focus group at the end of the workshop to gather any additional experiences that were not verbalized during the workshop, and to elicit group discussion around idanceForms and choreography. We grouped the choreographer’s responses based on themes that emerged from the analysis (Denzin & Lincoln, 2005). We ran the workshop using choreographic exercises to explore three topics of composition:

Workshop Design

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5 This section draws upon previously published writing:
• Still Forms and Movement: The first topic was creating still forms, or static ‘poses’ as opposed to the transitions between static poses. It is in the transitions through still forms that movement happens. We challenged choreographers to explore the difference between stillness and movement by creating multiple still forms and exploring how shifting the order of still forms changed how they transitioned (or moved) from one still form to another. In animation, this process would create different kinds of movement through the still forms based on linear interpolation: what the shortest pathway is between two still forms. By changing which two still forms are paired there will be a different movement pathway between them. This exploration of different movement pathways between stillness is a regular exploration of movement in choreography. The subtle shifts between the initiation of a movement and where it ends up creates very different options for a movement pathway. We explored the concept of still forms and movement pathways between still forms both through the bodily experience of movement without technology and in creating an animation in idanceForms (as organizing a linear order of keyframes).

• Sequencing: The second topic explored the act of sequencing by manipulating an animated movement sequence. We provided an existing animation sequence of an exercise from Cunningham Technique and asked choreographers to shift and manipulate the sequence, both on the device and in their individual movement experience. Manipulation options within idanceForms include: exchanging and inserting keyframes of still forms, shifting the timing of individual keyframes and reflecting on the edits in the playback window. This exercise required choreographers to learn the existing movement phrase on their body, then shift back and forth between manipulating it in the software and ‘trying it on’ experientially. Choreographers needed to iterate between system and physical experience to attain the desired result by manipulating keyframes, reflecting on the resulting playback in the system and assessing it based on their moving experience.
Capture: The third topic explored how to use the camera keyframing function. This function uses the camera embedded in the mobile device to photograph a still form performed by a choreographer and selects the closest corresponding keyframe in the database. By capturing a still form the choreographer could create a new keyframe, and construct a sequence of keyframes populated by their own individualized movement, as it relates to the existing database. Choreographers were asked to improvise with the camera keyframing function to generate their own individualized movement, and to create a movement sequence from camera keyframes. It was requested that choreographers both used the device and explored movement through their bodily experience.

While choreographers articulated their responses, experiences, and challenges throughout the workshop, they also participated in a final focus group at the end. The focus group consisted of an open discussion about choreographic experiences with the existing functionality and brainstorming about potential features and how they could support choreographic exploration and creative movement.

idanceForms Professional Dancer Results

From our study we present themes that emerged throughout the workshop and final focus group. Themes focus on aspects of the creative process, both articulated by the choreographer participants as well as observed by the researchers. These themes detail the values that choreographers hold around their practice, and what their expectations are of technology that might play a part of their sketching process.

In-Between

Choreographers discussed 'transitions' as important aspects of movement design. Participant 2 mentioned, "I am interested much less in form and shape than I am in states and dynamics. Effort is my world. Working with states and drives". The participant was referring to the concept of focusing a choreographic process on the movement itself. The terms 'states and drives' refer to terminology in a movement framework called Laban.
Movement Analysis (LMA) that articulates qualities of movement independently of and in relation to each other (Studd & Cox, 2013). Participant 1 stated their interest to explore from the dynamics of movement: “[there is] no sense of weight - wondering about how it can play with dynamic, more than just time”. Participant 3 was also interesting in seeing the ‘weight’ of the animated figure and how the weight affected the qualities of movement. While weight has always been a difficult feature to design in animation and believable characters (Bishko, 2007), we are researching opportunities to access ‘illusions’ of weight through representation. By focusing on the dynamics of movement, it does not matter what the still form or shape of the body is, how the limbs relate to each other or what the precise body’s ‘points in space’ are. This shift of focus away from body position and onto qualities of the movement are difficult to capture in technology but are meaningful to the energy and ‘essence’ of a movement.

To move from the still form into movement, participant 3 explained that it "would be great to articulate where on the form the transition initiates". In real physical life, we cannot start to move by automatically shifting the entire body at the same time. Through felt experience a person shifts their weight and initiates a movement from their knee, hip, head, or other body part to start the transition to move. How the movement initiates on the still form changes what the transition and quality of movement will be.

One option that would alter the linearity of transitions between still forms was addressed by participant 4, who states: "when using the iPad and connecting shapes, I was thinking that I wish I could do a half turn or quarter turn or a jump turn.". Adding rotation and jumping options in the transitions would be a novel option to manipulate the 'shortest path' between two still forms. By adding parameters for rotation and jumping many dynamics could be achieved by designing how quickly or slowly the choreographer moves into and out of a transition.
All Together

The theme 'All Together' emerged from choreographers talking about how to group keyframes together and use features to manipulate a sequence of keyframes as a whole. Participant 1 asked if "there [was] a higher level function for grouping keyframes? So that you can group say 9 keyframes and call it a phrase, [and then] move it here". This would provide additional editing functionality, similar to how a choreographer works in the studio with dancers. This could include changing the speed of a phrase, shifting the orientation, spatial positions or the transitions between still forms. An example in a real-life studio could include a choreographer telling a dancer to take the movement sequence and perform it only using your hands, or make the whole body performance of the phrase as large as possible.

Figure 20. Participants Working Experientially
'All Together' is also a key component in designing for 'Relationships'. The compositional tool of theme and variations is a model for creating a core idea and developing it in different ways that are woven through a work to create a composition.

**Relationships**

Choreographers were interested in how to design for relationships in the software. Participant 3 discussed having 2 or more figures in the animation space that are "doing the same thing or different...[using your] history or library of movement phrases where you could add in another figure from your [personal] history". This phrase supports the importance of building relationships for meaning-making within the creative work to support evaluation in iteration. In the playback view it is useful "to rotate the stage space 360 degrees...and see it from all different angles". Having two figures, access to the history of sequences created and 360 view of spatial relationships could give perspective when dancers can't make it to rehearsal, suggested by participant 3: "sometimes they can't [come to rehearsals], so you can't see the possibilities".

Relationships also include application features such as working with two figures and having the ability to draw spatial configurations. Participant 4 mentioned that "[this] could be useful outside the studio with lots of dancers. I am always drawing pictures of how their spatial pathways should go and intersect so to be able to see broadly and test a lot of options at once, then could go into the studio knowing better what you want, what fits or what you are going for. I find that drawing pictures is really helpful because it helps you to see the broad picture of what it is". While drawing spatial pathways with multiple figures would be a useful feature and could provide 'creative situations' in the animations to be negotiated in real life by dancers, choreographers also view the idanceForms application as a tool that could support the negotiating of multiple dancers in their live studio practice. Being able to 'see the possibilities' or the 'broad picture' is an important aspect of creative process, where the creator is iterating between a focus on details and broader context to ensure that the relationships they have build can bridge to meaning-making.
Additional touch interaction options that were suggested included being able to 'draw' spatial trajectories for the figure to follow or to draw a trajectory for a limb to follow. Participant 1 asked "could you give direction in space with your finger?" Working with the concept of sketching, being able to draw trajectories for both moving in space and initiating a still form to move could provide a more tacit exploration of movement on a mobile tablet. We are also exploring ways of using the internal sensors to map accelerometer data to moving a figure’s limb, to play with more improvisational but embodied ways of moving figures.

Meaning-Making

The theme ‘Meaning Making’ emerged from choreographers discussing how to personalize movement design in idanceForms. Personalization was a topic in designing sequences by using music from their personal library to adjust animation in relation to was asked for to support editing choices and dynamics. Personalization was also requested in a feature to "choose images that already exist in your camera library" (Participant 1). However personalization was also discussed as the process of improvisation; how does this unique choreographer sketch? How does this unique choreographer make meaning in movement while using this mobile application?

In the camera keyframing exercise the choreographers used idanceForms in a manner that the researchers expected for about the first minute. This included taking a photo of a printout of a still form person, or photographing a live choreographer from straight-on while the subject was standing still. Taking photos in the expected way, by using a contrasting background to create a keyframe, created the exact still form keyframe that they were anticipating. However the choreographers quickly began exploring unique ways to take images that would produce novel results.
Choreographers were lying on the ground and taking images from above (See Figure 20), photographing objects in the space (rather than people), and photographing multiple people at once. The choreographers who took pictures of objects and architecture located around the room were interested in what kind of movement poses random objects would generate. They didn’t care if the resulting keyframes were related to the pose, or if the keyframe was shaped like an object rather than a figure. Choreographers also experimented with photographing multiple bodies in the virtual space to see what could be generated. The camera keyframing feature was very popular because of its potential to create random or vaguely associated content from meaningful initial material.

Just like the earlier articulation of ‘theme and variations’, choreographers create variations based on a development of material that can be, but does not need to be, visibly connected to earlier themes. One of the researchers commented in the workshop that “[it]
doesn't have to be human forms. Even the mistakes [are] really interesting". The exploratory sketching process creates meaning through the iteration and evaluation of content, based both on its personalized meaning and its novelty in relationship to the choreographer's interest.

**Manoeuvring**

As researchers and designers we hold specific interests in designing tools to support embodied creativity by using mobile devices and the sensors they contain. The use of mobile devices in the studio by choreographers is more prevalent now than it was even 5 years ago. However, how choreographers use mobile tablets such as iPads and android devices continues to be restrained to photo and video documentation and review. To use a mobile tablet *while* dancing or choreographing takes some manoeuvring. They are not as small as a phone. They will not fit in a pocket. They will not stick to skin. There are not desks or tables or furniture in a studio to place a device on while the choreographer shifts focus. Hence, how the device is held, placed and put down matters in a dance studio that contains many moving bodies.

The workshop took place in a large open room with many windows. There is a sprung marley floor, a ballet barre and a piano. Throughout the workshop, choreographers were asked to shift between constructing animation on the mobile tablet and experientially moving. While this is an action that we regularly do in everyday life with our mobile phones, as we text a friend while we are walking to the train, this shift is more difficult due to the tablet's size. Choreographers were required to manoeuvre the devices in the space with only their own bodies, the floor and the device's case (which often functioned as a stand).
Figure 22. Choreographers Maneuvering the Mobile Devices

While choreographers both sat on the ground and stood up to perform tasks with the iPad on their lap, they were often standing and holding the iPad with one hand while imitating the phrase with the rest of their body (See Figure 21). This immediate and in-situ interaction authoring option would not be possible without a light, mobile device with current processing power. Sometimes choreographers would place the iPad on the ground, using the fold-into-a-stand cover to place the iPad in a visible location to watch while they could move unencumbered. The ability for choreographers to lay on the floor or move through the space holding the iPad was an important feature to bridge an authorship system with embodied movement experience.

Discussion

‘By making the familiar strange, we familiarize ourselves anew with the familiar.’
(Sheets-Johnstone, 1999)
Through the development and workshop process with choreographers we discovered 6 design goals that are important to prioritize for idanceForms. Sketching creates a low-risk environment for exploration and iteration. Sketching enables rapid prototyping and is open to interpretation, creating a situation where catalysts for movement ideas can be provoked and developed. Every design choice in idanceForms will be appropriated as a catalyst for creative movement because our users are so adept at thinking 'outside the box'. The open environment, sketching and catalyst design evokes playfulness, improvisation and unexpected uses.

idanceForms is a defamiliarization tool because it re-invents the concept of movement and creativity for choreographers (Bell et al., 2005; Benford et al., 2013; Loke & Robertson, 2013). The creative process is separated from embodied craft knowledge and articulated anew. This requires choreographers to experience movement and think about movement differently, provoking creative opportunities in improvisation and sketching.

Whole-body interaction and a design based in the craft knowledge of the choreographer (Benford et al., 2013) are the critical design elements in a choreographic support tool. By engaging the expertise of felt experience (Larssen, Robertson, & Edwards, 2006) and designing for the affordances of mobile tablets we can create provocative, open creative environments for choreographers to explore personalized movement choices in which to create meaning.

Future Work

This work describes the beginnings of the idanceForms application development and our work collaborating with choreographers in the design. We plan to implement the functions requested by our choreographers to increase opportunities for relationship building and meaning-making in addition to our interest in compositional features. We articulate these requests in sections based on their functional, expressive and meaningful components.
Interaction: Moving Sensors

The process of choreography is epistemologically different from the process of animation. By engaging in the felt experience of movement and epistemological underpinnings of movement we generate more opportunities for innovation. The sketching process of trial and error is a rapid prototyping tool for quickly creating, reflecting on and assessing the value of the resulting work. We are continuing to explore the implementation of expressive qualities that can shift the compositional focus from what static, still form to make (body position) to how it moves over time in a sketching context. By providing unique tools that require the user's embodied engagement we can catalyze the user's embodied expertise and in situ creativity.

Choreographers requested methods to use touch-interaction to initiate movement from a body part, to draw pathways in space and to create relationships between figures. While these interaction methods are explicitly available and innovative to implement in a choreographic tool, we are interested in further exploring the use of embedded mobile sensors as controllers for interaction. Can a choreographer use the accelerometer to initiate a body position? Could a large walking path provide GPS data to create spatial pathways? Could devices that are within Bluetooth range create a relationship?

Since the study, the idanceForms development team has embedded a communication protocol similar to Open Sound Control (OSC) to connect a mobile phone and use it to control the figure in through the gyroscopic and accelerometer data. This interaction enables both precise and freeform manipulation through movement. While this feature currently controls the figure in playback view we plan to soon be able to use this interaction to capture and manipulate keyframe and interpolation design in the editing view. We also plan to explore further interface design options to help us navigate through the many interaction options that we have, to enable designs that are innovative and movement based while supporting options for choreographic control. idanceForms is committed to creating new opportunities for movement interaction by using technologies in natural user interfaces that supports the necessarily embodied and iterative choreographic creative process.
Composition: Iterative Authorship

Choreographers discussed being able to select sequences of movement to manipulate, seeing the big picture and working from dynamics. Due to the tremendous amount of movement data present in choreography, the team plans to design a variety of 'levels' that can be shifted between in the application. We can currently edit joint angles on a low-level, selecting joints the axis to move on to manipulate the limb. However this continues to be very detail oriented, and we are searching for new opportunities to design for embodied interaction. Being able to 'zoom out' and see the big picture of choreographic choices was also a value. This could be addressed with different forms of representation to highlight certain qualities of movement, and could be appropriated by choreographers to 'start with the dynamics' in their creative movement process. Compositional tools that manipulate a sequence are also of interest: how do choreographers retrograde, invert, speed up, or move 'bigger' in a sequence? One opportunity we are exploring is to use a generative tool titled Scuddle to create unique keyframes from a database either in idanceForms or the choreographer's personal library (Carlson, Schiphorst, & Pasquier, 2011).

History-Keeping: Functionality and Personalization

We are also working on more functional aspects of idanceForms to ensure that is works as a 'support tool' for choreographers. This includes designing for history-keeping and re-access of material. idanceForms functionality will supports creative authorship by enabling access to music, existing photos in the Camera Library and sharing between collaborators.

We plan to further explore how idanceForms can be used as a choreographic authoring tool with updated features and modes of interaction. We are planning a long-term study with a variety of choreographers to begin after the next iteration of idanceForms development. We believe this will provide us with additional information about how
choreographers work through creative ideas using felt experience in addition to understanding how idanceForms can support and provoke their creative process.

Conclusion

The design process and workshop study of idanceForms enabled us to observe how choreographers make personalized meaning through their sketching process while continuing to engage their expertise and craft knowledge. We observed how choreographers improvised and iterated their movement choices to create opportunities for discovery and deeper engagement. Our workshop with professional choreographers illuminated the sketching process as an important tool for creative design and whole-body interaction as leveraging the epistemological underpinnings of movement. These values in design provide a rich area of inquiry towards designing for creative, felt movement experience.

We view idanceForms as a preliminary exploration of mobile authoring tools for movement to evaluate how the affordances of such a system can support the creative values of a choreographer. We observed the playful discovery process that each choreographer experienced and began weaving into crafted movement sequences. We see potential for systems that utilize sensor-based movement to create embodied and personalized qualities of work, as opposed to designing for known creative processes using traditional interaction methods.

3.2.5. idanceForms Study: Youth

With idanceForms, I designed and ran a second study with the support of the development team with youth to explore their experience of creativity with an iPad app.

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The second workshop was with 18 children (10-12 years old) in a jazz dance class. While all participants were familiar with iPads and the interaction options, none of the participants had used interactive technology as a part of their movement process beyond documentation with video.

The studies were run as a choreography-based workshop where the researchers planned and supplied sketching tasks within an exploratory movement structure. Researchers observed choreographers throughout the workshop (and observed again later by transcribing and watching videos of the workshop) and ran a focus group to articulate the participant’s experiences and responses to the process. The choreographic tasks helped participants bridge the understanding of movement in animation with the movement experience of choreography, exploring three topics of composition: Poses, Editing and Capture.

We held the focus group at the end of the workshop with pre-designed open-ended interview questions constructed to provoke conversation about the participant’s experience and ideas.

_idanceForms Youth Study Analytical Results_

We articulate our findings from the youth dancer’s workshop in two sections: our observations on how children managed the device in analytical tasks and what children said about their experience throughout the sessions and the focus group. While performing editing and playback actions in the app, children tended to sit down when focusing solely on the iPad, using minimal movement beyond their fingers. While children were physically learning the movement themselves they would leave the iPad on the ground to view while standing to move.

Tasks for capturing and generating poses by using the camera keyframing function required more interaction between youth. One child would need to hold the iPad to take a photo of the other, or of objects that were provided to provoke creative pose capture. In this workshop, children were more interested in how accurately their pose was captured rather than generating creative options.
Children talked about their experience throughout the class and the focus group. Three applications that students were interested in included being able to be more creative, having a tool to use when getting stuck and having a tool to help them practice and remember a dance. We also highlight some areas to work on, relating to some functionality being difficult for the youth to use.

**Being Creative**

Children found the software useful because they could create their own movements and personalize existing ones. This function facilitated their own exploration of creativity in movement without constraints. They were excited that they could create options that would be silly or impossible to do.
P3: “I liked how I could invent things and make them look cool”

P5: “…you got to make up your own dances, and that was cool and you could move body parts around.”

**Getting Stuck**

Youth acknowledged their own process of getting stuck when they are making up their own dances. While this topic is similar to being creative, the youth also acknowledged the ability to be reminded of material that they already know. This application was useful as a tool to remember steps and refer back to prior work.

P6: “it was really nice because sometimes when you’re choreographing you can get stuck but this is cool because you can do it and follow the steps”

P7: “… when you have choreography block you don’t always know what to do and then this could really help, because you can change it up to make it more personal”
Practice

Children acknowledged the use of the tool to help them practice both existing and new material. Practicing included both remembering the movement accurately, as well as having the ability to shift parameters such as timing to help better understand the movement.

P10: “If you could take pictures at first and then could practice it”

P12: “… I liked how you could adjust how fast or slow the figure moves”

Children did have some difficulty with the software due to the detail and refinement of the application.

P2: “I got lost when all the arrows kind of curved around and I tried to press one but it changed something that was an accident.”
Using the touch interface for editing the skeleton was difficult for some children due to it requiring small or detailed surface area for interaction. Some children didn't have the patience or fine motor control to manage small icons for moving and rotating joints.

P8: “What kinda scared me was the mannequin on it, you could see these markings on the face that looked like scars.”

We didn’t realize there were still some small rendering issues on the avatar that some children interpreted as scars. This comment highlights the importance of visual resolution for youth to keep them engaged in the function of the application.

P13: “It was cool to use the camera but sometimes it wouldn’t recognize the way you were holding the camera and the picture would be sideways.”

The camera keyframing function currently only works in portrait mode, which was confusing to some children. Also, due to current 2D camera limitations the skeleton selected from the camera capture is not always an accurate representation of the pose captured. This was difficult for some children to work with, even in a creativity context.

P14: “The thing with the camera is that you need 2 people to do it.”

The children seemed very interested in being able to make dances in the car on a roadtrip, or as a play activity when they are by themselves. This makes the camera keyframing function difficult because it requires a second person to take the photo. However poses can still be created by using the skeleton editing feature.
Discussion

While there is obviously a difference in the skill levels between children and professional choreographers, we found differences between how the children and adults interact with the iPad device. There was not as much in-between-position movement with youth as with the professional dancers, who were actively embodying movement as they worked with the app. When editing a captured pose, children would sit down again to focus on selecting and moving joints, often attempting to create accuracy rather than creative options. We believe that at the younger skill level students are still learning the technique of “the moves” and are less comfortable with creatively manipulating them. This would also be due to the different level of “creativity” that children are at than professional choreographers working in the contemporary art world.
Children were guided through many movement games before we began focusing on creating choreographic content on the iPad. The iPad drew their whole attention into the screen right away, requiring guided instructions on how to use it to shift back into whole body movement. The children were more interested in using idanceForms as a tool to create a dance on a roadtrip or to document a dance for reviewing later. This is quite different from the professional dancers who were more interested in using the application to support their existing movement practice. Choreographers used idanceForms as a tool for sketching ideas, to provoke and prototype movement experiences.

Whole-body interaction and a design based in the embodied knowledge of the choreographer or of the dance student are the critical design elements in a choreographic support tool. By engaging the expertise of movement experience and designing for the affordances of mobile tablets we can create provocative, open creative environments for choreographers to explore personalized movement choices in which to create meaning.

3.3. Conclusion

Through these four design iterations the idanceForms team and I learned many items about how choreographers (both more and less experienced) thought through choreography and creativity. Some design considerations reflect functionality (such as how to hold or engage with technology in a studio space), some reflect practical choreographic processes (such as documenting a movement phrase, or using cues to help remember choreographic choices, or enabling choreography on a roadtrip) while many considerations reflect aspects of creative process (how to create a situation in which you think differently, how to create value and meaning in movement material, how to engage physical attributes of movement within a non-physical digital environment). This work fuelled my final system design for this dissertation, implementing Cochoreo as a generative feature in idanceForms, in which to support the interactive choreographic process of choreographer creating movement alongside the generative tool to iteratively develop movement phrases.
Chapter 4. Cochoreo and idanceForms: A Choreographic Support Tool for Interactive Creative Process

Figure 26. Implementing Iterative Design Process for Choreographic Tools

Thus far this dissertation has explored existing research around choreography, creativity and defamiliarization, where I have investigated four design iterations

7 This chapter draws upon previously published work:


implementing creativity tools for choreographic process. Chapter four presents the final system design, adding the Cochoreo generative feature to idanceForms. This chapter reiterates the design motivation and context while providing a historical account of DanceForms. The design choices for idanceForms are then presented, highlighting salient features and the technical details of Cochoreo.

While there are many facets of communication that are important in the co-imaginative choreographic process, this research focuses on visual representation of information, both in how generated material is presented to a choreographer and how a choreographer’s movement is captured into the software. The basis of how choreographers work with movement is the visual and kinesthetic shape. Visual representation can be high resolution, which provides articulate instruction of generated movement, or low resolution, empowering the choreographer’s interpretation of information. Low resolution of information can be a useful tool when using defamiliarization techniques. Defamiliarization, or ‘making strange’, is a pragmatic tactic for making the familiar unfamiliar in order to bring new awareness to known practices (Crawford, 1984). This form of ‘disorientation’ incites the user to assert their agency within a creative scenario and can be used to engage a user with a creative system. Schiphorst notes in her Master’s Thesis that ‘through the dances he has made, Cunningham has amplified the understanding that choreographers can work with computer technology to extend possibilities in creating dance’ (1992). This approach to extending possibilities in creating dance has initiated the approach to using technology in choreographic process, and I have been interested in how to add more creative control to the technology in support of extending possibilities.

To investigate methods for designing co-imagining features in creativity support tools, I explored generative compositional functions in idanceForms, an existing tool for choreography. idanceForms is a creativity support tool, designed as an extension of the choreography animation software (DanceForms) for mobile devices. idanceForms is developed by researchers at Simon Fraser University and Trinity Western University as part of the movingstories Research Partnership. idanceForms is a highly versatile choreographic support tool which enables choreographers to capture movement ‘still
forms’ as keyframes by using an iPad camera. These keyframes can be manipulated, sequenced and played back in idanceForms by using a combination of touch interaction and accelerometer interaction with other mobile devices. idanceForms has been designed through the epistemology of choreography; by leveraging whole-body interaction and sketching to create a mobile support tool for personal meaning-making (Carlson et al, 2015). Using an animation platform for movement composition maintains an element of precision that the original DanceForms software has, while opening to new opportunities for interaction, design and representation of movement (Calvert et al, 1991). I evaluated idanceForms as an assistive tool for choreographers through multiple studies to maintain the focus on designing for a choreographer’s embodied experience.

To further explore the role of interaction in an iterative creativity support tool, I have designed a generative function for creating novel movement keyframes titled ‘Cochoreo’ (as a feature within the idanceForms’ base). The integration of a generative feature (Cochoreo) in idanceForms enables us to create a tool that can be tailored to support both choreographer’s existing practices as well as provoke them to explore new creative ideas for movement. The idanceForms software team implemented the generative function into the existing code. This generative feature bridges towards the domain of computational creativity, yet engages with the choreographer’s embodied process through innovative techniques in both the physical domain (using existing movement frameworks such as Laban Movement Analysis) and the cognitive domain (defamiliarization). The feature generates unique body positions, or still forms, by either using the choreographer’s own movement as source material or evaluation criteria, by generating keyframes based on criteria defined by the choreographer, or by generating novel keyframes based on pre-defined criteria. The generative feature will be implemented directly in the software and tested with choreographers in studio workshops.
4.1. Cochoreo System Design

I designed Cochoreo as an online, generative feature of idanceForms, used to interactively generate novel keyframes for creative movement. It was designed through an extensive embodied process of evaluating different body positional parameters in movement and testing their relationship to codified movement techniques and typical individual movement habits. Cochoreo was implemented by the idanceForms development team. Keyframes consist of a still form body position, a human-shaped avatar with movement possibilities in all 3 axis. Cochoreo uses a Genetic Algorithm to evolve new keyframes from an initial gene pool. The initial gene pool can be created randomly or through choreographer parameterization. Genes are evaluated using either the prescribed goals for success or goals selected by the choreographer. This initial population is then subjected to an iterative cycle of selection and breeding. Genes are bred using a two point cross over function with a 10 percent mutation percentage to create a new population that maintains diversity. Once a cycle is complete the new population is judged on its fitness once again and the process continues for a fixed number of iterations (5) or until a certain fitness threshold is reached (Russell & Norvig, 2010).

Currently Cochoreo operates using 2D data with the z-axis zeroed out. While we plan to eventually move to 3D it will require another iterative design process to develop a constraint system for preferred creativity.

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8 This section draws from previously published work:
4.1.1. Genetic Algorithm

A Genetic Algorithm is used to evolve movement catalysts. This allows the system to control fundamental components that problematize the dancer’s process of generating movement. Genetic Algorithms are typically used to explore a wider range of potential solutions than other search algorithms can (Floreano, 2008). Initially a large population of random individuals are generated and given a score for their fitness against the prescribed goals for success. This initial population is then subjected to an iterative cycle of selection and breeding. Once a cycle is complete the new population is judged on its fitness once again and the process continues for a fixed number of iterations or until a certain fitness threshold is reached (Floreano and Mattiussi 2008; Russell and Norvig 2010). Cochoreo has both a pre-defined and parameterized fitness function to enable choreographic engagement with the generated keyframes.

Populating the Gene Pool

The system generates keyframes randomly, which are designed to allow unlimited possibilities. The number of 9 genes was also selected as a number that is reasonable for a choreographer to input that will give sufficient information to breed from.

Fitness Function

A rule based system is used to evaluate the fitness of each movement catalyst. We have developed heuristic rules based on movement patterns discussed in Bartenieff Fundamentals and the author’s expertise in contemporary dance practice to inhibit traditional habits when creating movement. The fitness function evaluates each catalyst component separately (body position, height, effort qualities and Bartenieff) and then calculates the overall score.

Laban Efforts and Bartenieff Fundamentals

The design of incomplete movement data is based on studies in movement patterns and effort qualities by Laban and Bartenieff (Bartenieff et al., 1984; Bartenieff & Lewis, 1980; Hackney, 1998; Studd & Cox, 2013). Rudolf Laban developed a method of categorization to analyze, notate and create movement. One property of movement that
Laban explores is ‘effort’, the quality used to execute a movement. He emphasized that 
every movement possesses effort qualities as forerunners of the movement execution. He 
describes four quality components (See Figure 30.A): weight (light to strong), time (sudden 
to sustained), space (direct to indirect) and flow (bound to free). For example, ‘Movements 
performed with a high degree of bound flow reveal the readiness of the moving person to 
stop at any moment in order to readjust the effort if it proves to be wrong, or endangers 
success. In movements done with fluent flow, a total lack of control or abandon becomes 
visible, in which the ability to stop is considered inessential’ (Laban, 1947). Scuddles uses 
all effort quality components as ‘instructions’ for executing a position. The combinations 
of qualities are designed to create interesting yet complex physical patterns for the body 
to execute.

![Figure 27. Laban’s Effort Quality Graph and Bartenieff’s Separation of Bodily Planes](image)

Bartenieff Fundamentals are a further development of Laban’s research to the 
moving body (Hackney, 1998). Bartenieff uses anatomical body planes to deconstruct 
movement into categories such as pathways of movement, movement patterning, spatial 
intent and core support. The body planes (see Figure 30.B) sagittal, coronal and 
transverse help to illustrate movement patterns. For example, homologous positions 
(same limb positions for one side of the transverse plane), homolateral positions (same 
limb positions for one side of the sagittal plane), contralateral positions (same limb position
for one opposing limb on each side of the sagittal plane). Additional movement pathways include distal positions (all limbs fully extended) and medial positions (all limbs fully contracted). Bartenieff Principals are used in Scuddle to explore and inhibit habitual movement patterns. To create complex catalysts, emphasis on inhibiting habitual movements is designed through the use of asymmetry and complex variations between joint angles on a position (Birkhoff, 1956).

**Fitness Function Implementation**

To compare the catalyst components we map each value separately. Each of the 8 joint angles are weighted based on their location within quadrants. For example, angles between 0-90 degrees are placed in one quadrant and 90-180 degrees in another. The orientations of quadrants are based on their location from the center of the body (See Figure 31). This weighting is designed to lower the score for fully outstretched or contracted limbs by placing all joint angles on diagonals that score 1, creating an overall body position score of 8 (1 x 8 joints). For example, the bent arms in Figure 2 have scores as follows: the left shoulder is 340 degrees which is mapped to 4 and the left elbow is 220 degrees to map to 1. This sum of these mappings gives Figure 31 a body position score of 14. Height is the level at which the body position is to be executed. These values are used to emphasize more unstable positions such as balancing in crouches and on the toes (See Figure 32).

Effort Qualities refer to the effort used to execute a body position and height. Fighting efforts are direct, strong, sudden and bound. Indulging efforts are indirect, light, sustained and free. A combination of four fighting or indulging efforts results in modifying the sum of the position and height by -60%. Combinations of two fighting and two indulging efforts modify the sum of the position and height by +20%. Three fighting efforts and one indulging effort or three indulging efforts and one fighting effort modify the sum of the position and height by +40%.
Figure 28. Weighting of Quadrants for Body Position

Figure 29. Height Weighting and Bartenieff Modifiers

Symmetry of body position is analyzed as movement patterns (based in Bartenieff Fundamentals). Contralateral motions explore the diagonals made across the body. In homologous motions the relationship of the top half of the body is compared to the lower half. Homolateral motions compare the limb position of one side of the body. All limbs fully extended are considered distal and all limbs fully contracted as medial. To address habit inhibition, heuristic rules are designed to favour contralateral motion (asymmetry) while
hindering homologous and homolateral motion (a tendency of codified dance techniques). See Figure 33 for the assigned modifier that is applied.

Figure 30. Example Illustration of Movement Catalyst Score with Application

The fitness for a movement catalyst is calculated as the sum of body position and height that is modified based on the combination of Laban effort qualities and Bartenieff movement patterns. See Figure 34 for an example of mappings and fitness score. The equation for the score is:
\begin{equation}
\text{Fitness}(mc) = \quad BP_{mc} + \text{Height}_{mc} \times (1.0 + Bartenieff_{mc} + \text{Laban}_{mc})
\end{equation}

Figure 31. Example of Scoring for Fitness Function

**Parameterized Fitness Function**

There are two options for using the parameterized fitness function to evaluate novel body position criteria in keyframes. The options are: a non-parameterized pre-defined fitness function and a parameterized fitness function based on Bartenieff Fundamental’s movement constructs. The non-parameterized fitness function uses a pre-defined set of criteria specifically for provoking novel keyframes based on traditional dance movement. We have developed heuristic rules based on movement patterns discussed in Bartenieff Fundamentals and the author’s expertise in contemporary dance practice to inhibit traditional habits when creating movement (Bartenieff & Lewis, 1980; Studd & Cox, 2013). The fitness function evaluates each catalyst component separately (body symmetry, body position and levels) and then calculates the overall score. Positions that highlight contralateral movement (body asymmetry), unstable levels and partially bent joints are preferred to create novel movement options.

**Selection, Cross Over and Mutation**

We select 20 percent of the movement catalyst population by Roulette Wheel to be parents for the next generation of offspring. The Roulette Wheel process selects individuals with likelihood proportional to their fitness. Two individuals at a time are bred through two-point cross over, chosen from the pool of parents. The breeding takes place by selecting two random placeholders from the two individual’s values and switching the values between place-holders (See Table 1). The offspring are added into the new pool of individuals. The breeding process continues until the population has grown back to the original size. Once the size of the population has regenerated, ten percent of the individuals are randomly selected to mutate. The mutation occurs by choosing a random
placeholder in the values of the individual and generating a new value for that place (See Table 2).

| Individual 1 | [4, 1, 2, ||1, 1, 2, 1, 2||, 3, 2, 1, 2, 2] |
| Individual 2 | [1, 1, 2, ||2, 4, 2, 3, 1||, 3, 1, 1, 2, 2] |
| New Indiv 1  | [4, 1, 2, ||2, 4, 2, 3, 1||, 3, 2, 1, 2, 2] |
| New Indiv 2  | [1, 1, 2, ||1, 1, 2, 1, 2||, 3, 1, 1, 2, 2] |

Table 1. Example of Cross Over

| Individual 1 | [4, 1, 2, 1, 1, 2, 1, ||4||, 3, 2, 1, 2, 2] |
| Mutated1     | [4,1,2,1,1,2,1,||2||,3,2,1,2,2] |

Table 2. Example of Mutation

The cycle of Selection, Cross Over and Mutation repeats until the termination criteria has been fulfilled. This has been set at 6 generations to retain diversity in the population. For the final selection of individuals, Roulette Wheel selection is used to choose 5 individuals from the population to be presented in sequence to the choreographer.

4.1.2. Cochoreo Interaction

To use the Cochoreo feature in idanceForms, the choreographer goes into the keyframe editing screen and selects a new keyframe. The Cochoreo screen is simple, providing a button for ‘Generate’ and a gear icon for access to the settings. Every time the Generate button is pressed a new keyframe is created. This keyframe can then be re-edited in the skeleton editing view. Limbs can be isolated by selecting them, changing the
color from pink to white. Isolated limbs will stay in place during the next generation cycle and can be un-selected by touching them again. If generation including a spinal configuration or spatial orientation is desired the user can manipulate these features first and then generate new keyframes in which the edits will be retained.

The default fitness function generates keyframes based on the pre-defined rules as described in section 4.2.1, developed through an iterative design process to specifically restrict habits from dance technique and provoke novel movement options. This default fitness function weights body asymmetry, uneven reach space and unstable levels more strongly to encourage novel movement exploration.

Figure 32. Cochoreo Default Fitness Function

The parameterized fitness function enables the choreographer to select options based in the Bartenieff Fundamental parameters to weight the probability of that feature more or less strongly. Parameters include: Body Half (symmetry on one side of the body), Upper Lower (symmetry on top or bottom half of the body), Cross Lateral (symmetry across the body with one arm and one leg), Near Reach Space (arms contracted), Far
Reach Space (arms extended), Knee Extension/ Flexion (creating more or less stable levels). The following images illustrate the resulting generation positions of Cochoreo by isolating two limbs.

Figure 33. Cochoreo Parameterized Fitness Function with Left Limbs Isolated
4.2. idanceForms: A Sketching Tool for Creative Movement

Cunningham balances the computer’s precise representation with the realities of human physicality, “I look at some things and say, “well that’s impossible for a dancer to do. But if I look long enough I could think of a way it could be done. Not

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9 This section draws from previously published work:

exactly as its done on the screen, but it could prompt my eye to see something I’ve never thought of before.” (Calvert et al., 1993)

Cochoreo resides in the software ‘idanceForms’ (idF), which is a new tablet based mobile animation tool. This creativity support tool allows the choreographer to sketch movement by creating, editing and viewing human figure animation on a tablet. Specifically, the choreographer can compose and edit dance sequences using both the traditional editing of the human figure and the use of Camera Keyframing where a camera is used to create new keyframes. Camera Keyframing is an application of pose estimation and markerless motion capture where there has been extensive research. idanceForms has been designed based on the epistemology of choreography; leveraging whole-body interaction as well as the playful and low-risk properties of sketching to create a mobile support tool for exploring creative movement in-situ. By using an animation platform we can continue to provide an element of precision that the original DanceForms software maintains while opening to new opportunities for interaction, design and representation of movement. Our contribution with idF is its application to the live, in-situ creation and iteration of creative movement.

IdF is a player where the user can visualize the animation files in a flexible 3D environment. This supports a variety of skeleton based bodies and is able to read animation files in a variety of formats: including the .lfa files used by LifeForms and DanceForms, COLLADA files (this is an evolving standard for animation files) and .bvh files (a standard format used in motion capture data). A prototype of the Player has been implemented for the iPad and is available in the iTunes App Store. (https://itunes.apple.com/ca/app/idanceForms/id689409314?mt=8). It is a significantly greater challenge to design and implement a tablet-based tool for composition and editing. A high level challenge involves the approach to screen layout. Many tablets adopt a strategy where the running app takes over the whole screen without any sub-windows. The challenge here is that the original DanceForms composition/editor tool typically had 4 or 5 active windows in use simultaneously to allow a multi-tasking workflow. To limit editing to a single window, the keyframes on the Score (timeline) are folded onto a 3X3 matrix, starting at top left and ending at bottom right. Moving through the timeline there are successive 3X3 displays. In any of these 3X3 displays a particular keyframe can be
selected and edited as required. The lower level editing tasks that must be supported include:

- Creation and editing of keyframes. This typically gives the user access to forward and inverse kinematics to set the pose of the underlying skeleton for each figure.

- Design of the movement over time. This traditionally uses a timeline formalism and display so that the user can slide a given keyframe backwards or forwards in time.

- High level editing of movement sequences. This form of editing is analogous to cut and paste editing in a word processor. A sequence of keyframes can be copied from one location and pasted into another location, or cut and removed all together.

It is clear that innovative screen design is necessary if the new idF system is to allow simultaneous editing in space and time. The design and implementation of different strategies to achieve this is the focus of much of the remainder of this chapter.
4.2.1. Camera Keyframing Feature

When a choreographer opens the idanceForms application on a mobile tablet, they have access to a camera function to take a photograph of a dancer. The choreographer can frame the dancer's still form by viewing the dancer through the device's camera, and capturing their pose as a keyframe. This enables a "moment by moment" accumulation of movement poses that produce a simple movement sketch that can be played as a movement sequence. Utilizing the 2D camera in mobile devices, the background is removed and the dancer's keyframe is compared to an existing database of images with existing skeletal data. The existing skeletal data is used to create a keyframe that can be added or reordered within a sequence of other keyframes to create a movement sketch that can be further manipulated by the choreographer. This ‘capture’ process is an novel innovation for movement interaction which enables us to capture a wide variety of keyframe poses.
“To use the Camera Keyframing feature the person posing for the keyframe needs to be dressed in dark (black preferred) clothing in front of a white background. The built-in computer vision algorithm will then capture the pose and search through a database of pre-stored standard poses in order to try to find a corresponding skeleton pose. Once the skeleton pose has been found, it will be added to the list of keyframes. We have designed a database of movement using planar poses that can be easily detected from the front without occlusion” (Calvert, 2016; Carlson, Schiphorst, et al., 2015; Carlson, Tsang, et al., 2015). These poses include general and creative body positions as well as an imitation of alphabet letters to use in our study with novice users.

4.2.2. Sequencing Procedures: Touch-Based Interaction

Once the choreographer has captured still forms to use as keyframes in their animation they have options for adjusting sequencing and timing of keyframes. After the keyframes are created, the user can use the touch interface to select, reorder, drag and drop the keyframes. This procedure allows the user to reorder the sequence of poses as they appear in the sequence. Because we are working with keyframes, there is built-in linear interpolation that takes the shortest path to move from one keyframe to the next. This creates a unique 'movement' from the transition between a starting and ending still pose. The choreographer can control the timing of this 'movement' by adjusting the timing into and out of a stillframe with the timing bar at the top of the editing screen.
Figure 36. idanceForms Frame Sequencing Screen

By using finger gestures the user can manipulate the skeleton at a joint and limbs level through direct manipulation. This fine control is facilitated by the gimbal ball visualization where the user can select the axis of the movement and then move the limbs accordingly. A pose contains a transform for each joint in the figure’s skeleton and each transform contains a quaternion for rotation and vectors for translation and scaling. When playing the animation, we keep track of the current keyframe and the current in-between frame. When a new frame is requested, the current in-between frame will be incremented. If the requested new frame is greater than the current keyframe in between frames, then the current keyframe is incremented.
The skeleton setup and skinning method we use is based on the COLLADA standard. The skeleton is a simple tree of joints with a single root. Human skeleton skinning is the process used to make the connection between a bone in the skeleton and the character’s visual rendering. In idanceForms, skinning is done by assigning each vertex in a mesh to up to 4 joints with a weight value for each joint. The bind pose (also called the rest pose) is embedded into every transformation for efficiency. An inverse bind pose transformation is stored to keep transformations oriented around the origin so that joint rotations are applied correctly.

We use a linked list of keyframes to store our animations for two reasons a) this makes it easier to swap or move keyframes around during editing and b) it is also faster to play back the animation. Each keyframe stores a pose and an integer representing the number of in-between frames until the next keyframe. We do not store the explicit frame number in a keyframe, this is determined by the sum of the previous keyframes in the
linked list added to the sum of in-between frames for each keyframe, and this allows keyframes to be easily swapped / moved without recalculating their frame.

A linked list of keyframes are stored in the animation, which makes it easy and efficient to swap or move keyframes in the keyframe view. Each keyframe stores a pose and an integer representing the number of frames until the next keyframe. A pose contains transformation data for each joint in the figure’s skeleton. Each transformation incorporates a quaternion for rotation and vectors for translation and scale. When a new frame is requested the current in-between frame is incremented. If it is greater than the current stillframes stored in-between frames, then the current keyframe is incremented. An in-between frame is calculated as the linear interpolation between two poses based on the current keyframe and current in-between. Each transformation in the poses are interpolated using slerp for the quaternion rotation. Standard linear interpolation is used on the vectors for scale and translation.
4.2.3. Viewing Sketches: Playback Sequences

Once the choreographer has created, sequenced and adjusted timing of keyframes they can view the animation in the playback screen. The playback screen enables the choreographer to view the animation on a 'stage' that they can move around using single finger touch to rotate around the space as well as pinch gestures to zoom. There are multiple lighting options to highlight the movement depending on creative vision of the choreography. The playback view is an important piece of the choreographic process, because it provides opportunity for viewing the animated movement, understanding the movement through the kinaesthetically empathetic experience and reflection on the selection of and sequencing of still forms as keyframes. Playback is the portion of the creative process that provokes reflection and evaluation of choices made in the sketching process. Playback is the result of rapid prototyping, creating a space for
choreographers to externalize movement ideas, reflect in action and quickly continue working to create and evaluate movement ideas.

4.2.4. idanceForms' Design Process

idanceForms has been designed by utilizing the craft knowledge held by the participating research team, in co-imagination with professional choreographers (Benford et al., 2013). Design features for the current and future visions of idanceForms are developed from the literature of choreographic process in addition to the researcher's craft knowledge, observations of and conversations with choreographers. This history of choreography provides frameworks and strategies for sketching, sequencing and reflecting on movement to make personal meaning from movement material both experientially and analytically. Frameworks and strategies include Laban Movement Analysis, Viewpoints and techniques developed in disciplines such as Ballet, Modern and Improvisation (Blom, 1982; Bogart & Landau, 2004; Hagendoorn, 2008; Humphrey, 2003; Studd & Cox, 2013). These specific techniques for generating and assessing creative movement can be leveraged in technology design to support composition through new lenses, creating a tremendous amount of potential for creativity in choreography (Carlson, Schiphorst, & Pasquier, 2011).

Advances in mobile devices are enabling exploration of touch and qualities of motion in-situ that can create new spaces for creative exploration (Thecla Schiphorst, 2011). This can greatly change the opportunities for movement and technology. In an choreographer's practice, prior options for authoring movement in DanceForms or other systems required them to leave the studio, or to have a full desktop station in the studio. The separation between experientially exploring movement and analytically navigating software was difficult to bridge before mobile devices. The portability of current mobile technology with the power for natural touch interfaces, embedded sensors and cameras creates a unique tool that is easily accessible while in motion and in the moment. These new developments provide a plethora of opportunities to explore how technology can extend the existing practices of artists such as choreographers, animators, and special
effect artist in order to augment their creative and compositional experiences with movement.
Chapter 5. Evaluating Choreographic Creativity in the Field

Prior chapters have illustrated the research context, iterative experiential design processes and pilot studies, methodology approaches and system design details. Chapter five describes the demographics of the study participants, provides the study protocol and indicates the data analysis process used.

In this chapter, Cochoreo is investigated for how it supports iterative choreographic creativity and evaluated the choreographic experience in co-imagination. Creativity was provoked and observed through three in-situ workshops with novice choreographers: first a dance composition class at the University of Illinois at Urbana-Champaign Dance Department (UIUC), second an open call for choreographers in Illinois State University’s Dance Department (ISU) and third an open call for choreographer in the University of Illinois at Urbana-Champaign’s Dance Department (UIUC). The study was developed to explore the choreographer’s experience to see evidence of co-imagining through the iterative process of ‘sketching’ movement, using the digital tools as ‘catalysts’ for generating and augmenting movement material. Dancers created content through multiple stages, which was documented through focus groups, video documentation, and
notebooks. Data is analyzed using a grounded theory-based method to support emergent themes that develop in stages.

These studies are identified as Study 1 (composition class from UIUC), Study 2 (open call at ISU) and Study 3 (open call at UIUC). Studies were performed in this manner to gather data in steps and also to accommodate busy student choreographer schedules. Study 1 took place in two classes with a homework assignment in between over a week. Studies 2 and 3 took place as six concurrent workshop sessions over a week each at the end of the academic term. We have used a Grounded Theory inspired methodology where initial data is collected and analyzed and then additional data is gathered and concurrently analyzed and compared to the initial analysis. We used the common practice of collecting data in steps to support a variety of novice choreographer contexts while maintaining similar protocols while supporting the validity of the results.

An example video of a CoChoreo file and the choreographer’s correlating movement phrase can be viewed here or at the bottom of the accompanying website: https://youtu.be/bFQZnpCyQfM or http://my.ilstu.edu/~kacarl1/index.html

5.1. Demographics

5.1.1. Study 1: Composition Class at UIUC

Participants in Study 1 were 1 male and 13 women dancers in their second year of university dance training at UIUC, known for its strong technically trained dancers. At this point of the training the dancers are taking more improvisation and composition courses, alongside many technique courses. This relatively new focus on generating and augmenting movement compositionally is often a very different perspective for a technically trained dancer, who has spent their performance career thus far being concerned with how precisely they can perform another person’s choreography. This seemingly subtle shift from dancer to choreographer can dramatically shift the experience of cognitive load, because a choreographer (particularly when performing improvisation) is making choreographic design decisions in the moment, while aware of both the immediate situation of a dance and the whole picture of the composition. This experience
is very different from a focus on mimicking dictated movement where the experience is on
the body’s adherence to a defined aesthetic standard. The participant choreographers had
varying comfort levels with composition that seem to reflect their attention to and reflection
on their personal movement preferences. This is apparent in their comfort when working
independently, hence this study had a more rigid protocol for developing movement
phrases.

5.1.2. Study 2: Workshop Sessions at ISU

Participants in Study 2 were 1 male and 7 women dancers who varied from being
at the end of their first year of university training to seniors at the end of their program.
While ISU is a smaller dance department than UIUC (and resides within their Theatre
Department) I found the choreographers to be equally strong in technique and composition
training. ISU dancers are not as strong in improvisation as UIUC, though they were very
comfortable with composition and working independently. Hence this study had a looser
protocol for developing movement phrases to encourage choreographer-led creativity.

5.1.3. Study 3: Workshop Sessions at UIUC

Participants in Study 3 were 7 women dancers who were in their second or third
year of university training. One of the participants had also been in the composition class
study. These choreographers were overall stronger and more confident as improvisers
and composers than those in the composition class and were much more comfortable
working independently. Hence this study had a looser protocol for developing movement
phrases to encourage choreographer-led creativity.

5.1.4. Study Demographic Conclusion

While I find it important to indicate the state in which the choreographers were
working, the process of defamiliarization always disorients the participant initially (which
is the point of using a defamiliarization technique). It has been my experience just as often
when interacting with strongly established professional artists that they react strongly at
the beginning of the process, a reaction which is transformed over time with patience and support.

5.2. Study Protocol

5.2.1. Study 1: Composition Class at UIUC

Study 1 was run as three separate sections with undergraduate choreographers in a second year composition class. The limitation of the study to this time period was due to taking place in Rebecca Nettl-Fiol’s scheduled dance composition class. Because of her tight semester schedule we were not able to take over more than two of her classes. However this structure enabled us to have a large number of consistent participants. The composition class focused on different ways to generate movement material, including chance procedures used by Merce Cunningham. The course instructor, Rebecca Nettl-Fiol is a choreographer, Alexander Technique teacher and Labanotation expert. The students met in two classes and had an assignment between classes to use the digital tool in their choreographic process to generate and iterate movement material.

The digital tool, idF was presented first as a platform for sketching movement ideas. Facets of the tool were presented one at a time through the study, then used as a tasks for creating and iterating movement material. This meant that movement material was generated first using the skeleton editing tool, developed further with the camera keyframing function and iterated again with Cochoreo's default function. Cochoreo was presented last to confirm participant capability working with the software platform. Between the classes, choreographers rehearsed the phrase they finished the first class with and augmented it using three instructions to further develop the phrase. In the second class movement material was iterated again using the parameterized Cochoreo feature and by reversing the process (capturing body-designed movement into idF and re-learning it).

Data was captured in focus groups at both the beginning and ending of each class, supported by phenomenological interviewing techniques. Phenomenological interviewing
techniques were used to help choreographers unpack their experience, since movement experiences often tend to be less verbally articulated and more descriptions of sensory experiences. Every variation of the movement sequence was video recorded using the iPads by each participant. Both class sessions were documented with video to support deeper investigation by observation. In between the sessions the choreographers took notes about their experience of iterating the movement sequence without technology.

5.2.2. Study 2 and 3: Workshop Sessions at ISU and UIUC

Study 2 and 3 were run as five to six workshop sessions with undergraduate choreographers who voluntarily participated through an open call. This method gathered as many participants collectively as Study 1, yet when separated into two groups it enabled collection of deeper data over a longer timeline.

In these sessions Cochoreo was presented as a tool to generate movement ideas with the rest of the idF framework available to support iterative development. This is different from the first study in that idF was minimally described, enabling a strong focus on Cochoreo itself. The first session asked choreographers to create a phrase themselves, without technology, to create a control for creativity to compare future work to. The second session presented Cochoreo and asked choreographers to devise a movement phrase with it. Following sessions iterated this movement phrase, created variations and contextualized it in a larger compositional concept. The studies concluded with choreographers creating a phrase from all the things they disliked about their last iteration of the movement phrase created with Cochoreo. Studies 2 and 3 differed subtlety in structure. Study 2 had 6 sessions that focused on one choreographic task per session. Study 3 had 5 sessions (due to restrictions in choreographer availability) that were longer time periods and sometimes had two choreographic tasks per session.

Data was captured in focus groups at the end of each session, supported by phenomenological interviewing techniques. Phenomenological interviewing techniques were used to help choreographers unpack their experience, since movement experiences
often tend to be less verbally articulated and more descriptions of sensory experiences. Sessions were documented with video to support deeper investigation by observation.

### 5.2.3. Conditions of the Studies

Research Question:

How does a novice choreographer’s experience of defamiliarization with a co-imagining choreographic-support tool effect the development of ‘ah ha’ moments?

### 5.2.4. Study 1: Composition Class at UIUC

Process: Developing one movement phrase over time while using multiple instances of a tool to support the generation of movement material and sequences of movement.

Conditions:

1. Choreographing using idf features (creating keyframes manually and with camera keyframing)
2. Choreographing without the tool (no technology)
3. Using cochoreo features (generating keyframes with existing and parameterized FF)

**Workshop 1 Protocol (Section 1) Focusing on Condition 1**

- Participants sign consent forms
- Introduce Material: Describe the history of Dance/LifeForms and Cunningham’s work with technology
- Initial Focus Group: Discussion about personal composition practices
- Present idanceForms: Teach how to use digital tool
- Composition: Create original movement material as a sequence using idF as part of your process: Condition 1
  - Generate material in 3 ways, iterate with time limits:
- Skeleton editing
- Camera keyframing
- Cochoreo default
  - Choreographers save their editing files
  - Choreographers use iPads to video each variation of their sequence
- Final Focus Group: Discussion about experience of sketching with idF

In-Between Workshops Protocol (Section 2) Focusing on Condition 2

- Practice final sequence each day in-between
- Iterate the movement sequence 3 times with constraints (without technology) and write about the experience and changes: Condition 2
  - Mutate two movements in the sequence
  - Perform the sequence without one limb
  - Retrograde the sequence
- Document the experience and new ideas by writing in the provided notebooks

Workshop 2 Protocol (Section 3) Focusing on Condition 3

- Initial Focus Group: Discussion about in-between iterations
- Composition: Continue to develop movement sequence with Cochoreo: Condition 3
  - Rehearse augmented movement sequence from in-between iterations
  - Present Cochoreo’s parameterized fitness function and how to use it
  - Create additional variations of the movement sequences using Cochoreo as part of your process
  - Iterate a body-designed movement by capturing it in idF and re-learning it
  - Choreographers save their editing files
  - Choreographers use iPads to video each variation of their sequence
- Final Focus Group: Discussion about experience of sketching with idF
- Provide honorarium to participants

Study Example Questions

Day 1 Intro Q Sample (open ended):
- How do you invent new movement? What techniques, tricks or exercises do you use?
- How do you ensure you’re not inventing the same movement?
• How do you gather inspiration? What senses do you use? Do you use sensory cues or feeling cues or body cues? When does a movement ‘connect’ for you?
• How do you define creativity in your own movement?
• What is a ‘creative’ choice for you? How do you manage your habits/preferences?

Day 2 Intro Q Sample (open ended):
• What was the experience without technology?
• What was similar to your own process?
• How were the constraints similar to the technology?
• How is the technology different from the instruction constraints?

Concluding Q Sample (each day):
• What did you find inspiring about the tool? How was it inspiring?
• What sensory modalities did you use? How did these modalities change your experience?
• How did your movement choices develop over your time using the tool?
• How did automatically generated material work into your existing content?
• How did generated material compare to your designed material in the tool?
• How did the tool support or shift your composition experience?

5.2.5. Study 2: Workshop Sessions at ISU

Process: Develop one movement phrase over time while iteratively using the Cochoreo tool to support the generation of movement material and sequences of movement.

Conditions:

1. Choreographing without the tool (no technology)

2. Choreographing using Cochoreo features (generating keyframes with existing and parameterized FF)

Session 1 (Condition 1):
Choreograph a phrase without using technology, relying on personally preferred methods

Session 2 (Condition 2):
Choreograph a phrase using Cochoreo to generate movement ideas

Session 3 (Condition 2):
Iterate the movement phrase using Cochoreo and idF if possible

Session 4 (Condition 2):
Create a variation of the movement phrase using Cochoreo and idF if possible

Session 5 (Condition 2):
Think compositional towards a complete choreography and situate the current phrases within that context

Session 6 (Condition 2):
Create a movement phrase from aspects of the last session that you dislike

5.2.6. Study 3: Workshop Sessions at UIUC

Process: Develop one movement phrase over time while iteratively using the Cochoreo tool to support the generation of movement material and sequences of movement.

Conditions:

3. Choreographing without the tool (no technology)
4. Choreographing using Cochoreo features (generating keyframes with existing and parameterized FF)

Session 1 (Condition 1):

a. Choreograph a familiar phrase without using technology, relying on personally preferred methods
b. Choreograph an unfamiliar phrase without using technology

Session 2 (Condition 2):
Choreograph a phrase using Cochoreo to generate movement ideas

Session 3 (Condition 2):

a. Interpret a Cochoreo animation created by the researcher into a movement phrase
b. Iterate the movement phrase from Session 2 using Cochoreo and idF if possible

Session 4 (Condition 2):
Create a variation of the movement phrase using Cochoreo and idF if possible

Session 5 (Condition 2):

a. Think compositional towards a complete choreography and situate the current phrases within that context
b. Create a movement phrase from aspects of the last session that you dislike

5.3. Data Analysis

Collected data was analyzed as a grounded theory-based procedure that articulated emergent themes in stages of analysis. Grounded Theory is a social science methodology that extracts the resulting model from the data itself (Denzin & Lincoln, 2005). This procedure differs from traditional research that initially identify a theory with which to evaluate the data on the chosen theoretical framework. A grounded theory approach is often recommended for exploratory research that has limited prior research upon which to base a theoretical framework. Because my literature review indicated that minimal research had explored choreographic support tools with generative or 'co-imagining' features, I chose a grounded theory-inspired approach to allow for an analysis based on the experiences of the choreographers. In addition, this approach allows for an analysis to occur on multiple levels, articulating a process, and assisted in identifying experiences through both focus group and observational data.
Interview data in this dissertation was first coded by highlighting salient details directly in the transcriptions, as emergent themes. These ‘codes’ were then analyzed amongst themselves, as Axial Coding. Axial Coding takes place away from the initial data, to extract underlying characteristics and search for new connections between them (Strauss & Corbin, 1990). This second level of analysis provided ‘concepts’ that informed broad ‘categories’ from the connections between the first and second levels of analysis. Categories were correlated with the theories of defamiliarization and collaboration (the third level of analysis), along with the codes (first level) and concepts (second level), from which the final model was extracted (Denzin, Lincoln, 2005). The general model emerged by examining the data through a variety of perspectives in relation to the research question and prior code, concepts and categories through spatial relationships. The codes, concepts and categories used in the analysis were derived from the data itself. The focus group data of each choreographer was transcribed, coded and analyzed to construct a model of the choreographer’s experience using idanceForms in their personal choreographic process.

The general model was then validated through the steps of data collection. The general model was developed from data in the Composition Class of Study 1, then was evolved and confirmed with the analysis of additional data in Workshop Session of Studies.
2 and 3. This analysis is the result of 28 participants with ~5-12 hours of composition time in the studies.
Chapter 6. Interpretation and Assessment of Novice Choreographic Process

'The aim is to set the mind in a state of radical unpreparedness; to cultivate the willing suspension of disbelief. We see and hear things as if for the first time. We see through the eyes, as Blake put it, instead of with them. In other words, the conventionality of our perceptions is put into question. We see the world afresh. This requires effort. We do not economize our creative effort in defamiliarization; instead we maximize it. By 'making strange' - ostranenie - we force the mind to rethink its situation in the world, and this requires an expenditure of effort.' (Wall & Jones, 2009, pg.20)

Figure 41. Results of Testing Experiences with Choreographic Tools

This chapter on Research Results articulates the findings of the final three focus group studies. The process for analysing the data is described, with data from each stage presented in order to provide transparency of the connections that I see in the data. Once the focus group discussions were transcribed, I went through the data of Study 1 in multiple passes to highlight salient moments, reports on experience, descriptions of process and areas of inquiry by the choreographers. This process happened in four parts: the first highlighting emergent codes, the second assessing the emergent codes for their own emergent themes. The first and second passes on the data focused on the temporal aspects of the experience. The third pass focused on merging concepts into more specific
or articulate themes that highlighted the temporal process as a shift in experience. The fourth part relates the data back to the initial research questions designed into the study, highlighting the key elements of focus in the participant’s experience separate from their temporal context. Data from Studies 2 and 3 was then transcribed, identified for salient moments and relationships between experiences and assessed in comparison to the analysis for Study 1. This chapter presents the final results first, to clarify the actual findings and compares the evolution of the analysis from Study 1 to Studies 2 and 3. The process is presented second, to support the exploration of data leading up to the final results. Choreographer comments are presented as the initial of their first name and the study they were part of, for example: B(S2).

Figure 42. Cochoreo Study 2

6.1. Final Results

Through the process of analysis presented in this chapter, I have constructed a ‘General Model’ of the choreographer’s process of developing ‘ah ha’ moments through their defamiliarized experience of sketching movement interactively with a digital tool. This
model suggests that creative choreographic experience shifts over time, particularly in relation to priorities of emerging insights + attention, movement choices and volition + intention. The study has been designed to catalyze creative experiences in interaction between the choreographer and the digital tool, and to gather both verbal and observational data about the experience. First, choreographers were asked to describe and/or illustrate their existing choreographic process and creative inspirations. Second, choreographers iteratively learned how to operate the idanceForms software and Cochoreo feature to support their own process of movement sketching while creating movement sequences. Third, choreographers iterated their movement phrases away from the technology. Fourth, choreographers iterated their movement phrases with Cochoreo to re-introduce new opportunities for movement sketching in their development of a sequence.

**Figure 43. General Model of Choreographer Experience in Interaction for Study 1**

The development of the systems and pilot studies leading up to the formal study utilized Practice-as-Research methods to iteratively research, design, experience and test the interactive experiences. All stages of the study gathered data through focus groups supported by phenomenological interview techniques and observational data. Collected data was analyzed using a Grounded-Theory inspired method of allowing themes to emerge from the data itself and to develop context and relationships through many layers and perspectives of the data, which is described in detail in the following sections of this chapter.
6.1.1. General Model: Fluid Stages of Interaction

The General Model’s fluid stages of interaction identify that the choreographer has different responses to their choreographic process at different times. These stages reflect the experience of defamiliarization, of being slightly disoriented when confronted with a new perspective from which to create (choreographer in response), of becoming more comfortable with the experience yet not taking risks (choreographer in exploration) and of being comfortable with the new perspective and able to dynamically explore and take risks while in interaction with the new perspective (choreographer in interaction). These stages and levels of comfort iterate and shift many times throughout choreographic process in response to the new approach or perspective used. In the case of idanceForms and Cochoreo these shifts were in response to the body position of a newly generated movement still frame or in exploring a transition of the animation.

These stages were seen in all the final studies performed, though ‘Choreographer in Response’ was less apparent in the open call studies (Study 2 and 3) where volition was often a positive component of the choreographer’s experience. In Figure 43 illustrating all studies, it became more apparent in later sessions of Studies 2 and 3 that choreographers were able to continue to iterate their movement material over time (as ‘Choreographer in Composition’), though they tended to use Cochoreo/ idF as a prompt or tool for creating additional material than as a tool for iterating their current material. This finding illustrates that while we have made progress on designing choreography support
tools, there continues to be more to discover in how to support creative iteration with digital tools.

One example of ‘Choreographer in Response’ is from the first session of Studies 2 and 3, where choreographers began by creating a familiar movement phrase. Choreographers were very happy to create something they felt comfortable, which reflects their volition and high agency in this stage (and again when presented with Cochoreo where many choreographers were aware of having a different form of agency in the process). They were asked to create a phrase that reflected their typical style, and favorite way to choreograph. They were then asked to describe their process. Participant L1 of Study 2 described her experience this way:

The more that I mature in my dancing the more that, Number One: I am aware of my habits and Number Two: that like, I consciously try to like, stay away from them. Of course I’ll have a signature like style, a teaching style … And even myself as an artist, like, I want to have access to the most and my body has limitless access so like breaking the habits of your mind to match your body is like this thing that’s a constant, like constantly trying to break down the build up of one another.

Choreographer L was wrestling with the process of developing choreographic habits that create a personal identity while simultaneously trying to be able to create new movement opportunities. This statement emphasizes that the notion of creativity is valuable to choreographers and is a balancing act to explore.
6.1.2. Reoccurring Macro Themes of Experience

**Emerging Insights + Awareness**

Macro themes appeared through each stage of the choreographer’s experience with Cochoreo. These themes include: Emerging Insights + Awareness, Movement Choices and Volition + Intention. Emerging Insights + Awareness refers to the choreographer’s attention to their process: moments when they became aware of their preferred choices, their own abilities and of new creative opportunities. These are essentially the ‘ah ha’ moments. These are the moments that choreographers reflect and
new insights about themselves and their process emerge, and often highlighting overlaps in the other two categories, Movement Choices and Volition + Intention. A quote about one component effecting the general process which highlights the shift of awareness:

D(S1): ‘I liked working with the program because it pushed me to do movement I would never think of. I don’t typically think of just moving the upper half and the lower half of my body and seeing how dynamically different they can be. So that was really interesting to me to try to put myself in this uncomfortable place and now a week later be comfortable in moving in that sort of way. So that was a new experience for me.’

This quote indicates that the design of using Bartenieff Fundamentals (movement separating the upper and lower halves of the body) was unfamiliar in itself. Combined with an interactive software, which represented movement in a way never seen by these choreographers, this was a very unfamiliar situation to be choreographing in. However this choreographer indicated that they became comfortable moving in this way after some time to get to know the software, allowing it to sit in their body and stepping away completely. This choreographer also stated that they found it exciting to explore movement that they otherwise wouldn’t, indicating that they discovered new movement opportunities. Also, because this statement was made in a focus group after the last session, it indicates that there was some reflection on this choreographic process to verbally communicate it. Another quote describes an emerging insight that is more specific to a movement choice, and is most likely heavily influenced by the felt experience:

A3(S1): ‘I feel like elongating the time has something to do with momentum, that the suspension can lead to something else. The time and momentum work together.’

This quote indicates an emerging insight that the manipulation of time and momentum are connected. While this might seem obvious on a cognitive level, due to momentum being a reflection of change over time, the understanding of these concepts on a body level can be profound. These specific parameters of movement experience can have very specific meanings to a body that exists in very specific contexts. By shifting and overlapping the contexts these parameters exist in, the choreographer is creating new parameters and contexts for their movement experience, enabling them to see new opportunities and take new risks. The above quote might also indicate that time is
structural or conceptual, while momentum is a tangible embodied sensation that engages dynamics of Effort Quality (from LMA). The overlap of a cognitive context with a sensation context also indicates a shift in perception of the choreographer.

M(S2): I thought it was really cool how there was so much freedom of space that could be utilized in the program. Every direction, every corner, every angle and then the figure itself could be moved in any way that was impossible or possible. So what I took from that was a sort of free world sort of thing, and manipulating my limbs in ways that we don’t normally do.

This quote indicates a willingness to explore movement in unusual ways while using both the information provided by the software as well as the negative space, or information that was not present in the software. The choreographer was fascinated by the options provided whether directly or indirectly and the ability to manipulate and work within these options. The Volition and Intention to explore movement in new ways supported future Emerging Insights and Awareness around personal habit, preferences and how the choreographer saw patterns in choreographic structure.

**Movement Choices**

Movement Choices refers to the choreographer’s embodied choices throughout their interactive process with Cochoreo. This includes actions that the body makes, reflections on the body’s choices and awareness of one’s existing body and its habits and physical abilities. While all these experiences are ‘ah ha’ moments, they mainly refer to experiences of the body discovering new options through sensation and perception.

A1(S1): ‘I felt that my body was more free. In general I have a sense of release but because I’m always thinking, I think too much always, that doesn’t let me move to my full ability. Even though I was thinking about it still...I was like ok, I’m going to do it and then it happened.’

This quote identifies the struggle choreographers often have between ‘thinking’ too much and ‘moving’. There is a discrimination about ‘thinking’ because it will ‘take you out’ or ‘away’ from your bodily experience, which is an important knowledge bank in movement. While the interactions of explicit and implicit decision-making can be argued
in another context, here it does indicate an awareness of the struggle. This quote also identifies the result of the struggle, that ‘just doing it’ enabled something to happen. And the ‘something’ that happened is a result of allowing the body to ‘figure it out’ on a sensation and physics level.

A3(S1): ‘I feel like none of my technique can apply to this, so that was interesting.’

This quote indicates the context of working with defamiliarization on an embodied level. This experience could be called a movement ‘problem’, similar to a ‘bouldering problem’ in rock climbing, where the mover has to figure out a strategy to successfully work through the problem. This choreographer notes that ‘none of their technique can apply to this’, which emphasises that nothing they have learned in the past can solve the current movement problem. However, the choreographer’s ability to move in a physical environment still provides movement options that might not have been present before. The process of solving the problem provides at least one, if not many, options for movement. All these options can then be included in the body’s knowledge bank for exploring new movement in the future.

S(S3): ‘It was really hard...I looked at the keyframes again and tried to make my body look as much like the frames as possible. But, this being given to me, I had to just feel it or see myself doing it, feel it on my body and put it together too.’

This quote indicates the various forms of sensory information that was used to figure out how to make movement choices. Choreographers often had to compare how something felt on their bodies to how they could visualize it in their minds to how it looks in the mirror in order to assess what the best choice was. Or in the case of this quote, how to make sense of the unusual information presented to them. The choreographer was attempting to map the shape of the figure in the keyframe to the shape of their own body but it was challenging to make the movement physically possible, interesting and fitting into the context of the phrase they have been creating.

In addition to evidence from transcribed focus groups, much of my data in this category of Movement Choices is from observational data. I saw movement trends appear
through watching the videos of choreographers over the length of their process. These trends include topics such as joints folding linearly at the beginning of the process that shifted to rotational or spiraling execution by the end of the process. The timing of executing the joints shifted as well, from all joints attempting to move simultaneously to one joint initiating and other joints following sequentially, like a slinky moving down a staircase.

The overlaps I saw between focus group and observational data include topics such as the choreographer’s fallback response, an awareness of their habits or preferred movement patterns. I also saw topics of trust in themselves, the interactive tool and the environment appear. These topics, while described in more detail in the following section on micro categories, are important for their indication of the choreographer’s awareness both cognitively and on an embodied level of their experience and choices.

**Volition + Intention**

Volition + Intention refers to the experience choreographers have of their own agency in decision-making processes. The same way that all choreographers have a bank of learned movement knowledge from studying various techniques, choreographers also have a bank of strategies for movement composition. A choreographer’s awareness of their agency (their ability to act and make choices aside from a habitual option), combined with their intention to use their agency enables their choreographic exploration. In order for choreographers to take risks by trying new options they need to be willing to make a choice and/ or be aware that an accidental choice is worth acknowledging. Volition + Intention relate to ‘ah ha’ moments because they enable a choreographer to be open to and aware of knowing that a potential solution just presented itself.

A1(S1): ‘I know my body couldn’t do it, but I was like, how could I interpret it anyways? So that was frustrating but also very enjoyable. I felt both emotions. But I felt that it helped me think about different ways I could move my body. I feel like there are different ways that we could support that...’

This quote indicates that the choreographer was working in an unfamiliar place (their body could not perform what Cochoreo had generated), however they were willing
to explore other interpretations of the movement material. By being open and willing to explore, the choreographer was able to think of additional ways to move their body, even though it was not an ‘easy’ experience. The last bit of the quote that notes ‘different ways that we could support that’ seem to suggest options in two domains: choreographically developing more techniques to leverage movement opportunities when they arise and technologically developing the ‘scaffolding’ components in a system. ‘Scaffolding’ refers to the design qualities in technology that give hints or suggestions about what a user can do, which can be literal instructions or can be affordances of the design. Supporting different methods of choreographic exploration will also cycle back to support volition + intention by affirming that curiosity and taking risks is a rewarding experience.

A(S3): ‘...I don’t like generating phrases and choreography which is set [prefers improvisation] and I didn’t really feel anything when I made it, I wasn’t attached, but once I watched it on the iPad I thought there was some interesting things happening, so maybe I could work from there. So it was an interesting way because it encouraged me to work with set choreography, there was something interesting in it.’

This quote indicates that the choreographer was required to work out of their comfortable preferences when creating choreography, and initially were not interested in the material being created. However once seeing the playback on the device they saw options for exploring that challenged their typical approach to choreography. This quote refers to Volition and Intention because while the choreographer was not as interested in working with set choreography initially (though they were willing to play) they became much more engaged through the process, and potentially shifting their relationship to designing set choreography.

D(S1): ‘I think that last time someone mentioned that they felt there wasn’t room for error, but I actually think there is a lot of room for error with it (idanceForms), because if I can’t do a certain movement that is an ‘error’ so then I create it into something else. So it allows more creativity with the amount of error if your body can’t do what it has created, and it doesn’t feel natural.’

This quote discusses two views on ‘error’ in making movement choices. One view is that there is no room for creative movement options with the software because only one
option is presented, while the other view is that this one option can provoke many additional options if you are open to seeing the options. So it is in the willingness and openness of the choreographer to explore new movement opportunities, and trust that they can be successful to reinforce the experience of curiosity and risk-taking.

**Shifting Priorities of Experience Themes**

These three macro themes, Emerging Insights + Awareness, Movement Choices and Volition + Intention are all present through the three stages of choreographer experience: Choreographer in Response, Choreographer in Exploration and Choreographer in Interaction. However they appear to have shifting priorities throughout the progression of choreographic experience. These priorities appear throughout both the transcriptions of focus group and observational data as the preoccupation of the participant choreographers. More information can be found in section 6.1.4, Relationships Between Macro Themes of Experience.
6.1.3. Reoccurring Micro Themes of Experience

Micro themes were found consistently through the data, and related to Macro themes discussed in the previous section. All components relate to a dynamic model of creative ‘ah ha’ moments in choreographic process, when working with the interactive tool idanceForms.

Through studies 2 and 3 the initial model was shifted to clarify one micro theme and add two new themes. ‘Mimicry Vs. Creative Problem Solving’ was changed to ‘Mimicry Vs. Inspiration’ to emphasize the distinction of creating new movement material by attempting to recreate movement from Cochoreo exactly (by mapping the body positions directly onto the body) as opposed to using Cochoreo as inspiration to create new
movement from. This is also in relation to, but separate from, ‘Reactive Disorientation Vs. Situated Action’ which refers to the Choreographer’s state of mind and whether their intention to create is in reaction to being disoriented or is able to utilize the disorientation to make new choices.

The two new topics include ‘Unpacking the Body’ in Bodily Self/ Movement Choices which illustrates the choreographer’s experience of ‘divide and conquer’ to understand the body position generated by Cochoreo. This is also to illustrate the choreographer’s reflections on how their own bodies work, specifically becoming aware that more joints move than they realize they are controlling. The topic of ‘Context’ was added to Volition and Intention to emphasize the importance of the choreographer’s current state of mind on their choices. If a choreographer was performing a task rather than thinking about designing an entire piece it effected their choices.
Figure 47. Micro Themes Organized by Macro Theme from Study 1

Figure 48. Shift of Micro Themes Organized by Macro Theme from Studies 2 and 3
Emerging Insights + Awareness

Figure 49. Micro Theme Emerging Insights + Awareness in Study 1, Confirmed in Studies 2 and 3

Self-Capabilities

Self-Capabilities refers to a choreographer’s insights and awareness of what they can do. This can refer to the physical movements they can execute, what choreographic devices they know and can use in their compositional process or how they reflect on or perceive their aesthetic ‘taste’, personality or emotional state. This theme was indicated in a variety of ways, such as this example about making choices based on preferences of emotional state:

B(S1): ‘I like to make it super internal, so I am still aware of my surroundings but it’s basically all about what I’m feeling.’

This choreographer described not being sure if she could execute a movement as asked but found ways to accomplish it by thinking outside the typical options:

A(S3): ‘At the beginning I was like, I don’t know if I can do it because this body can move in every direction and there is no gravity involved. But it was very interesting to think about this in that way because it allows me to be more creative’
Another choreographer described her ability to explore movement options as always being a little bit different:

A2(S1): ‘I can never replicate it 100% exactly the same.’

This choreographer knew her strengths and could use them in this situation:

K(S2): ‘It is easy for me to visually think something and then make it happen.’

All these examples illustrate an attention to what the self is capable of doing that is guided by their interests, personality, physical abilities and environmental factors.

**Overlap Between Emerging Insights + Awareness and Movement Choices**

![Image](image)

**Figure 50. Micro Theme of Emerging Insights + Awareness Overlapped with Movement Choices in Study 1**

**Sensory Feedback**

Sensory Feedback refers to the sensation that a choreographer receives when making a movement. This is the information the body gives about how a movement was performed and how it feels. This information is often then used to evaluate the movement.
and assess its ‘fit’ in the context of other movement or choreographic aesthetic. One example out of many descriptions about ‘feeling’ from the choreographers includes this:

A1(S1): ‘I felt that my body was more free. In general I have a sense of release but because I’m always thinking, I think too much always, that doesn’t let me move to my full ability.’

Typically, a feeling of ‘free’ or ‘release’ from a choreographer is a signpost telling them that the movement is working effortlessly (which is often the criteria for a successful movement choice, at least to a novice). This data emerged from both focus group discussion about how the choreographic process ‘felt’ and observational data of choreographers performing trial-and-error explorations with movement.

P(S3): ‘I think I was making choices that were comfortable in my body and things I wanted to do. And I think it would be a very different phrase if I was tasked in making it in an uncomfortable way.’

This choreographer noticed the sensation of ‘comfort’ guiding their choreographic choices and the resulting work. Sensation played a strong part in evaluating the success of a particular movement choice, and often brought awareness to personal preferences.

**Fallback Response**

Fallback Response refers to the choreographer’s habits on many levels (physical, personal, cognitive). The Fallback Response is the most efficient, obvious choice for compositional decisions because it requires minimal reflection and can just be enacted. When novice choreographers are in a new situation, especially working with idanceForms as their first experience including technology in their choreographic process, they often rely on their Fallback Response to make initial choices until they are more comfortable with a tool. Many choreographers performed their first movement phrases of working with idanceForms by relying on their habitual movement patterns and habitual knowledge (which was minimal) of how to map information from the system to their bodies.

D(S1): ‘... it pushed me to do movement I would never think of ... to try to put myself in this uncomfortable place and now a week later be comfortable in moving in that sort of way.’
This comment from the focus group data illustrates a reflection on exploring new movement outside of their fallback response. It also illustrates how the fallback response shifts over time. The experience began as unusual to the choreographer but became more comfortable over time and through exploration, enabling them to take riskier options.

M(S3): ‘I did what was comfortable.’

This comment indicates that the choreographer was consciously making movement choices based on what felt 'good' to them. This criteria is often used to evaluate how ‘successful’ a movement choice is, by assessing how comfortable it feels on the body.

K(S2): ‘All the risk-taking was initiated by the app ... it was very interesting to coordinate and I thought I took a risk there because it was more inventive than something in my comfort zone.’

This comment refers to using the Cochoreo app to generate positions, which were designed to be uncomfortable to choreographers to prompt their creativity. This indicates that the app was generating options outside of the choreographer’s comfort zone and challenged choreographers to make conscious movement choices.

M(S2): ‘As a dancer I have to capture the feeling to be able to recreate the exact movement’

This comment refers to the process of developing a fallback response. Because choreographers and dancers are moving and making many decisions in-situ, having a fallback response is highly important to keep moving. However, being aware of the fallback response as ‘one tool in a large toolkit’ and having broader awareness of movement options enables more choices in the moment.

Trust in Self and Environment

Trust was difficult to capture but a very present element of choreographer’s process. Trust was reflected in the choreographer’s awareness of their own abilities and understanding that their body has a knowledge that will help them through unfamiliar movement opportunities. Trust was also reflected in the choreographer’s willingness to
work with the idanceForms software, and excitement at having new choices to explore. Trust is very tied to risk-taking and knowledge of self, and allowing that to shift over time. Trust was observed through choreographer’s commitment and comfort in developing movement and their engagement with the software. One example of trust on a physical level is from a focus group discussion:

A3(S1): ‘I feel that we tend to knit those together using momentum and breath and using gravity to get into things... some things come easier to you.’

This comment indicates that by understanding the body level mechanics to move through unusual movement phrases, a choreographer has more agency and volition because they can trust their body to perform itself, without needing to make conscious decisions about every aspect of the movement.

M(S3): ‘I didn’t think of space. I used a lot of space, and always do, it’s just who I am. Wherever my body goes it can take me and it will travel.’

This comment indicates the choreographer’s knowledge of self and trust in that knowledge. It is important that while choreographers are exploring and taking risks that they hold trust in themselves or the environment to support their actions. This is important for both physical safety and creative safety, because a choreographer cannot take risks if they don’t hold trust first.

**Isolated Body Vs. Spatial Tensions**

There was a difference between the choreographer working with an isolated body (a body in space, without a physical environment to engage with) and a live body in an environment. The isolated body is only aware of their joint actions and timing, yet has no comprehension of weight shift, momentum or spatial tensions. Spatial tensions are the engagement and enlivening of the limbs in relation to the space. While this is a nuanced embodied detail, it becomes very recognizable in whether movement is engaging with its environment (which could just be the floor, engaging in weight shift) (Studd & Cox, 2013). Whether the movement is engaging with an audience (which could be the space in front of them) or just engaging with a corner of the room. The use of spatial pulls enables a
dual-pull system, utilizing the body’s mechanics to simultaneously reach towards and away from a point that creates a fuller and more enlivened body and presence.

J(S1): ‘Some of my movement on this technology was unrealistic because I can’t move my arm 360 degrees and come back, it was just this idea that if there was momentum with it or I could change my facing. Because this dancer, this body faces the same way and doesn’t change its facing, how could you interpret that outside and away from the software.’

This comment indicates that when the technology could not provide information relating to the execution of a movement beyond an isolated body, the human choreographer had to make up that information. This ‘filling in the spaces’ was noted by choreographers to be where the creative work was happening for them.

JJ(S2): ‘This gave me a kind of structure that was very shape oriented which was my motif, in which I came up with this reaching thing that kept coming up so I kept exploring.

This comment indicates that while the app generated a body shape, the choreographer developed a motif (or a reoccurring element) that utilized space. While the app does not include space it also creates opportunity for choreographers to explore it themselves, supporting a co-imaginative perspective to designing movement.

Reflection on Movement Choices and Attention to Process

Choreographers reflected on their movement choices and their attention to the compositional process in many ways over the study. They became more cognisant of their movement options and ways to knit movement together over time and could articulate it. They also became more aware of their compositional options and risk-taking opportunities. One example includes:

A2(S1): ‘It was interesting working with this movement away from an image because I feel like when you have this image in front of you, the mirror neurons you want to mimic this movement, and that’s the way we learn movement, rather than learning from feelings, so not having that mirror and taking what this movement was in our memories and playing with the feeling of what it was, it was interesting and illicited new... it helped me evolve the movement. Having the exposure to it and then taking it away.’
This comment indicates a reflection on the difference between seeing the instructions in front of you so that it’s not based on the ‘feeling’ of the movement. Yet then shifting to an approach from the ‘feeling’ to make sense of the movement on a consciously embodied level.

A(S3): ‘...I was watching other people and thinking like how many joints we have and how much we ove that we don’t think about here in the everyday.’

This comment indicates the choreographer’s observation of others and reflection on both their self and other’s movement patterns. The awareness that so many joints move that one is not aware of brings attention to fallback responses and awareness of one’s own patterns.

Movement Choices

Emerging Insights + Awareness

Sequential vs. Even Time
Linear vs. Spiraling Joints
Unpacking the Body
Physics of the Physical Body
Simultaneous vs. Sequential Joint Initiation
Using Body Mechanics To Support Movement

Movement Choices Volition + Intention

Figure 51. Micro Theme Movement Choices

Body Mechanics Support

Using the Body Mechanics as Support was very prevalent in observation, yet was discussed less. Many of the movements generated from idanceForms did not account for moving in an environment with gravity and a floor. Legs would swing around in full 360
degrees and transitions could include both legs jumping together to move through space. While the choreographers did not specifically discuss the need to use the support of their body mechanics (or the functional use of their body to move in the context of their environment), it was observed frequently. Choreographers were problem-solving to find ways that their bodies could perform new movement options while continuing normal functional such as minimalizing falling down, keeping support under them to stay vertical or to navigate the coordination needed to perform a unique jump. This micro theme is important to note because it is a key factor in the Fallback Response, or habits used to efficiently solve a problem. It is also a core component in reflection and awareness by understanding the body’s capabilities in order to take new creative risks.

**Physics Support**

Physics Support is the next level up from Body Mechanics Support, in that it references the ways the body can utilize the environment and its relation to gravity to perform movements that might not otherwise be explored. This theme includes factors such as momentum, weight shift and spatial tensions to move through space with dynamics. An example is highlighted in this quote:

B(S1): ‘I felt this time also, people played with momentum more, in order to get both legs off the ground you have to have energy and momentum to get off the ground. Like where you (M) did your handstand cartwheel thing, it was interesting to see people’s approaches to these challenges and incorporating it in a way that their body can best tackle the challenge.’

This theme of Physics Support is separate from Body Mechanics in that it highlights the approach that a choreographer takes to execute the movement through space, rather than on a body in isolation. In order to move through space a choreographer needs to utilized energy and timing as well as the mechanics to step and jump.

M(S3): ‘...so I thought about the movement quality which is kind of inhuman, and then I thought a lot about contemporary dance where it is also sort of striving to be inhuman, so I was like, ok, I’ll just try to do the movement and the timing. Spatially it was hard to figure out when to put my foot down on the floor.’
This comment indicates that while the movement was challenging to execute, that by just trying to make the movement happen, the physics of the physical body would be the enabler. This connects to the above quote by including space in the execution, not the just isolated body.

Linear Vs. Spiraling Joints

Another movement trend that was observed throughout the novice choreographer’s process included joints folding linearly at the beginning of the process. This action is tied to the Body Mechanics theme, though joints do not operate linearly. While possibly mimicking the animated joints of the avatars in idanceForms this action could also be a perception of the novice choreographer believe joint movement to be linear. By the end of the process almost all choreographers were using the spiraling or rotational features of their joints. It was clear by the end of the process that joints rotating or spiraling as they executed a movement was a more sophisticated method of moving that merged the mechanics of the body with the physics of the environment over time. While it could also be an aesthetic choice, it seemed from observation to be a more nuanced tool of interacting with the material in the world that may be tied to habits as well as function.

M(S3): ‘I was looking at the keyframes and it looks completely different from when it moves.’

This comment refers to the interpolation between keyframes, which illustrates movements as having extra circular motion. Circular motion is often sequential and apparent in choreographers when the movement ‘feels good’ and is comfortable on the body. However, choreographers expected movement in the idanceForms app to be linear and spoke-like and were surprised at the rotation they found. This rotation and reference to circular motion appeared to be helpful when translating the movement from the app to their bodies.
Simultaneous Vs. Sequential Joint Initiation

Joint Initiation refers to the order in which the joints move to execute a movement. This was observed frequently in the choreographer’s process. Initially the novice choreographers attempted to perform a movement generated by idanceForms while moving all the joints at once (essentially creating a moving version of a position). However the body mechanics and physics that support movement operate through a coordination of joint action over time, not a simultaneous movement. Over the compositional process of choreographers this simultaneous movement became more sequential, enabling the movement to flow more naturally through the body and playing with nuance in movement opportunities.

L(S2): ‘I think that the fluidity of it all... I just watched how the limbs in the app were continuous so I tried when I did movement to reflect that fluidity of one right into another.’

This quote notes that the interpolation of the app appeared to be continuous and fluid, so the choreographer attempted to mimic this quality of movement. The disparity in this process is that the figure in the app is moving all joints simultaneously, while live people move various joints at different times to create fluid motion. So by attempting to recreate the movement quality of the app the choreographer needed to find sequential movement in their joints and not follow the body shape of the app.

Even Vs. Sequential Timing

Timing refers to the way a movement is executed over time. This was an essential component of movement, and was initially indicated by the length of keyframes in idanceForms. The novice choreographer could change the keyframe timing when designing their movement phrase in idanceForms, and initially attempted to perform the phrase using that timing. However the timing from idanceForms is even with minimal options for manipulation, which effected the choreographer’s performance of the movement phrase. Over time the novice choreographers began working with more dynamic timing by exploring their movement phrases with longer suspensions and quick shifts that were mapped to different facets of joint initiation when executed. This created
a sequential timing in the movement, with a suspension of an arm circle while a head turned quickly.

**Unpacking the Body**

Unpacking the body refers to how a choreographer understood the body actions of the figure in Cochoreo. The choreographer often needed to watch just the legs or the arms move in order to parse the action. However this theme also addresses moments when choreographers became more aware of the complexity of their own movement. A choreographer might notice that their knee was moving to create a movement but didn’t realize all the activity in their lower back as well, so this supported their understanding of themselves and the movement more deeply.

B(S2): ‘It made me want to use more joints than normal. ... I might have just done a straight arm but I had to use the elbow because this guy did!’

In Studies 2 and 3 I added a category to Movement Choices of ‘Unpacking the Body’. Many choreographic comments articulated how they needed to consider both the figure in the keyframes and their own bodies in pieces to ‘unpack’ a movement into pieces, understand them separately, and then put the pieces back together in order to understand the whole. Choreographers did this in many ways, but this quote indicates that a choreographer developed greater awareness of their preferred movement habits by noticing that they had options to bend the elbow. By noticing a portion of a movement they could transpose that awareness onto their movement choices.
Overlap Between Emerging Insights + Awareness and Volition + Intention

Emerging Insights + Awareness

Movement Choices  Volition + Intention

Figure 52. Micro Themes Emerging Insights + Awareness and Volition + Intention

Mimicry Vs. Inspiration

This micro theme indicates the overlap between becoming aware of a process and being willing to participate in it. Mimicry refers to choreographers executing a movement phrase as close to the idanceForms software animation as possible, compared to Inspiration which uses idanceForms as a springboard to navigate new movement territory. Mimicry was observed as relying on the Fallback Response to perform the movement phrase and assuming that it would match with the animation. This was often used at the beginning of the choreographic process, but shifted to Inspiration once there was more trust in the choreographer’s self and idanceForms as a catalyst rather than a dictator. Once a choreographer moved in to a phase of Inspiration they were more curious and excited about new movement opportunities and were reflecting on their habits in the process. One example of a choreographer describing the shift:

J(S1): 'Whereas last week it was more like I was getting frustrated if I didn’t get one thing. Now I know... what its like and I know that its generating things, and its computerized and some things cannot be exactly the same.'
This choreographer was becoming aware of the context they were working in, in interaction with technology, and noticed that when mimicry wasn't working that finding other opportunities became a necessity.

M(S3): ‘I tried to do it exactly at first, but thought no, I can’t, this doesn’t feel like a dance to me. So I inserted whatever feels the nicest.’

This quote indicates that the choreographer initially tried to mimic the app exactly, however it did not feel right according to sensory feedback and what was assessed as ‘successful’ or ‘correct’ movement. In attempting to solve the problem and achieve a successful feeling movement, the choreographer inserted movement based on their fallback response to achieve the ‘nicest’ feeling.

**Reactive Disorientation Vs. Situated Actions**

When novice choreographers were exploring idanceForms as an interactive tool, they had an initial reaction to the new environment. This reaction was disorienting, because choreographers were working in an unfamiliar, unusual and somewhat uncomfortable environment. Choreographers did not trust the system yet, and did not know if their trust in their body mechanics would support their exploration in movement. These types of situations are often used to provoke content creators into thinking differently and making new choices specifically aside from their Fallback Responses (even though Fallback Responses are triggered initially, iterations of the process open new areas of exploration). Situated Actions refers to another phase, when choreographers made new, unique choices based on the present situation and environment (Suchman, 1987). The novice choreographers in this study shifted from an initial Reactive Disorientation to making Situated Actions that were intelligent, thoughtful and aware of their impact on the movement choices.

N(S2): ‘The transitions that the system just normally came up with was all like [waving limbs wildly] and I was like, no I can’t do that, so I had to modify it and just do an arm.

This comment indicates that the choreographer did not know how to approach this particular movement problem and was disoriented. However they were able to mind a way
to maneuver the problem space to come up with a successful solution, resulting in a situated action based on the specific situation they were in.

**New Approaches to Movement**

Once the novice choreographers developed more Trust in the system, themselves and were comfortable with making Situated Actions, they were actively exploring new approaches to movement.

J(S1): ‘I usually focus more on momentum so it’s interesting to approach with more emphasis on the angles, because it’s like whoa I have limbs! I just realized I have limbs and it’s in my face! Also realizing peripheral vision because there is a lot of stuff with angles happening back here which I don’t usually think about.’

When approaching new movement, choreographers illustrated reflection on their typical responses and body awareness. These new facets of awareness, such as peripheral vision noted above, created new opportunities to explore movement.

K(S3): ‘...It felt like a nice base that I could work from. It was nice to have another way to generate movement that could go so many places.’

This choreographer trusted their own knowledge and creative process enough to be open to new approaches to movement. Instead of seeing impossible movement they were able to see many opportunities that they had control to make choices from.
**Volition + Intention**

*Emerging Insights + Awareness*

**Movement Choices**  Volition + Intention

**Willingness to Investigate**

This section within Volition + Intention highlights the choreographer’s intention to engage in their creative process as a core component of exploring new movement opportunities. In order to use a system interactively in a choreographic process, the choreographer needed to be Willing to Investigate new material. Being Willing to Investigate comes with trust and awareness of the context a choreographer is working within.

B(S1): ‘I felt that it felt better on my body if I used the app for inspiration for my movement and didn’t necessarily try to replicate it exactly. So that really helped. And then when we sped up our movement or added repetition that helped it flow more easily through my body.’

This statement illustrates a novice choreographer who worked through various ways of engaging with idanceForms, found an approach and then used it as a springboard to explore other compositional methods with new movement.
B(S2): ‘The only part that is uncomfortable for choreographing was that I had a lot of random shapes, so transitioning was a little weird but you just gotta go with it.’

Even though this choreographer struggled with the provided movement material they were willing to keep working. This process frequently surprised choreographers with new approaches to movement and creative movement that they found interesting and would not have discovered otherwise.

**Emotional Assessment**

The novice choreographer’s emotional engagement is another important component of their Willingness to Investigate. Emotional Assessment relates to the choreographer’s interest, trust and comfort levels in their process. This can also relate to their method of using their emotional state as part of the compositional process. An example of a choreographer’s positive Emotional Assessment that fueled further exploration is:

D(S1): ‘I liked working with the program because it pushed me to do movement I would never think of ... that was really interesting to me to try to put myself in this uncomfortable place and now a week later be comfortable in moving in that sort of way. So that was a new experience for me.’

This choreographer was emotionally engaged and curious to use idanceForms right from the beginning of the process. This engagement supported her wide exploration of creative opportunities and excitement about new experiences.

A(S2): ‘[felt stuck because she couldn’t get off the floor] ...I cleared my mind ... literally laid on the floor and closed my eyes and let everything go out of my head. Then I go to where I left off and started moving and saw what happens. It sparked other ideas that worked better.’

This quote indicates that getting creatively stuck and effect the emotional engagement with the process. This participant took a ‘time out’ to reset her movement options so she could make more engaging choices.
Perception of Agency

Perception of Agency refers to a choreographer's awareness of how much control they have in their process. At the beginning of working in a new, unfamiliar situation a choreographer might feel that they have minimal control and are relying on their Fallback Response to get them through a task. However, over time the choreographer becomes more aware of the choices they have, and the amount of control in those choices. The Perception of Agency is also effected by different ways of understanding movement information as indicated in the following quote:

D2(S1): ‘You don’t realize such details of coordination when you are thinking. Because the way you think and feel movement is different than trying to put it in a computer. Because I was watching back what I thought I had done... and it came out so differently than what it was in my mind and what it was in my body. I just thought it was really interesting.’

S(S3): ‘I think that stringing shapes, what happens between each keyframe was cool because I could decide what that would look like. And what the pathways were going to be to get from each frame.’

This comment illustrates the choreographer’s perception of agency, that they could decide what the movement was about. It was important that the choreographer felt that they were in control when working with the app because it was too disorienting otherwise. However when choreographers were comfortable and knew that they were in control, the use of defamiliarization supported their new approaches to creativity.

Context

Context refers to a choreographer’s awareness of how the framing or situation of their current actions effect their choices. If the context is a task-based exercise that is different from a context of creating a choreography with no set tasks. Choreographers often create their own contexts by becoming interested in a movement or conceptual aspect to explore. While Cochoreo is a strong context that disrupted the choreographer’s familiar creative process, using it as an exercise was different from using it as the inspiration for a choreographic work.
B(S2): ‘...if it was a piece I was performing I would want to set things that I am strong in, it is different when setting something on yourself rather than someone else because you have to think of what is beneficial for the dancer. I didn’t necessarily have the things I wanted in certain places.’

This quote indicates that who the performer is and how they move will dictate the choreography. This places an emphasis on knowing who the performer is to make creative choices about the work and will impose a context to work within. This quote also indicates that the choreographer did not have a particulate structure in mind for the choreography and assumed that the performer would dictate the outcomes.

M(S3): ‘I decided that I wanted to do it almost exactly like the video, because I was thinking – should I approach it in a way that is exact? Or in an interpretive way?’

This choreographer was assessing which approach to take to make creative choices. She had the option to mimic the figure in Cochoreo exactly or to use it as inspiration for creating new choices. While this quote also fits into the ‘Mimicry Vs. Inspiration’ theme it also refers to the context that the choreographer is making choices within. This context is important to support the choices about to be made with the co-imaginative tool.
Overlap Between Movement Choices and Volition + Intention

One facet in the overlap between Movement Choices and Volition is dependent on the Affordances of the System Design. Affordances refer to the inherent suggestions that are made by a system due to its design. While choreographers are making movement choices based on the animated positions generated by idanceForms, they are also embodying movement information based on the system. This includes observations of timing patterns, joint rotation options, minimal core movement, minimal spatial tensions. This micro theme highlights the importance of design in the system, as it aids in the next theme, Choreographic Mappings. An example from the focus group about the skeletal representation of the movement includes:

B(S1): ‘I felt that after going back and forth, like when I was first working with it it was very planal, but once we took it from there and took the movement home I could explore the other aspects of it. So then today in the space, even though we went back and added that bit in, I tried to keep the idea of my home movement but from a generated source.’
This statement illustrates the 2 dimensionality of the generated movements and how a novice choreographer made choices about how to manipulate it to fit their body. Another quote is from a choreographer who viewed a movement sequence from idanceForms in another file that had an animation of a character:

D2(S1): ‘I looked at it and it’s an actual person, and its doing impossible things, but I could have memorized that phrase. Plus it was a modern-ish phrase. It was interesting because it was like oh, I could pick that one up right now, but going back to mine it was like I have no idea what I’m doing.’

The differences between the skeleton representation effects how the choreographer will interpret the movement, in how it provides visual suggestions for the interpretation (DiPaola, 2009).

D(S3): ‘Parts of mine felt very two dimensional, and I think it was the parts that I was able to copy almost exactly from the movement as opposed to something when the legs were going over here and I had to improvise to make something work.’

This quote indicates that mimicking the app exactly is when she felt planal or two dimensional. However, if the choreographer needed to make choices about how to execute the movement they inherently used their body knowledge (fallback response) to create something that felt more three dimensional.

K(S2): ‘I tried to see what would happen if I played in the app and changed the order with the little frames, and it was not going to work out because it made a completely different dance.’

This comment notes that the way interpolation works between frames is that it is taking the shortest path, so shifting the order of frames creates completely different movement. This highlights another issue in the translation of movement information from the app to the body is that choreographers tend to think of movements as the transition between two end points. However idanceForms creates keyframes that are the end points, and the system (or choreographer) fills in the transition.
Choreographic Mappings

The way in which a novice choreographer interprets information provided by idanceForms onto their own body is highlighted as Choreographic Mappings. Choreographers perceived information from the system and explored it through their own movement, figuring out the Body Mechanics and Physics of Movement. They mapped this information into their own way of moving, first through their Fallback Response and later into their New Approaches to Movement. This choreographer’s statement illustrates the mapping process and how it had to be unpacked:

B(S1): ‘Sometimes it can be frustrating when you are learning the first time a phrase, because you can see very clearly on a person’s body what they are doing, but then suddenly trying to translate it into your own it feels weird. So looking at this and watching it, I could clearly see what each section was, but I had to break it down to legs and then arms and do them separate and then build from there and I don’t feel that I have to do it as much when I am learning person to person.’

The process of Choreographic Mapping required some effort, which resulted in a deeper awareness of the choreographer’s movement choices and compositional methods.

L(S2): ‘I noticed that there was a lot of circular movements and some sharp angles to my shapes and they kindof intersect a lot, so I tried to have those concepts reflected in the movement. I looked to where – like if I had no limbs and my torso half was a line of symmetry and each side, like crossing that line... so I tried to use that concept and the concept of circular motion throughout.’

This comment indicates that the choreographer saw interesting movement qualities in the app though found it challenging to map them onto their physical body. The choreographer had to make abstract choices that mapped certain qualities of app movement to some aspect of physical movement, even if the movements were not translated exactly.
6.1.4. Relationships Between Macro Themes of Experience

These three macro themes, Emerging Insights + Awareness, Movement Choices and Volition + Intention are all present through the three stages of choreographer experience: Choreographer in Response, Choreographer in Exploration and Choreographer in Interaction. However they appear to have shifting priorities throughout the progression of choreographic experience. These priorities appear throughout both the transcriptions of focus group and observational data as the preoccupation of the participant choreographers.
In the first stage, Choreographer in Response, the theme of Volition + Intention was a priority because there was not yet solid trust in the situation and therefore minimal willingness to take risks right away. Volition was visible because most choreographers were mimicking the avatar’s animated movements and only narrowly exploring movement options. Movement Choices is second in priority because the experience of executing the movements, generated by idanceForms, was a consuming part of the process. This is illustrated by the choreographers both in their focus on mimicking the movement but also in how they moved themselves – often choosing linear joint movements rather than more sophisticated rotational movements. Emerging Insights + Awareness was third in priority because choreographers were attending to how to create any movement that they can devise in the moment rather than attending to their many choices or awareness of movement options. Choreographers were mainly using their fallback responses, or habitual responses, to enact the movement options in any way that could be familiar to them.

In the second stage, Choreographer in Exploration, the theme of Emerging Insights + Awareness became the first priority because choreographers had time to reflect on the choices that they made in the first stage. This was often indicated by choreographers describing their perception of their own capabilities: in moving, in making decisions, in reflecting on their personalities. Through reflecting on their choices, choreographers utilized the theme Volition + Intention more to become comfortable with exploring available movement options. Choreographers described their experience as allowing them have ‘freer investigation’ of movement. This second priority enabled more curiosity alongside the more Emerging Insights had by the choreographer. The third priority of this stage is the choreographer’s Movement Choices. At this stage choreographers began to explore weight shift and momentum more in their movement choices. While the choreographer made many more movement choices in this stage, the newly important ability they had to be aware of the choices was more prevalent.

In the third stage, Choreographer in Interaction, the theme of Movement Choices became the first priority because choreographers had already developed their reflection and awareness (the second priority) and engaged in their Volition + Intention (the third
priority). This was observed by choreographers moving sequentially through their joints while using more rotational or spiraling movements. Therefore Awareness and Volition could continue operating as themes in the choreographer’s experience but did not require their direct attention. Choreographer’s Emerging Insights+ Awareness was observed through their trust in interaction with idanceForms and other choreographers as well as their playfulness with the movement choices. Choreographers were also able to map the information from idanceForms more smoothly onto their own bodies and movement choices. Now that choreographers had the confidence and interest in exploring movement widely and taking risks iteratively, they were able to explore successfully creative movement opportunities.

Figure 57. Choreographers Working In-Situ
6.2. First Step of Data Analysis Process in Study 1

The first step of the data analysis included reading through the transcriptions to highlight salient comments, note important themes and or articulate an emerging concept I had from my observation of the study in relation to the data I was reading. This process of re-visiting the data helped to merge my observation experience of the study sessions with the verbal descriptions of the participants, strengthening my experience of the data and highlighting important details. Because of the nature of the study and the four focus groups that highlight very different parts of the study choreographic process, my emergent themes reside in these four ‘stages’ of the study, in their temporal context. Examples of
emergent themes in each stage include (the full data analysis text is included in Appendix A):

Stage One: How do you create movement normally?
- Starting with existing material and seeing the affordances, associations and possibilities
- Interpreting a feeling/ emotion/ experience

Stage Two: How was working with skeleton editing, camera keyframing?
- Focus on replication first – reflects not having the extra skill to problem-solve/ compose/ improvise in the moment
- Awareness of constant shift (of self, world, experience)
- Self control/ letting go of control/ getting out of the way of the self
- Prior knowledge is very important in exploring movement, particularly the transitions

Stage Three: How was working with the phrase over the weekend without technology?
- Away from precision, back to experience gave permission to explore
- Not important that it doesn’t feel natural
- Switching from ‘mirror’ to ‘no mirror’ gave big perception change
- ‘staying with’ the movement has different ‘evolving’ options appearing

Stage Four: How was movement after working with Cochoreo?
- Starting material was helpful
- Excited about new movement and LMA approach
- Recognized that it is uncomfortable initially but with time it becomes new and exciting
- How you think and feel movement is different

At this point in the analysis, the data was illustrating the participant’s immediate reactions to idanceForms and Cochoreo. Many comments were around the participant’s
level of comfort in the process, their level of control and how their personal movement habits supported or did not support their exploration process. The temporal shift of experience was very apparent, as well as each individual’s approach to a ‘new’ choreographic process. While this first level of data analysis provides many insights into the participant’s immediate feelings, the following steps of analysis begin to separate the data from the participant’s personal reactions in more depth.
6.3. Second Step of Data Analysis Process in Study 1

The second step of the data analysis utilized Axial Coding, a procedure in Grounded Theory analysis to ‘turn the data perpendicular to itself to create a new perspective to view it’ (Gasson, 2004). This is a process of only looking at the results from the first part of the analysis, not the raw data, to develop emergent themes based on this information. This results in a ‘second layer’ of depth to the analysis, further separating the data from the researcher’s memories and bias of the in-situ study experience.

Stage One: How do you create movement normally?
• Self-generation, improv, habits, self-exploration and awareness
• The collaborative natures comes from the affordances of the movement – the affordances exist as sensation/ emotion
• Knowledgable spaces, ‘new’ happens as accidents outside of known spaces – technique, personal habits, personality
• How to see something in the negative space

Stage Two: How was working with skeleton editing, camera keyframing?
• Embodied understanding shifts – concerned about how that fits in an analytical framework
• Want to off-load as fast as possible
• Being ‘in your head’ doesn’t allow for being ‘in your body’ dichotomy (recognized that they felt ‘awkward and timid’)
• idF changed the affordances brought new attention to them (image shape -> energy) (‘none of my technique can apply to this’)
• ‘unknowns’ are playful

Stage Three: How was working with the phrase over the weekend without technology?
• Less tied to ‘realism’
• Natural evolution
• Permission/ no guiding force (control?)
• Feeling less important/ driving (mirror to no mirror)
• Essence stayed (something made sense! From the beginning!)

Stage Four: How was movement after working with Cochoreo?
• Enjoyed using ‘given guaranteed material
• ‘transfer’ issues relate to body too – how to coordinate?
• Heightened awareness of self in relation
• Excited about new perspectives
• More comfortable with process and unknowns
The themes that continued to emerge from the second step of data analysis begin to highlight the researcher’s background in movement and choreography expertise by re-framing statements by participants to terminology from Laban Movement Analysis, art theory and creative process. This layer includes re-framing some data points to relate to the context they were made within and building connections between different point of data. For example, ‘Being ‘in your head’ doesn’t allow for being ‘in your body’ dichotomy’ connects to the participant’s experience of recognizing that they felt ‘awkward and timid’ in their bodies, illustrating that they felt the cognitive load was high at the beginning of the choreographic process with idF. However this experience shifted later in the process once the participant’s stepped away from the software to feel that the software was ‘driving the movement’ much less and allowing the body to work out the movement problems, connected to an experience of shifting from ‘working with a mirror to working without a mirror.’

6.4. Third Pass of Data Analysis Process in Study 1

The third step of data analysis utilized Selective Coding, highlighting the most common themes and exploring where they overlap. This investigation of the data continued to work within the temporal context setup by the study, but explored how the emerging themes created relationships between each other to support a more general experience of the data. Within the first stage of the study, it was found that every choreographer had a very unique approach to their process. For example, A1: ‘I like taking a body part, for right now I’m so focused on hips in… I’m thinking of how I can use that and have myself focused on sensuality as well, so different ways I can present movement with a focus on that specific body part.’ Another participant focused on emotion driving their process, for example B: ‘thinking about a moment in time and that experience. A lot of times I usually am thinking about different emotions during the day, if I had a stressful day, how can I think about that when I dance and its usually very clear to me (how to execute that). This section focused on how to explore the emergent themes and how they overlapped, while also relating the themes back to the initial comments from choreographer participants.
Figure 60. High Level Progression of Choreographic Process in Defamiliarization

This image illustrates the high level progression of the choreographer’s experience in creative process, specifically while using new software as a defamiliarization technique. The choreographer ‘at rest’ is oriented at the top of the illustration, highlighting that this is the choreographer’s personal knowledge bank, or accessible knowledge about themselves and their movement options to support their personal exploration choreographically. This includes the individual choreographer’s learned technique, everyday movement preferences and aesthetic sense that has been developed over their career, all of which is very meaningful to the choreographer and valued information. The choreographer ‘in reaction’ illustrates the choreographer in a somewhat disorienting situation working with the software that may be different or unusual from their typical process, in which the movement material is not yet meaningful or valued. The choreographer ‘in exploration’ illustrates a stage where the movement material is ‘in their bodies’, flowing more naturally and becoming comfortable enough to explore in more depth. In this stage the movement material begins to develop meaning and value to the choreographer, in its evolving connections to the choreographer’s personal knowledge bank. The choreographer ‘in interaction’ illustrates a stage where the software becomes supportive to the choreographer, in which they can begin to work interactively with the system to create meaningful movement material.

This process is parallel to the process of defamiliarization used in the field of Human Computer Interaction, where defamiliarization is a technique used to put a user into an unfamiliar situation in order to create some space between the personal reactions...
or habits of the user and their ability to make creative decisions. The ‘User Not an Individual’ in the middle of the illustration indicates that the HCI user is often not considered for their idiosyncratic self with a unique skill set, but as a general public user. This is in contrast to designing for choreographers, who have a very specific skill set and personal knowledge bank of movement expertise. The user is initially disoriented with the new software or provided scenario and asked to make decisions and continue to operate in the new scenario even while disoriented. The user’s experience is often then scaffolded to support their decisions or exploration process into a new area. Scaffolding is a technique for supporting a user experience by providing hints or familiar information that will help guide a user towards their goal. The more successful situations at supporting user creativity involved an equal interaction between the system or scenario disorienting and scaffolding the user’s experience to support their exploration of new opportunities and iteratively develop ideas over time. Both of these processes (for the choreographer and the HCI user) identify where the choreographer/ user is in their beginning state, designing a scenario to disorient them from their beginning state, and then support the exploration process to where the system and choreographer/ user can interactively iterate ideas for creative development.
Figure 61. Defamiliarization Process Compared to the Choreographic Process with idF

Themes that emerged during this step included:

1. Personal Knowledge Bank
   a. Sensory Preferences
2. Highlighted Body Actions/ ‘Essence’
3. Control and Permission
4. Transfer as a Skill
5. Affordances of Movement Material
6. Transitions as Meaning-Making
7. Commitment Reflects Intention
The Personal Knowledge Bank illustrates how easily choreographers can cognitively off-load aspects of the movement information that is important in the moment. This includes off-loading or relying on their learned techniques or personal movement habits. This theme mostly reflects on the Choreographer at Rest stage, where choreographers were able to identify what their personal movement preferences were before the study began, as well as articulating their heightened awareness of their habits while working with idF.

D: ‘I feel that when we improvise we are really creatures of habit. We tend to chose movement that feels good in our bodies and we’re familiar with. And so it’s interesting to push ourselves outside of our box.’

D: ‘I feel that none of my technique can apply to any of this, so that was interesting to me with it.’

A2: ‘because I want to be able to do it ‘cause it looked really cool seeing it drawn out, but when I was trying to do it in my body I was like, this is impossible!’

M: ‘I only had 3 or 4 frames and it took me the entire time to put it into my body…and everything is very non-sequitor’

Within the Personal Knowledge Bank was also an articulation of choreographer’s sensory preferences. Choreographers described how they generated material from their experience in the world: utilizing gravity, momentum, rhythm and emotion.

A2: ‘Performing a phrase ‘full out’ gives more possibilities from ‘feeling’ feedback’

D: ‘I took this workshop where we all improvised but we had all these different ideas like living in different body parts. So like, if your arm is a pencil but your hips are jello’
B: 'or thinking about a moment in time and that experience. A lot of times I usually am thinking about different emotions during the day, if I had a stressful day, how can I think about that when I dance and its usually very clear to me’

The Highlighted Body Actions includes the ‘essence’ that would reappear throughout the study. It was often these remnants or fragments of the experience that guided choreographers. Aspects that stood out continued for a while in the development of a movement phrase.

- Timing stuck
- Limb-Focused
- No Gravity/ Momentum
- Body/ Effort/ Time

In Control and Permission, the precision of the system controlled the permissions to explore for the choreographer, especially at the beginning of the process.

B: ‘I felt that when we were in class and I had the iPads in front of us it was strictly movement movement movement, just figure out what you are doing, but then at home I was able to take a step back and smooth it out.’

A: ‘I can never replicate it 100% exactly the same. Because of the constant shifts in the way that I’m holding myself and the way that my body is proportioned to gravity.’

A3: ‘Cause when you think about it so much, it doesn’t leave any room for error.’

Transfer as a Skill was indicated because the shifting of movement information from the software to the choreographer’s bodies was a large part of the creative process.
Over time it became apparent that it was the iteration between the technology and the choreographer’s felt experience that enabled the transfer of movement information.

A: ‘I feel like there are different ways that we could support that, augmenting movement in improvisation, whatever it could be. I guess physically seeing it kinda helped the brain not think so much so that the body was just going.’

Affordances of Movement Material refers to the movement opportunities that choreographers could invent when they were working with the idanceForms software. Because the movement information from the software needs to be interpreted for a live body in 3D space, the affordances provided by the software become highly important. While some aspects cannot be changed, such as the size of the iPad or the visuals appearing on a flat, 2D screen, some aspects can be designed to provoke the choreographer into imagining more creative opportunities.

D: ‘it was really interesting working with this technology because in a computer gravity doesn’t exist. And momentum doesn’t exist, and there are all these other elements that we use in movement that when working with pictures that you can’t necessarily incorporate’

Exploring Movement Transitions as Meaning-Making devices became important because it was the ‘transitions’ between the idF keyframes where the choreographers were able to make ‘sense’ of the movement material. Even though they were working from the animations of the movement keyframes, the choreographers tended to interpret the movement data on their bodies as many less-dynamic instances strung together. However once the choreographers took time on their own to find an embodied sense of the movement, mainly through exploring new transitions and a sense of weight shift and timing changes, they were able to find new value and make meaning in the movement material.

A4: ‘I just feel ..I had trouble picking up the movement that it was the transitions of the movement, not so much the movement itself. Because you can easily look at the skeleton and see ooh, this arm is here and this arm is here, but it was the transitions between the movement that felt so foreign on my body.’
M: ‘It felt that in the last class transitions were non-existent but working on it on my own helped me to flow into the movement, kind of like what [A2] said just getting it more into my own body. But the transitions morphed more naturally on my own. The transitions feel more a part of the dance, rather than movement to movement.’

6.5. Fourth Step of Data Analysis Process in Study 1

The fourth step of the data analysis utilised Applied Coding, relating the current state of the data analysis back to the research question to indicate what facets crystallize within the research context. I outlined the various parts of the research question and explored how the current results fit within these sections. This also enabled me to go back to video of the study and observe body actions and choices made by the choreographers, and how they shifted over time. This step of the research process is not limited to the temporal structure anymore, yet combines focus group transcriptions with observational data.

What is being catalyzed?

- Awareness of self/ personal habits
- A process of exploration
- Investigation of new movement
- Investigation of new ways to think about movement
- New affordances of movement
- New ‘feelings’ of movement

What are the affordances of the software?

Beginning of the process:

- Precisions = limited freedom
• Initially mechanical, rebound timing
• Choreographers used the same facings (orientation)
• Choreographer’s joints fold/ bend linearly
• Choreographers perform movement sequences without effort quality

End of the process:

• Choreographers used more joint rotation (moved more than one axis at a time)
• Sequential movement was prevalent – not a whole body action happening with all joints moving simultaneously
• Choreographers changed facings/ orientations
• Choreographers used levels of space and moved through space with sequences
• Swinging actions were used, emphasising more use of weight shift, momentum and rhythm
• Choreographers incorporated repetition, illustrating more compositional methods being used
• Comments on having ‘freer’ movement in iteration

Keyframe timing and gestural movements tended to ‘stick’ throughout the iterations (illustrating an ‘essence’ of the idF movement)

How did the study process defamiliarize the participant’s creative process?

• Disoriented the choreographers, they were unsure of how to proceed
• Highlighted awareness of personal movement and learning preferences
• Highlighted situations around trust of their own creative process or of the study situation
• Emphasized a shift in the choreographer’s approach to choreographic process with idF, from replicating or mimicking the movement in the software to taking a stronger problem-solving approach to designing movement.

• Movement transitions shifted from simple, linear options to more complex and environmentally-engaged options (utilizing momentum, weight shift, etc).

Aside from arranging data into the selected research questions, another topic emerged around how choreographers ‘transferred’ their existing embodied and choreographic knowledge to a new situation. I named this topic ‘transfer as mapping’, relating the process of transferring knowledge from one context to another with the digital media topic of ‘mapping’, indicating how a computational input is ‘mapped’ or designated to control an output. This highlights how a choreographer ‘maps’ their personal embodied knowledge of movement and choreography to the idanceForms software, literally mapping their understanding of body position to the designed joint angles of the software. Thus, over iterations, enabling the choreographer to re-map their understanding of a movement with idanceForms back into their embodied experience, making it ‘work’ on their own body. This process is often non-verbal and discovered experientially through trial and error and requires multiple iterations. Aspects that I observed included a mapping of body position, of keyframe timing, of transitions between movements or interpolation between keyframes, and of how the affordances of the software ‘instructions’ were used. This includes the initial use of instructions as explicit/direct instructions and mapped somewhat crudely onto a physical body, and then over multiple iterations enabling the software instructions to become more implicit/indirect to guide a facet of the movement design and not necessarily the entire package of information.
The fifth step of data analysis accounted for the new data collected in studies 2 and 3. Focus group data was transcribed, with notes taken throughout regarding new or extended concepts relating to the results. Transcripts were coded with the existing topics from the General Model and new, emergent codes (see Figure 60). Videos of the choreographer’s process were reviewed and notes were taken regarding new or extended concepts.
These results were correlated with the results of Study 1 and I illustrated where similarities and differences occur. Most of the existing General Model was confirmed with the new results from studies 2 and 3, though one micro theme was adapted and two new micro themes were added. The process of assessing new and existing micro themes can be viewed in Figure 61.
6.7. Conclusion

In conclusion, the final model of novice choreographer’s experience of ‘ah ha’ moments illustrate a shifting experience of the choreographer and their relationship to their own creative process. This experience moves through three stages, Choreographer in Response, Choreographer in Exploration and Choreographer in Interaction. Within each of these stages there are three macro themes that exist, yet they shift priority in each state. These themes are Emerging Insights + Awareness, Movement Choices and Volition + Intention. Within the macro themes are micro themes that overlap, yet they illustrate nuanced details about how a creative choreographic process is experienced. These micro themes highlight the building blocks of a choreographer’s defamiliarized experience, identifying basics such as Body Mechanics that are needed to make movement choices that don’t fall down to more complex aspects such as Perception of Agency that effects how much control a choreographer believes they have.
This model of experience in choreographic process was developed through many iterations. These iterations explored the data from a variety of perspectives, including direct responses of the choreographic participants to my emergent revelations while using my expert lenses in movement analysis and choreography. While choreographic stages and macro themes appeared predominantly and presented itself as a fluid structure, micro themes required more process. The final model including micro themes was explored from multiple perspectives to assess relationships between content including temporal, causal and spatial perspectives. Below is a table of micro themes listed from their macro categories with the location of the data collecting. Insights received from this step of the process include the connections between types of data and the macro themes they support. Many of the Movement Choices theme emerged from observational data, whereas data specifically from focus groups support the Emerging Insights + Awareness theme. Data from both observations and focus groups is highlighted in the overlapping and shifting priorities between micro theme relationships.
The final chapter of this dissertation will revisit the motivations for this research and will highlight the connections between the research question and the contributions of this work.
Chapter 7. Conclusion: Development of a Model for Interactive Choreographic Process and Technology Design

In this chapter I present a review of the research design that supported the investigation of the research question, how novice choreographers experience ‘ah ha’ moments while creating with a choreographic-support tool. This summary relates the findings of the study back to the research question to highlight the contribution of this work of novice choreographers iteratively interacting with a choreographic support tool. This work is contextualized by connecting it to related research projects and literature. Chapter 7 concludes by discussing limitations of the study and proposals for future work.

7.1. Context of the Study

This research investigates the experience of novice choreographer’s ‘ah ha’ moments in creative process in order to address a gap that exists between current models of digital creativity tools. ‘Ah ha’ moments refer to moments in a creative experience that bridge connections for a choreographer, resulting in a new awareness and often reflection.
of an iterative process. I specifically explore the domain of choreographic practice because movement is under researched, yet movement is a core component of our everyday interactions and is rich with information about creative process. Movement can also reveal moments of ‘ah ha’ experiences that are sensed in the body and might not be able to be communicated verbally. In choreographic practice collaboration is recognized as a key element in compositional process between choreographers and dancers, and is recently described as a process of ‘Co-Imagination’ by performance theorist Andre Lepecki (Cunteanu, 2016).

Co-Imagination is articulated as the process of imagining the creative possibilities interactively together, yet the co-imaginer might not be a co-author. The term ‘co-imagination’ places emphasis on creative interaction as a ‘prompt’ for creative ideas which has an unequal balance of creative control, whereas the term ‘collaboration’ is often considered to have equal share of creative roles. Co-imagination requires the choreographer to be highly responsive to the imaginative influence of others, and enabled to work outside their comfort zone. However in co-imagination, the choreographer maintains creative control. While this is a common practice in contemporary choreography, the choreographic strategies of back-and-forth interactions (with mutual participation from dancers) is often implicit, seldom considered in creative acknowledgements and are under researched as a creativity tool for choreography.

This study explores how co-imagination can be incorporated into the creative process between a choreographic support tool and choreographers while leveraging defamiliarization. With the definition of a ‘prompt’, co-imagination supports a system design that provokes novel ideas. This is different than a system attempting to have the same amount of creative control as a live choreographer in which to work equally, in collaboration, between the choreographer and the system. I implemented an approach to co-imagination in the idanceForms system by designing a generative feature which was tested in studio workshop environments with university-level students. The success of this approach was evaluated by inviting choreographers to develop a movement phrase with the system over multiple sessions and assessing how they experience ‘ah ha’ moments. Experiential data was collected through guided focus groups utilizing phenomenological
methods in each session. The focus group data was correlated with observational data of the researcher to develop the final model. Data was analyzed for emergent and resonate themes using a grounded-theory approach to exploring the data through multiple layers and perspectives. The goal of this research is to find patterns that can contribute knowledge to how we understand the choreographer’s collaborative creative experience while working interactively with a choreographic support tool. This analysis is a first step in advancing knowledge that can enhance models for co-imagination in system design for choreographers and whole-body movement experience.

7.1.1. The Research Question

How does a novice choreographer’s experience of defamiliarization with a co-imagining choreographic-support tool effect the development of ‘ah ha’ moments?

Through investigating this core question, the research will advance knowledge needed to enhance interactive design of choreographic experiences with technology by:

- Identifying components of novice choreographer’s interactive and co-imaginative creative process
- Identifying and implementing specific characteristics of how technology engages performer creativity
- Identifying and analyzing the effect of co-imaginative features in a creativity support tool for choreographic experience
- Exploring when and how ‘ah ha’ moments were experienced in the choreographic process
- Engaging focus groups to gather choreographic suggestions for how they might experience movement using this tool
These activities support the investigation of the core question by articulating choreographic devices used in co-imagination and in creating an environment in which to study the choreographic experience.

### 7.1.2. Review of Research Protocol

To facilitate the investigation of ‘ah ha’ moments in choreographic process, I designed the generative component ‘Cochoreo’, that was implemented in the idanceForms platform, which specifically guided movement choices towards ‘new’ opportunities through a defamiliarization process. Cochoreo guides movement choices by generating ‘movement catalysts’, suggestions for positions that are animated by idanceForms. Movement catalysts are generated by using parameters from Bartenieff Fundamentals and Laban Movement Analysis. These parameters constrain positions that relate to typical movement techniques (extended limbs, symmetry, stability) and provoke positions with variations in limb extension, asymmetry and instability. While working with movement parameters in this way was a unique experience for most novice choreographers, this experience was specifically designed to create a defamiliarization experience. Defamiliarization is a strategy for provoking creativity by using ambiguous and often disorienting situations to fully engage a participant in a task, both in a cognitive and embodied state.

Within three studies, novice choreographers were asked to iteratively develop a movement phrase over a week-long period with various studio sessions. Participants in the first study explored the software with guided instructions in the first session, iterated their material without the tool outside of the class with choreographic instructions, and continued the development specifically working with the generative feature in the second session. Choreographers participated in a focus group at the beginning and end of each session. The first session began with a discussion about existing choreographic practice and preferences and ended with a discussion about how they experienced the process of choreographing with the tool. The second session began with a discussion about their experience working with choreographic instructions but without the tool and ended by discussing the entire experience of choreographic iteration and creative opportunities with
the tool. Participants in the second and third study explored the software with looser instructions over five-to-six sessions, creating and iterating a movement phrase towards a choreographic work. Choreographers in these studies also participated in focus groups at the end of each task, which often took place at the end of the session.

7.1.3. Research Findings

Stages and Macro Themes

Research findings emerged as having multiple levels. The highest level illustrates stages of the choreographer’s experience as shifting iteratively throughout their creative process. The first stage of Choreographer in Response recognized the process to ‘getting to know’ a new situation, yet often responding with the most typical actions to that choreographer (their fallback response or habits). The second stage is Choreographer in Exploration, illustrating a better understanding of the creative situation, trust in themselves and the tool yet with minimal risk taking. The third stage, Choreographer in Interaction, illustrated a more fluid interaction between the choreographer’s personal decision-making process and engaging with the tool. This stage came closer to being a co-imaginative experience by making movement suggestions (when prompted by the choreographer) that could be interpreted in a real-world body. The digital steps taken to create those movement suggestions could then be recorded as a reminder or cue sheet to prompt the memory of the choreographer in future interactions.

Within each stage are macro themes which shift priority throughout the process. These three macro themes, Emerging Insights + Awareness, Movement Choices and
Volition + Intention are all present through the three stages of choreographer experience: Choreographer in Response, Choreographer in Exploration and Choreographer in Interaction. In the first stage, Choreographer in Response, the theme of Volition + Intention was a priority because there was not yet solid trust in the situation and therefore minimal willingness to take risks right away. Movement Choices is second in priority because the experience of executing the movements, generated by idanceForms, was a consuming part of the process. Emerging Insights + Awareness was third in priority because choreographers were attending to creating any movement that they can devise in the moment rather than attending to their many choices or awareness of movement options.

In the second stage, Choreographer in Exploration, the theme of Emerging Insights + Awareness became the first priority because choreographers had time to reflect on the choices that they made in the first stage. Through reflecting on their choices, choreographers utilized the theme Volition + Intention more to become comfortable with exploring available movement options. The third priority of this stage is the choreographer’s Movement Choices. While the choreographer made many more movement choices in this stage, the newly important ability they had to be aware of the choices was more prevalent.

In the third stage, Choreographer in Interaction, the theme of Movement Choices became the first priority because choreographers had already developed their reflection and awareness (the second priority) and engaged in their Volition + Intention (the third priority). Awareness and Volition could continue operating as themes in the choreographer’s experience but did not require their direct attention. Choreographer’s Emerging Insights + Awareness was observed through their trust in interaction with idanceForms and other choreographers as well as their playfulness with the movement choices. At this point choreographers had the confidence and interest to explore movement widely and take risks iteratively, and they were able to explore successfully creative movement opportunities.

In the fourth stage, Choreographer in Composition, more embodied development cues emerged and supported the fluid shift between stages, including being wary of new
material while simultaneously taking risks. For example, participant K in Study 3 at UIUC took a new direction in the workshop session on creating a movement phrase they disliked from Cochoreo. Instead of exploring movements that she physically did not like, choreographer K explored the detail of a movement by designing an arm stroke in real life and attempted to animate it. In the process of animating it in idanceForms she discovered how detailed the movements she was physically making were after creating 15 keyframes. A video with the idF file and K performing the movement phrase side by side can be viewed here or at the bottom of the accompanying website:

http://myilstu.edu/~kacarl1/index.html
Micro themes refer more concretely to the ‘ah ha’ experiences that novice choreographers had during their process. These include moments that were described in focus group discussions as well as moments observed by the research when a choreographer seemed to discover or ‘make sense’ of a movement choice in their body. Micro themes are categorized within the overlapping macro themes because they relate to specific themes of choreographic experience. Emerging Insights + Awareness has a single theme to itself: Self Capabilities (the realization on what the choreographer was capable of). Movement Choices has four themes to itself: Even vs Sequential Time (experience of augmenting time), Linear vs Spiraling Joints (experience of finding nuanced motion in joints to support sophisticated movement), Body Mechanics to Support Movement (needing to have basic alignment and function in the body to execute a movement) and Physics of the Physical Body (the experience of adding weight shift, momentum, attention to the environment to support nuanced execution of a movement).
Volition + Intention has three themes of: Perception of Agency (the choreographer’s perception of their control in their creative process), Emotional Assessment (the choreographer’s state of mind and emotional engagement) and Willingness to Investigate (the curiosity and interest to take risks in the choreographic process).

Overlapping macro themes also contain micro themes that touch on multiple aspects of the choreographic experience. Emerging Insights + Awareness and Movement Choices has five themes: Sensory Feedback, Fallback Response, Isolated Body vs Spatial Tensions, Trust in Self and Environment and Reflection on Movement Choices and Attention to Process. Emerging Insights + Awareness and Volition + Intention has three themes: Reactive Disorientation vs Situated Action (the experience of reacting with fallback response vs making improvised but informed choices), Mimicry vs Problem Solving (choosing actions that replicate the instructions as closely as possible vs using instructions as a risk-taking springboard) and New Approaches to Movement (discovering the awareness of new opportunities alongside a curiosity to explore them). Movement Choices and Volition + Intention overlap with two themes: Affordances of System Design (design choices that effect the choreographer’s experience and decision-making) and Choreographic Mapping (the choreographer’s choices of how to map information from the choreographic tool onto their live body).

These findings illustrate that iteratively choreographing within a defamiliarized environment engages the choreographer in a way that provokes reflection and awareness of their movement and compositional choices. The ‘ah ha’ moments illustrated through micro themes were experienced repeatedly and were a result of their accompanying macro themes: Emerging Insights + Awareness, Movement Choices and Volition + Intention. Novice choreographers found that iteratively working with a tool that could contribute to generating movement ideas provided new opportunities not just for creating content, but for understanding their own process and preferences. This process enabled choreographers to better understand their own approach to movement and how to construct new approaches to co-imagine in choreographic process.
7.2. Relating Research Results to Research Questions

7.2.1. Correlating Analysis of Literature with Final Research Results

To begin my comparison, I bring attention to Cross’s overarching design strategies for creativity and correlate them to my research in choreography. Cross noted that design strategies which are apparent in all case studies include:

1) Taking a broad ‘systems approach’ to the problem, rather than accepting narrow problem criteria. In my work this relates to using the concept of ‘co-imagining’ to create a broad potential for experience without an equal balance of creative control. ‘Co-imagining’ can relate to many experiences in many contexts, without constraining options.

2) ‘Framing’ the problem in a distinctive and sometimes rather personal way. In my work this relates to the use of defamiliarization to frame the problem in a new way, that then distorts the typical personal approach to solving the problem. While this framing constrains the options in some ways, it also supports exploration of new options simultaneously.

3) Designing from ‘first principles’ (or the mechanics/affordances of the task)(pg. 75). In my work these ‘first principles’ relate to the fitness function choices in Cochoreo’s generative feature, provoking choreographer’s exploration of unstable, asymmetrical, angular and complex movement opportunities. These parameters enabled specific movement choices over a dynamic but specific decision-making process that was unique to choreography.

These strategies are regularly implemented by choreographers as a way to manage the creative process and guide attention to support exploratory creativity. My combination of these strategies was used to consciously [and strategically] design a situation that would guide choreographers to explore and discover new movement options.
**Literature Analysis**

The literature analysis of creative systems resulted in the emergence of four designated categories. These categories illustrate the relationship between system-led and user-led agency (or potential for action) in Human-Computer Interaction. The choreographic stages illustrated in the final results support the categories found in the literature analysis of creative systems.

While investigating the gap in existing creativity support tools in HCI and choreography, I analyzed literature on systems and how they were deployed in ambiguous or defamiliarization contexts to engage participant’s creative idea generation or decision-making. From this analysis I found that systems tended to fall into one of four categories relating to the level of system and/or user agency in the experience. System agency refers to the level of suggestion or control provided by the system (for example, autonomous systems have a high level of agency with minimal input from a user). User agency refers to the level of suggestion or control provided by the user (for example, creativity support tools often have a high level of user agency with minimal input from the system).

The four categories are listed from minimal to high agency: Disorientation (low system and user agency, neither has much control in the situation), Closed Exploration (low system agency but high user agency, a typical creativity support tool that provides a number of options for users to engage with), Open Play (high system agency but low user agency, a typical metacreation system that generates creative options without user input) and Creativity Systems (high system and user agency, supporting co-imagination through co-control). These categories align with the choreographic stages found in the final results. Disorientation and Closed Exploration correlates with the Choreographer in Response because the choreographer experiences a feeling of constrained agency even when they are in control. Open Play correlates with the Choreographer in Exploration stage because the choreographer is able to receive generated creative options from the system though may still feel ‘not in control’ of their own process. The Creativity category correlates with the Choreographer in Interaction stage because both the system and the choreographer can iterate movement content dynamically, with agency, yet continue to experience a feeling of control and co-imagination.
7.2.2. Correlating Results of Pilot Studies and Prior Practice with Final Research Results

Final research results coincide with prior practice and studies by the author in designing experiences for choreographic creativity with digital technology.

![Image of Scuddle Vs. CoChoreo](image)

**Figure 69. Comparing Iterations: Scuddle Vs. CoChoreo**

In the original design of Scuddle, generated positions were static and minimalistic stick figures. This design prompted choreographers to focus more on the interpretation of figures (and invention of new positions) than attempting to map the exact 2D position onto their moving 3D bodies. The low resolution of data catalyzed novel exploration, yet it could not guide positions into movement. CoChoreo generates keyframes, yet they are animated to create movements and use a 3D stick figure. This design uses a higher resolution of data, which prompts more attention to the physical mapping from screen to body. When choreographers were learning material from the static keyframes, the higher resolution of data prompted them to focus less on their creative interpretation of the positions themselves, but brought attention to the transitions between positions as they had to maneuver dynamic changes in the data. Though when choreographers attended to the animated phrases instead of the static positions, they attended to the translation of dynamic parameters such as time and momentum more than the body position.
B: I felt that it felt better on my body if I used the app for inspiration for my movement and didn’t necessarily try to replicate it exactly. So that really helped. And then when we sped up our movement or added repetition that helped it flow more easily through my body.

B: I felt that after going back and forth, like when I was first working with it, it was very planar, but once we took it from there and took the movement home I could explore the other aspects of it. So then today in the space, even though we went back and added that bit in, I tried to keep the idea of my home movement but from a generated source.

Scuddle generated movement positions for choreographers to use in creating new movement material. Scuddle also created a defamiliarized experience because of the complexity of movement information provided for the choreographer to interpret. In this research it was found that choreographers: compared their usual process to the current one, they had a heightened awareness of their actions, they re-examined their approach to movement in the current process, movement was initiated in creative and non-habitual ways and choreographers could articulate much of the process verbally. The integration of Cochoreo in idanceForms took the concept of Scuddle further by enabling animation of positions to create movement and to enable the choreographer to have more control (or agency) of the fitness function. Findings discovered again that choreographers could discuss their process and decisions within it verbally, they had a heightened awareness of their choices, they explored movement in new ways and re-considered their typical approach to creative process.

The exploration of practice by creating the piece ShiverSlouch revealed both technological limitations as well as unique aesthetic opportunities. This process combined a variety of systems in order to capture, manipulate and choreograph movement material in iterative collaboration with technology. This process found limitations in technology such as the Kinect camera because limited space, high speeds, unusual body positions or movement at odd levels (i.e. on the floor or jumping) was difficult to capture. In attempts at manipulating captured movement files in DanceForms, movements became very jittery yet provoked creative opportunities for quality of movement alongside movement material. Through live engagement with the choreographic content a piece was constructed, but there were many issues of trying to use the existing technology as a trustworthy ‘collaborator’. Yet in the final study, the shift to using technology as the co-imaginative
sketching partner the results were much more satisfying. Technology glitches were not the focus of the movement content. Unique movement opportunities continued to be generated. Choreographers were able to map the technology content onto their bodies. A feeling of trust developed through learning the system, learning to let go of some control and developing a process of co-creation. The ShiverSlouch study was important as a process of seeing in-situ where and how technology was limited as a collaborator. While many of the aspects were technologically limited (framerate, skeleton models, etc). the afforded aesthetic or compositional features were also limited. These affordances developed more in the final idanceForms and Cochoreo iterations, supporting choreographic iteration.

idanceForms studies resulted in both aesthetic and functional experiences that were focused around the tool itself (not as much about the experience of choreography). Two studies were performed, one with professional choreographers and one with youth. Choreographers were observed using the Camera Keyframing tool in unique ways, photographing objects or bodies from odd perspectives to capture material that could generate unusual content. Results identified a desire for compositional options for transitions between keyframes, the ability to group keyframes, to use multiple figures and to personalize content using music or prior photographs. The tool was identified as an important contribution to sketching movement material, exploring the development of phrases, remembering and practicing choreography from a ‘cue’ perspective (rather than from a video). Both studies highlighted the importance of having a support tool for creating material when they were 'getting stuck’. All these components correlate with the findings in the final study, that the idF compositional tools enable new perspectives to movement and support generation of unique content. From an observational point of view these findings also correlate with the dynamic process found in the final study, that the attention and response of a choreographer shifts over time. Additional features are continuing to be developed that will address these results.
7.3. Contributions of the Study

7.3.1. Model of Novice Choreographer’s Experience of ‘Ah Ha’ Moments

The main contribution of this study is a better understanding of how novice choreographers experience ‘ah ha’ moments in creative process dynamically, while in interaction with the choreographic support tool idanceForms. Choreographers experience three distinct stages, particularly in relation to the defamiliarization approach used: Choreographer in Response, Choreographer in Exploration and Choreographer in Interaction. These stages are dynamic and contain a macro and micro level of reoccurring themes. Macro themes include: Emerging Insights + Awareness, Movement Choices and Volition + Intention. These findings illustrate how the choreographer relies on the shifting priorities of the themes to become more comfortable to take creative risks in interaction with idanceForms, illustrating a level of co-imagination.

Of special interest is the finding that themes had a reoccurring level of priority in relation to the stages. Volition + Intention was a higher priority while the Choreographer was in Response and a lesser priority when the Choreographer was in Interaction. This illustrates that choreographers were staying creatively ‘safe’ at the beginning of the process, though as they became more comfortable and aware of the process and available opportunities could start exploring more widely. Emerging Insights + Awareness was a low priority while the Choreographer was in Response and a middle priority when the Choreographer was in Interaction. This illustrates that choreographers were mostly responding to movement suggestions through their fallback responses (or habits) to find...
the most efficient solution to a movement problem. By the second stage, Choreographer in Exploration, they were becoming very aware of their own movement habits, compositional choices and decision-making processes. Awareness became less important (to the middle priority) by the third stage, Choreographer in Interaction.

‘Ah ha’ moments are particularly important in the expansion of a choreographer’s movement vocabulary at any stage of their career. Movement material revolutionizes codified technique which in turn transforms compositional processes. New approaches to compositional process in turn inform the evolution of movement material. This creates new opportunities to problematize movement that might not exist otherwise. While this study has been focused on novice choreographer’s experience it can be inferred to professional choreographers who are always in reflection of their habitual and developed movement knowledge and often searching for new perspectives to their movement knowledge.

This project contributes to this research fundamentally by demonstrating that choreographic awareness and decision-making is dynamically shifting over time, effecting the use of options designed into technological tools. While designing a tool to ‘co-imagine’ with a choreographer must also be able to dynamically shift, this study indicates specific themes that are useful to consider when designing for ‘ah ha’ experiences in choreographic support tools.

7.3.2. Design Considerations in idanceForms to Support Co-Imagination

A second contribution of this study is the development of a generative feature for idanceForms, a sketching tool for movement. This feature, Cochoreo, enabled a choreographic support tool to ‘suggest’ positions that could be added to an existing sequence and manually augmented by the choreographer. Enabling the choreographer to keep an iterative record of sketch positions of both their own and the system’s design supports a co-imaginative approach to developing ‘ah ha’ moments. Shneiderman states that ‘While the Aha! moments of discovery and innovation are very personal, the processes that lead to them are often highly collaborative.’ In his paper ‘Creativity Support
Tools: Accelerating Discover and Innovation’, Shneiderman articulates design principles for creativity support tools as having the ability to: support exploratory searches, enable collaboration, provide rich history-keeping, should be easy for novices yet include ambitious functionality that experts need (Shneiderman, 2007). Yet how to make these design choices for the discipline one is working in is not clear; such as choreography and the complexity of capturing and managing movement data.

The design of idanceForms and Cochoreo relied on knowledge of how choreographers work, think and move. From using the camera-keyframing feature to capture positions as they are performed to generating unstable and asymmetrical catalyst to suggest movement options, design choices revolved around the experience of movement and moving. Through the flexibility of idanceForms many novice choreographers were able to explore a variety of ways to design and create movement material in ways that become fluidly interactive between choreographer and tool. idanceForms was able to support the shifting priorities of themes in the findings. For example, increased awareness of the body in a choreographer can increase volition, which in turn increases novel movement choices and sophisticated performance of those choices.

While the success of inducing ‘ah ha’ moments of awareness and reflection were high with the co-imagination process between choreographers and Cochoreo, it can continue to be developed further. To be a truly co-imaginative and assistive choreographic tool, Cochoreo will need to address additional movement parameters with various forms of representation. Additional parameters include time, effort quality, space and orientation. Representation of these parameters could be abstract and loosely connected to keyframe animation in idanceForms. This potentially modular perspective could bring more creative suggestion to the choreographic support tool, provoking new forms of ‘ah ha’ moments.
7.3.3. **Design Considerations of Using a Defamiliarization Approach**

A third contribution includes the implementation of a defamiliarization approach to how the technology was used to catalyze the choreographer. This approach was used in a variety of ways. 1) I designed the generative feature in idanceForms specifically to create unstable, asymmetrical and complex movement catalysts. This approach disorients the choreographer and engages their problem-solving skills to explore unique movement opportunities. 2) idanceForms was designed as a tool for sketching movement. It was not expected that the tool could capture movement in a high-resolution format and manipulate it easily. The tool operated with a keyframe structure, similar to using ‘cues’ to prompt the choreographer. While keyframes transition into movement when animated the choreographer’s design choices are on a position. This approach to design was also an unusual approach, to choreograph from a visual of movement rather than a sensation. 3) The use of technology as part of the choreographic process was new to all novice choreographers.

This experience required choreographers to reconsider many facets of the existing process for investigating movement and attending to their compositional choices. This experience also required choreographers to think greatly about how to map information from the digital tool onto their bodies in ways that was not flat, planar and frontal. Defamiliarization heightens the choreographer’s awareness and reflection on their current movement choices. This process of using specifically designed defamiliarization approaches to movement enabled the augmentation of novice choreographer’s movement choices and attention to new opportunities that would not have existed otherwise.

7.3.4. **Model of Design Considerations for Interactive Tools Using Defamiliarization Approaches**

The fourth contribution of the study is the model of creative agency developed from the literature analysis to explore the implementation of defamiliarization approaches in tools for Human Computer Interaction and Choreography. The literature analysis discovered that there were categories of how interactively creative a system was.
Interactivity was evaluated by how much agency a user or choreographer had when using the system, and how much guidance the system gave in interaction with the user. It was found that there are existing systems in every combination of these parameters, though few with both a high level of user agency and system guidance. The balance of agency as potential to act influences the amount of creative control held by both a choreographer and a creative system. When there is a high level of both user and system agency, yet an unequal balance of creative control (with the choreographer holding most control), having a co-imaginative support tool is highly valuable for provoking creative opportunities and reflection.

This investigation contributed four categories of interaction experiences. Disorientation has both low user agency and system guidance, and creates an unfamiliar environment in which the user has minimal ability to effect. This experience is often focused on an interaction in-situ or in-the-moment. Closed-Exploration has low user agency but high system guidance, inhibiting a user’s typical actions but highlighting new opportunities. This experience often has a clear objective and purpose. Open-Play has high user agency with low system guidance, enabling users to make many choices without input from the system. This experience becomes more exploratory and is reliant on the user. The Creativity category has both high user agency and system guidance, creating an environment of co-imagining. This category may both inhibit and provoke a user’s actions in relation to system suggestions to interactively explore a creative space. I found that these four categories applied to Choreographic Support Tools as well as tools in HCI, with few choreographic tools existing in the Creativity category. Many Choreographic Support Tools fell into the Open-Play category (supporting the choreographer’s own exploration without suggestions from the system) or the Closed-Exploration category (constrained systems allowing choreographers to manipulate structures or annotate video).
7.4. Limitations

7.4.1. Approach to Defamiliarization

This study explored the implementation of a defamiliarization method specifically to guide choreographic movement choices towards unstable, asymmetrical, complex and novel opportunities. As implied in the data collected from both pilot studies and the final study with novice choreographers, this approach to movement generation created highly unique positions that were outside of the choreographer’s prior experience with movement. The choices made to construct the movement generation were developed iteratively through a practice-based design process specifically to inhibit the use of traditional dance technique training when solving the movement problems. The results of the movement generation tool were positive, in that choreographers rarely created movement choices through their traditional process. While this is one approach to designed defamiliarization, many more could be created to augment particular movement experiences.

7.4.2. Experiences of ‘Ah Ha’ Moments

Through the defamiliarization design and interaction with idanceForms, all of the novice choreographers experienced an ‘ah ha’ moment. This moment of ‘synthesis’ refers to a small scale discovery about one’s own movement habits, preferred choices, opportunities for new choices and recognition of curiosity. These moments came from choreographers being momentarily frustrated or ‘stuck’ and then finding a new way through the problem. This experience often resulted in a reflection on the problem and recognizing their patterns and new opportunities. These moments were mostly minor, limited to reflecting small choices, yet they are slowly broadening movement options. While the ‘ah ha’ moments were small, mainly relating to what creativity theory describes as personal-C creativity (Sternberg, 1988), these moments accumulated to powerful experiences for novice choreographers. Focus groups articulated new understandings of their physical experience of movement and creative choices while observational data
illustrates embodied moments of ‘synthesis’ where movement experiences seems to ‘click’.

Because Cochoreo has been evaluated in a university-level workshop environment it is easy to perceive the system as useful for teaching, though not necessarily for professional creativity. Though the study data cannot be inferred to professional use, in my professional experience the process of expanding one’s movement vocabulary and of using dehabituation in one’s own professional development is common.

7.4.3. In Research Design

The design of the research required that a group of choreographers used the idanceForms application to choreograph a movement sequence over a period of time. Two limitations to the first iteration of the study were 1) I worked with a group of 2nd year university choreographers and 2) we only had two sessions to work together. I amended this in Studies 2 and 3 by working with varied-year university choreographers over 6 sessions. In future work I would like to run a study with professional choreographers, preferably who have had experience working with technology and choreography before. I would also like to perform a longitudinal study with professional choreographers in the future to further investigate the iterative experience of creating with a choreographic support tool.

7.4.4. In Creativity and Movement

Limitations of this research topic also double as benefits and includes the idiosyncratic nature of creative process and the complexity of movement information and lack of existing taxonomies to articulate this information fully. While all creative processes are individual to the practitioner, all processes follow a regular course of development that can be leveraged, however loosely in design. This complexity of movement information also affects the ability to directly model movement information in technology due to the mathematical and computational energy required to manage data with advanced analysis
methods (such as machine learning techniques). However, the richness of movement information is highly important because it holds many subtle and often-overlooked qualities that we as humans rely on for communication, social cues and guiding attention. The implementation of this research can be beneficial in the specific contexts of creativity support tools for choreography and creative movement but also in the broader contexts of HCI, robotics, cognitive science and design for furthering development of whole-body interaction technologies, believable virtual characters, physical computing and design for aesthetic experience.

7.5. Future Work

While I specifically target novice choreographers in these studies, the experience of ‘ah ha’ moments can be inferred to expert choreographers. This is due to the common experience of defamiliarization, anyone presented with a new situation will struggle at first to learn, understand and engage with the situation fluidly. Future work will include extended studies with professional choreographers after additional prototypes have been developed. This process will provide additional information on the dynamic model of choreographic experience and the interrelating themes, and will validate if the same model works for professional level choreographers. This exploration would generalize research results and while providing more detailed relationships of discovering ‘ah ha’ moments through creative innovation.

The findings of this study also suggest the importance of the aesthetic affordances of the system design and how they effect choreographic mappings. One project in future work will explore additional figure renderings for positional representation. Additional rendering options could support the volition of choreographers at the beginning of the choreographic process, or suggest additional movement alternatives based on the aesthetic affordances. Future work will also explore opportunities for leveraging other movement parameters through the use of aesthetic framing and defamiliarization. For example, exploring minimal visuals that could afford qualities of Disney animation principles (i.e. squash and stretch) could reference physics qualities. Utilizing a physical
model could also support more realistic natural environment parameters for supporting qualitative and experiential movement opportunities. Another step in movement content generation could explore the generation of movement sequences. This process would require and identification and assessment of movement dynamics to articulate what makes a 'successful' movement phrase.

The final studies of Cochoreo with novice choreographers brought attention to many movement parameters that are not included in Cochoreo and idanceForms. Parameters such as time, effort quality, dynamic change, space and relationship were identified as useful components. This also highlighted the opportunity to explore a modular system that might operate as a ‘score’ or a loose timeline of movement concepts rather than a precise record in keyframes. Future work will include new modular prototypes that explore additional parameters as abstract opportunities, that may be able to connect to Cochoreo and idanceForms through a score interface. These prototypes will be tested with professional choreographers for their support in co-imaginative processes.

7.6. Conclusion

This study on novice choreographer’s experience of ‘ah ha’ moments during choreographic process in interaction with the idanceForms system addresses the gap that exists between current models of digital creativity tools. By designing systems consciously to support ‘co- imagination’ in an embodied interactive process, we as system designers can engage with choreographic practice to support the creative development. In this work, the implementation of defamiliarization as a component of co-imagination is recognized as a strategy for stimulating creative decision-making. Pairing defamiliarization with a supporting or generative feature has appeared through my literature review on creativity in Human Computer Interaction projects and Choreographic technologies as an effective approach to engaging the experience of the user in ‘co-imagination’. This finding has appeared through prototypes and pilot studies exploring creative choreography in practice. However, while ‘co-imagination’ strategies have been found to be successful in choreographic support tools, there continues to be much more research to do in this
domain. The process of designing choreographic-support tools invites exploration into habitual and novel processes, the use of constraints in creativity and the knowledge and experimentation in choreographic domains to support the notion of ‘ah ha’ moments.

To investigate the notion of ‘ah ha’ moments in novice choreographic process, the study considered the experience of interacting with a system to design unique movement material. The study focused on the choreography of novel movement phrases through the process of mapping and augmenting movement material generated by the idanceForms system. Data was collected based on the novice choreographer’s experiences by gathering verbal descriptions in focus groups and the observations of the researcher. The findings provide a deeper understanding of how novice choreographer’s iterative processes can support future design of technological tools for choreographic creativity. The general model of choreographic experience in interaction illustrates three levels of detail that articulate the dynamic nature of creative problem-solving in a defamiliarized environment. This model acknowledges a connection to the analysis of literature that categorizes existing systems into various stages of experience, highlighting a particular aspect of the desired experience (for example, disorienting a user to provoke situated actions).

This research has investigated kinesthetic movement knowledge, creative cognition and technology design through the disciplines of Dance and Choreography, Somatic Techniques, Cognitive Science, Psychology, Human Computer Interaction and Artificial Intelligence. This work can extend knowledge about modeling movement information in technology, designing for creative process and in turn how to support practice-based research in the role of interaction and co-imagination in choreographic process. Future work can explore additional movement parameters, new representations of movement information and many yet un-imagined approaches to choreographic knowledge. Because choreography is an art form and not a reproducible science there are endless options for designing tools to provoke and support it. However this work has illustrated that designing tools for new creative approaches is important and useful to understanding how to better support choreographic process.
References


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Appendix A.

Supporting Media

Supporting media can be found at the following website:

http://my.ilstu.edu/~kacarl1/index.html

This page includes:

- Abstract and link to the dissertation file
- Introduction to the study and research agenda video
- Cochoreo and idanceForms demonstration videos
- Video clips from Study 1: UIUC
- Video clips from Study 2: ISU
- Video clips from Study 3: UIUC
- Video clips of special moments throughout all studies
Appendix B.

Written Permission From Co-Authors
To Whom It May Concern:

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In these publications Kristin was the first author and the main contributor of ideas and content.

Additional Comments:

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Yours Sincerely,

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If you have any questions please feel free to contact me at (604) 513–2121, x3229, or email me at herbert.tsang@twu.ca.

Sincerely,

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Dr. Tom Calvert
Emeritus Professor
School of Interactive Arts and Technology
Simon Fraser University
June 22, 2016

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