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Moving Collaborations: A Critical Inquiry Into Designing Creative Interactive Systems for Choreography

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Abstract

The use of technology in choreographic process has been encumbered by the richness of data in live human movement and the constraints of computation. While technology is often considered a tool in choreographic process, with developments it can participate as a collaborator by transforming and eliciting creative opportunities. We specifically define 'collaboration' rather than 'tool' to differentiate the nature of collaboration: a dynamic and iterative process with participation from both the user and the technology. This paper presents a contextual inquiry for an interactive system used to provoke creativity in choreographic process. Choreographic process is often distributed, relying on interactions between the choreographer and dancers to develop and evaluate movement material through exploration on different bodies. Based on this interaction model we choreographed and analyzed a dance work in order to design a set of features that support system collaboration in an intelligent choreographic system. Our contribution situates the design and practice of choreographic systems in theory to explore future design of iterative and provocative collaboration.

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1. Introduction

The use of technology in creative practices is often framed as a tool that facilitates human user's creativity. Creativity Support Tools (CSTs) are 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)[31]. While the term creativity support 'tools' is often synonymously discussed as facilitating 'collaboration' between a user and a creative system, we differentiate the terms here to articulate the distinctive interactive component of creative process. There is a history of designing systems (particularly CSTs) as 'tools' to support user's existing processes, including collaboration (as in the domain of Computer-Supported Cooperative Work and Social Computing, CSCW). However there is less research in designing systems that can 'co-create' with a user, intentionally provoking the user to realize new creative opportunities. CSTs that function as 'tools' are often designed to facilitate task-oriented human user interaction, without adding intelligent features that adapt creativity and cognition theory. 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 and provocative 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 an interactive collaborative process with a human user [10][29]. To enable such autonomous creativity the system must have the ability to listen and respond to the user with nuanced domain-specific behavior in-situ (described in artificial intelligence as beliefs, desires and intentions).

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The system must also enable iterative development and extensive history-keeping in order to retain a 'memory' of what choices have been made and support editing the history of choices.

We focus on the domain of choreography because movement as a modality is under-researched and its intelligent features are not well understood, while it is also rich source of data in form, function and expressivity [29]. Choreography is developed through embodied decision-making processes and is an established, parameterized exploration of movement composition [1]. We can consider the variables that affect choreographic decision-making as parameters [23][24]. Choreography is necessarily embodied and uses movement as its primary material [22]. Movement phrases are sequenced and developed through interaction with the environment, the conceptual frame of the choreographer and social interaction with dancers and other artifacts such as props, media and computation [10][3][6][20]. From cognitive science, we know that choreography is a distributed practice, devised by the choreographer, executed by the dancers with subtle differences based on their personal movement signatures and iteratively developed [22][2].

This paper presents a pilot study using contextual inquiry to simulate collaboration between a choreographer and a dancer through a set of parameterized choreographic processes. We used a Wizard of Oz technique to design a set of features that support system collaboration for the purpose of designing an intelligent autonomous choreographic system. Based on an analysis of the literature of the feature sets of contemporary choreographic systems, we selected and then blended three individual choreographic systems. Our selection criteria analyzed the systems' ability to generate and edit novel movement and to share data formats. We blended three systems, rather than utilizing a single system, to extend current choreographic models and to provide us with a richer combined feature set to capture, manipulate and playback movement. Using the three blended systems we simulated the iterative development between choreographer and dancer by creating a short solo choreography. We documented this process through contextual inquiry with video and reflective journals. During the choreographic process we extended the limitations of the choreographic feature sets available by focusing on how shifts in choreographic attention exploited a greater range of choreographic choice in decision-making. We found that techniques such as modality shifts and abstraction are useful design strategies for provoking creative compositional choices that can extend current feature sets of choreographic systems. Modality shifts are the translation of movement data from one representation to another. Abstraction refers to the resolution and aesthetics of movement data representation that can modulate between greater specificity and ambiguity as a compositional interpretive strategy. This paper describes our conceptual framework, the systems we reviewed, the contextual study we performed and our findings supporting our design method using simulated computational agency. Our contribution is in identifying design strategies for manipulating complex movement data through compositional concepts illustrating how modality shifts and abstraction of representation can engage a user's attention, interpretation and active engagement towards a collaborative system.

2. Cognitive Framework for Collaboration

Choreography is the art of crafting movement, developed through a long history of techniques [1][3][20]. Like other compositional processes, choreography is a complex creative process that explores a variety of formal procedures that can result in unique artistic creations [6]. The Belgian choreographer Anna 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' [15]. 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 constraints alongside new possibilities.

There has been a recent rise of research in dance and choreographic cognition to better understand the cognitive decision-making process in collaboration. Kirsh has researched choreographic process by closely observing and discussing the making of a large group work by Wayne McGregor [23]. 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 collaborative 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 [22]. Sawyer and DeZutter investigated improvised theater performance to track how a performance emerged collaboratively [29]. 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.

There are strong cognitive overlaps between the processes of movement, decision-making and creativity that can provide unique opportunities for designing

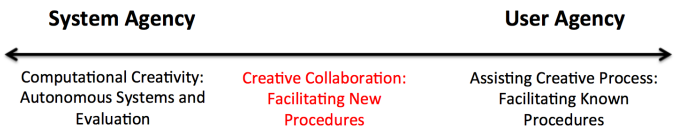

Figure 1. Current Creativity System Design from Autonomous Systems to CSTs

technology [9][10][16][11]. Currently within choreography, computers are used as CSTs to design the presentation of performance (set, lighting, sound, costume). 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. We are 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.

Creativity Support Tools have historically been designed to support the user's established cognitive processes. This results in momentary novel solutions with a focus on efficient, predictable methods [31]. By continuing to support established creative processes there is minimal engagement with the source of creative patterns. To 'design for designers' we need to explore the iterative creative cognitive process more deeply. Gathering information on process within creativity will develop methods to support and iteratively sustain the 'unknown', situated creative process [13]. 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.

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 [4]. Asserting agency utilizes users' own reflections, analysis and assessments of a given situation in order to engage in the task at hand.

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 [13]. 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 [27][33]. However, they focus on performing compositional decisions in the moment, rather than exploring and structuring a work as a whole. While these systems worked well in well-understood disciplines in visual and sonic mediums, there are many new challenges arising in the design of technology for gesture, full body movement and practice based endeavors. We are 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.

3. Computational Systems for Choreography

Though technology continues to develop exponentially quickly, technology continues to have inherent limitations that can be leveraged as creative constraints in artistic processes [9]. These limitations include sensing and capture resolution, in the algorithms to manage large quantities of data, in the circumstances where technologies can be used and in the mediums that technologies can be worked with. These limitations challenge designers and users to develop novel methods for interaction to contribute to the desired outcome, often despite the limitation. However, technology can only fulfill the role of creative collaborator if the interaction provokes the human to devise something divergent from their habitual practice, choices that can extend their creative range away from results they can create themselves, without technology. To address this research agenda, we ask the questions: What specific design features can provoke creative choreographic decision-making in a social and embodied context? How can prototypes through a Wizard of Oz method reveal techniques that can be applied as future design strategies for provoking creative compositional choices?

We reviewed eight systems that support creative process in choreography including: DanceForms, Dancing Genome, Scuddle, Web3D Composer, DANCING, Viewpoints AI, The TKB Creator's Tool and Choreographer's Notebook. DanceForms (previously known

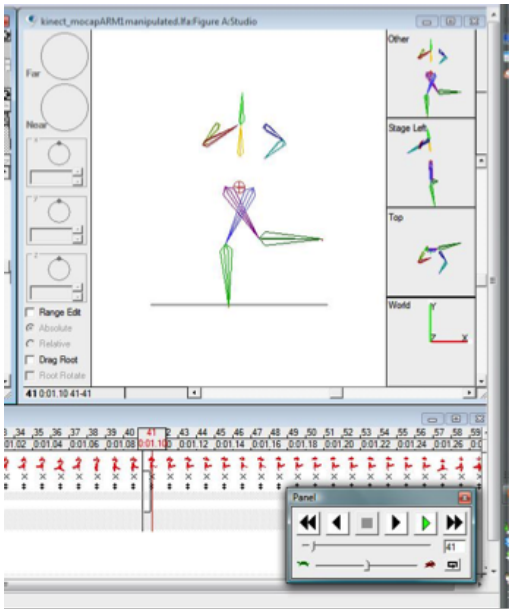

Figure 2. DanceForm's Studio Interface

as LifeForms) [7][8] is a graphical animation compositional tool for designing and visualizing dance movement based on user input or library selection (See Figure 2). The system has three views: space, time and body-position. The space view allows the user to design movement pathways as spatial patterns. The timeline allows the choreographer to design sequences and timings of movement. The body-position view allows the user to design body positions using joint manipulation or to choose codified positions from the libraries. DanceForms supports choreography of multiple figures, spatial patterns and orientation. Merce Cunningham used DanceForms to design movement on avatars, transposing the movement decisions onto live dancers. This process allowed him to explore movement options that he may not have otherwise considered while facilitating his use of chance operations. DanceForms, the most advanced system available for computer-supported choreography, however is not widely used. Perhaps this may be in in part because the form of interaction (low-level detail-oriented, not supportive of whole body interaction) is not aligned to physically exploring movement within choreography. DanceForms does provide multiple levels of abstraction, which encourages the user to view compositions in multiple unique ways.

The Dancing Genome Project [25][26] developed a genetic programming model to explore sequences of movement in performance. The system analyses movement data and re-organizes it to create a new sequence with the same movements. The movement data is created by gathering motion capture data extracted from a dancer performing the movement

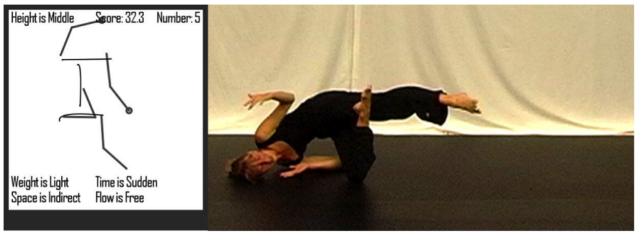

Figure 3. Scuddle's Movement Catalysts

sequence, in the studio prior to the performance. The motion capture data is manually segmented, then used as input to the genetic programming model to shift the location of dance movements. The final manipulated sequence is performed by projected avatars on the backdrop as the live dancers performed the original sequence, creating a mixed-reality duet. However, while dancers and avatars performed next to each other, neither are able to make decisions or changes in action during the performance. This genetic crossover and mutation process is similar to exploring themes and variations in the studio choreographic process, where variations of a theme are explored separately by are similar enough to be recompiled together.

Scuddle is a choreographic support tool designed to provoke creative movement decisions using defamiliarization tactics. By constraining the possibilities for movement generation Scuddle simulatenously provokes creative movement opportunities [10](See Figure 3). The system generates unique movement catalysts using a genetic algorithm with a heuristic fitness function, without input from the user. Scuddle is designed to explore and inhibit habitual body positions, levels and effort qualities typically performed by dancers in the studio, in order to bring awareness to new, non-codified movement options. Scuddle is used in the creative process, in the studio, the same way a choreographer would explore creative movement options without technology. However, the addition of technology helps to guide movement decisions towards unusual choices, that may not be addressed otherwise, that both create unique movements and make the decision-making process more apparent to the choreographer. These design choices support Scuddle as both a creativity support tool as well as a research tool.

Web3D Composer creates sequences of ballet movements based on a predefined library of movement material [32]. The system allows the user to select movements from a pool of possibilities, which shift based on structural ballet syntax. This interactive process allows the choreographer to select movements based on the possibilities presented through Markovian selection while presenting nearly complete graphic movement information The Web3D Composer system was designed with the intention of providing a tutoring

system for students and generates syntactically correct movement phrases for up to a second year ballet level.

DANCING used a series of music-related parameters, spatial pathway rules and a predefined library of traditional movements to generate Waltz choreography using a Genetic Algorithm [28]. By connecting the correct, predefined 'steps' in a domain- specific sequence that provides stage directions and orientations, this system generates syntactically correct movements in a complete choreography that are represented as ASCII symbols on a bird's eye view of the stage. DANCING illustrates the relationship of individual movements to the whole composition as generative output, however it is not a useful tool contemporary choreographic exploration as a creative problem in the studio since there are no opportunities to intervene in the output.

The Viewpoints AI project looked to the Viewpoints compositional framework to create a real-time interactive system exploring dance improvisation strategies [21]. 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.

All these systems engage in an interactive creative process with the choreographer yet (outside of Danceforms which has a small following) have rarely been used in creating dance. Tools for facilitating creativity and collaboration include video annotation tools for choreography such as the Creator's Tool and Choreographer's Notebook [11][14]. These are both opportunities for choreographers to objectively view their work, note ideas temporally, and see opportunities for editing their work. The tools afford the choreographer perspective of a whole work within the context of an annotation tool by presenting editing opportunities right in the video format rather than a focus on parts in the studio environment.

4. Pilot Study

We performed a pilot study to explore what kinds of features could support collaboration in an intelligent autonomous choreographic system. To test our process we devised a critical inquiry by developing a choreography in the studio 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 [18]. Data is collected about how a subject interacts with a system within their normal environment.

Figure 4. Choreographer Working with Kinect and Integrate Systems

Choreographic Process	Pilot Study Process
1. Generate movement	Scuddle System -> Choreography
2. Develop movement into phrases	Choreographer
3. Capture into DanceForms	Choreographer -> Integrate System -> DanceForms
4. Manipulate avatar in DanceForms	Choreographer/ DanceForms
5. Re-learn movement phrase	DanceForms -> Choreographer
6. Develop/ Capture/ Manipulate/ Re-learn	Iteratively between technology and Choreographer
7. Structure Sequences	Choreographer
8. Create spatial pathway plan	Choreographer
9. Reflective journaling	Choreographer

Figure 5. Comparing Choreographic Process Between Systems and the human choreographer

We composed a short choreography for a solo performer based on an iterative development process using 3 computational systems in the studio (See Figure 4). 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 [10]. The second system is Integrate, to capture movement data with a Kinect camera and translate the data to bvh format [17]. The third system is DanceForms, an animation platform specifically designed for choreography, which we used to playing back and manipulating movement files [8]. Choreography is often composed in 3 stages: generating movement material, sequencing and developing movement material and structuring movement compositionally. For this study we identified the interactions used and mapped them to the part of the process being explored (Figure 5). This section articulates what was explored in each stage, how technical limitations influenced the process and how the choreographer's choices influenced the process.

4.1. Steps of the Choreographic 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 6). 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.

4.2. Reflections in Composition: Choreographic Process

During the choreographic process we 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, our focus while developing movement was on the technology rather than on our explorations. We 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 our own movement habits when re-learning the movement. The 'information' that was represented to us 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 we were required to re- interpret the animated movement rather than re-learn phrases in the performers learn from video. This process became difficult and time consuming without providing additional compositional benefits. Once we had developed sections of movement we noticed the need for high-level compositional tools to structure it. Beyond exploring motion we 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. We designed a linear structure with pen and paper that we could be used to manipulate the animation in DanceForms. Ultimately, we focused on our 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 we could easily notate spatial location, speed, transition movements and dynamics in a way that we could remember. Our 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.

4.3. 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

Figure 6. Choreographer Working with Kinect, Integrate and DanceForms Systems

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 weightedness 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 we captured our movement into DanceForms we could not find any simple ways to manipulate the whole body or multiple movements, so we 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 we found that the choreographer 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 maneuver in embodied exploration with less articulation of details.

We 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, we are 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. We outline our findings in reflections on the remainder of our discussion on creative choreographic process.

5. Conclusions and Future Work

This paper explored opportunities for designing new feature sets for collaborative creativity into tools used for choreographic process. We developed a contextual inquiry to address this question using three existing systems to inspire, mediate and support choreographic development. Through this iterative process we 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 [5], integrating Scuddle to generate unique positions for

interpolated movement [10] or using unsupervised algorithms for large datasets such as deep-learning [12].

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 [23]. 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. [24]

- 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.

Our future work is to implement some of the features articulated in this paper in the DanceForms platform. We plan 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. We plan 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 Partnerhip (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.

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