Computational Aesthetics in Graphics, Visualization, and Imaging (2011)
A. Wanner and A. Bevans (Editors)

ActionPlot: A Visualization Tool for Contemporary Dance Analysis

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Abstract

This paper illustrates a prototype for visualizing contemporary dance through a movement analysis tool, entitled ActionPlot. Contemporary dance is an experiential and time based art form with few available analysis techniques. Our design facilitates structural analysis of dance performance by codifying and plotting expert viewer information. ActionPlot is then useful to experts familiar with choreographic strategies and illustrates three levels; viewing for interpretation or meaning, for structural or performative information or for detailed movement information. Plotted elements include the number of performers, the performer's attention and intention, the amount of effort used,tempo of the effort, the balance of the movement within the body and the time the action is performed. This process conveys information about the viewing experience in context, allowing the user to see structural and performative patterns, similarities and differences while comparing between two works. We detail our motivation, design decisions, implementation and a qualitative evaluation for the presented system.

Categories and Subject Descriptors (according to ACM CCS): J.5 [Computer Applications]: Arts & Humanities--Performing Arts, H.5.m [Information Interfaces and Presentation]: Miscellaneous

1. Introduction

Contemporary dance is a visceral art form that that is often considered to be abstract and avant-garde. It is distinguished from genres such as ballet, jazz and folk dance. Developed to break the boundaries of traditional ballet technique and strictly narrative dance forms, contemporary dance explores qualities of movement and the mechanics of the human body. Composition often focuses less on formulaic options and more on conceptual and experiential structures. Recent literature that explores how mirror neuron activity facilitates physical empathy has been incorporated by dance scholars to explain the experience of watching, understanding and interpreting contemporary dance [BP*10][GS*04]. This knowledge can help explain how connection is built between performers and audiences, which directly affects how we empathetically experience performance. While some structural elements are obvious to all viewers, the individual perception of a choreographic work can be very different. This is based on a combination of contextual, interpersonal and physical awareness during the process of connecting to a performer during a performance [CC*11]). Interpersonal understandings of intention through gaze and effort are a lower level understanding than the spatial and structural elements that are normally focused upon in an analysis of choreography.

We are interested in exploring the analysis and visualization of specific elements of choreography drawn from the *experience* of watching dance. While there are many notation methods and at least one movement analysis system, there are no designated methods for higher level structural analysis of contemporary choreography. We utilized a methodological approach to gather expert observational data inspired by grounded theory. We observed, sampled and then analyzed our experience of watching dance performance, and then from this data developed a heuristic model which we tested and evaluated with participants. We began by extensively watching dance works and journaling about the salient features that stood out through the viewing experiences. Among other attributes, these analyses highlight information covered by Laban Movement Analysis (LMA) for specific components such as the performer's attention (which Laban attributes to spatial intent) [L74][ND03]. While we acknowledge these similarities, LMA requires extensive training and notations of analysis are difficult to attain. We have also attempted to keep the experience of viewing neutral, without a structure

CAe 2011, Vancouver, British Columbia, Canada, August 5 – 7, 2011.

DOI: 10.2312/COMPAESTH/COMPAESTH11/113-120

to abide by, in order to identify the most prominent features of the experience. To construct a pilot study for this form of analysis, an expert choreographer and dance audience member analyzed 15 dance works to select prominent performative elements that supported the structural understanding of a work. From this notation and selection process, salient choreographic elements were chosen and standards for scaling the elements were devised from the experiential information of the viewer. Utilizing this structure an analysis of four contemporary dance works was made through rigorous first person journaling methods. After data was gathered, categorized and identified, we built a tool for visualizing the data, titled ActionPlot. Data illustrated includes energy levels, themes and variations, feeling of movement, structure and complexity. The aim of visualizing this data is to convey information about the viewing experience in context, allowing the user to see structural and performative patterns, similarities and differences while comparing between works. Results indicate that this information was useful to dance experts in its ability to contribute to interpreting the experience of watching dance, while it was minimally understood by non-expert viewers. ActionPlot is designed for dance experts with the goal of understanding choreographic structure and performative elements from a viewer's experience.

2. Related Works

The term 'visualization' with 'choreography' often refers to the ability to realize an artistic idea. While there are still no simple ways to illustrate artistic ideas accurately, there are some tools for doing so. Systems for computationally visualizing movement to explore choreographic possibilities without live dancers include DanceForms [CW*91] and DanceVerbs [HL05]. DanceForms transfers movement data onto interactive avatars as a digital tool for choreography. DanceForms allows a user to see a perspective of choreography in context through the use of a timeline; however the view is not capable of conveying performative qualities. DanceVerbs explores the animation of movement quality for choreographic inspiration. This system allows the choreographer to explore the possible physical qualities of a movement through visualization of effort and force.

Traditional design-based visualization projects includes Synchronous Objects [FP*09], which uses various data visualization tools to see the choreographic structure of one particular work. The tool is built around a documentation video of the work which uses post production to (literally) draw connections between performers and phrases through the piece to highlight structure (see Figure 1). Highlighted information includes emphasis on the initiator of a phrase of movement that follows the phrase through performers, adjusting color with changing variations of the phrase. This approach is used to guide new dance viewers in how to look at choreography with various tools to reflect specific components of the choreography. A drawing tool allows the user to define brush qualities assigned to individual dancer's data, in order to track spatial information of dancers. However the data initiates in locations relative to the screen space and is not connected to actual dancer relationships, hindering the use of the tool to further understand the choreographic structure. Statistical data is illustrated in a traditional parallel coordinate plot with brushing, density maps show each dancer's use of space and many other visualization 'objects' are available to illustrate specific components with an aesthetic twist. The many tools provide very interesting focus on specific information, though there is no central way of understanding the full structure of the piece with the multiple objects in context. In the project documentation it is stated that the visualizations were expected to be used by Forsyth to better understand his use of theme and variations and to adjust choreography based on the formulaic information provided. This information may be useful for someone very familiar with the piece and its components, and possibly the new viewer as a tool towards understanding structure in a prescribed way. Many of the aesthetic choices focus on new audience engagement and teaching of how to watch dance, which has successfully achieved the goal to support audience engagement with dance. However, the tools do not extend far enough to make suggestions regarding structure or performative qualities. Synchronous Objects illustrates themes and interactions within the structure, however is heavy on focus and less on context. This makes a comprehension or analysis of structure difficult without additional viewing capabilities or a merger of the 'objects'.

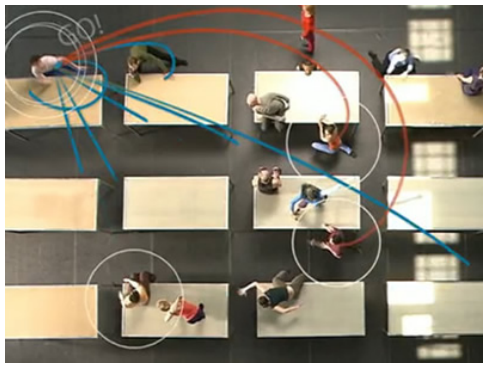

Figure 1. 'Synchronous Objects' Visualizing Structure (Synchronous Objects Project, The Ohio State University and The Forsythe Company)

Wayne McGregor of Random Dance, Phil Barnard and Scott deLahunta facilitated an interdisciplinary project with cognitive scientists to work towards an understanding of choreographic cognition [dLB*09]. As part of the project they collected information from dancers in one of McGregor's works about how they individually perceived the structure of movement phrases. Every dancer had a different understanding of the beginning and ending of a phrase which was mapped quantitatively to visualize the data. The visualization illustrated that there were 6 areas in the work that were perceived roughly as complete sections by the entire group, but the individual dancer saw as many

as 26 different sections. This project illustrated interesting observations about dancer and choreographer's perception of content**.**

The main system that inspired our work is the LayerBraid system [CQ*10]. This system was designed to minimize the gap between technical knowledge of formal music structures and the appreciation of music, hence making classical music more accessible to the general public. Emphasis was placed on the qualitative understanding of music to convey specific semantic information as opposed to quantitative structural materials. However, the rationale for the selection or mapping of qualitative elements to convey semantic understanding of music is not well articulated. Though the visualizations are aesthetically interesting and provide structural information there is a tremendous opportunity to expand the structural information that can be provided to the viewer.

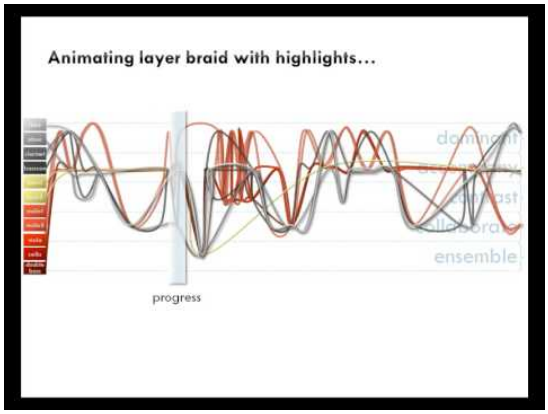

Figure 2. Semantic Understanding of Music in LayerBraid System.
(Image retreived from Demo Video available at http://www.cse.ust.hk/~wallacem/winchan/musicvis/)

A visual score that was created for Ligeti's work 'Artikulation' was intended as a visual mapping of an electronic music composition [WL70]. The information selected to illustrate the ideas was a combination of technical information as well as experiential information. Technical information was conveyed as the types of sounds and types of filters that were used to transform them, including the pitch, time, and speaker spatialization. Experiential information was conveyed by the design of visual components as metaphors that draw on real world representation. Comb filters were drawn like hair combs of various sizes and colors while reverberation was drawn as large clouds of gray. Although the visualization presented an aesthetic representation, its internal analysis of sound or filters remained low-level, and it did not attempt to draw higher level meaning or experience as a parameter of the visualization itself

These works attempt to address both technical and aesthetic issues in data visualization of dance and music. However, they tend to include a higher emphasis on the aesthetic representation than how the information behind and through the aesthetics was conveyed. The emphasis on strictly technical elements within these works, such as the LayerBraid system, did not communicate information as well as those that emphasized aesthetics, such as in 'Artikulation'. The gap in choreographic analysis techniques provides a space for understanding structure from a unique viewpoint that can utilize a combination of technical and aesthetic information, particularly the aeshthetics of experience itself.

3. Motivation

The authors' research interest is to gain a deeper understanding of choreographic cognition as applied to the computational modeling of creative decisions. However, compositional structure cannot be simply understood as the specific positions of the dancer and their spatial pathways. Compositional structure also includes higher level attributes of the performative qualities of the dancers. These qualities require a qualitative approach to extract first-person accounts of viewing performance. We gather phenomenological accounts of viewing dance as a primary source of data. We analyze this experience in order to construct a model that can be used for visualization of choreographic structure. In this sense our approach echoes grounded theory which emphasizes generating theoretical models directly from the data gathered. We developed this project out of an exploration of how this type of information might be gathered and interpreted, and then applied to visualization.

ActionPlot was developed out of a curiosity about how choreographic analysis could be made from experiential data and if it could be useful to the performance community. Questions asked included: how would data be gathered? What could a data visualization illuminate about choreographic structure that isn't just seen in the performance? Could it be a useful tool for understanding and assessing choreography? We decided the project would require choosing specific components, abstracting those components and re-casting them in visual form. As this project is focusing on a highly subjective art form, care must be taken in choosing elements to highlight experiential information. Reducing a work to strictly formulaic content and focusing on information about what codified movement is being executed can ignore many important components. Focusing on the experiential information could provide some insight to both the expert and new viewer. We aim to explore how an expert views a dance performance through prominent performative elements. The goal of ActionPlot is to illustrate similarities and differences in performative elements between the perception of multiple dance works. This attempt highlights structural information that is utilized to guide experts in analysis of performance components.

4. Data Analysis

The codified notation systems of Labanotation, Benesh and Eshkol-Wachman provide a defined set of movement data that would be very useful for analyzing choreographic

structure [A88][G98]. However notation scores are difficult to attain and read, while the information provided is focused on the reproducibility of the movement [J93]. While assessing the data we wanted to visualize, our goals for the system shifted from analyzing direct movement information to the experience based information of the viewer to support the understanding of choreographic structure and performativity.

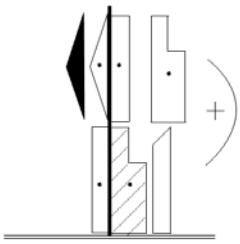

Figure 3. Labanotation Synbols on a Staff

A pilot study was performed by a professional choreographer to identify and analyze which performative elements drew focus. The choreographer viewed 15 dance works of various time and artistic periods. Focal elements were journaled at 3 time periods: within the first 10 seconds of a viewing a work (the immediate reaction and assumption of qualities), halfway through the work (with more information to assess prior assumptions) and at the end of the viewing (with as much available information as possible) (See Figure 4).

Figure 4. Journaling Process on Single Performance

Three levels of detail were observed as an individual performer's exact motions in detail (level 3), the general structure of the work including actions of multiple performers compared to each other (level 2) and the overall understanding of effort and relationships including artistic interpretation and metaphoric connection (level 1) (See Figure 5). We found that the middle level (level 2) provided the most understanding about the performance structure, while providing some reference to exact movements as well as interpretative markers. Elements that drew focus most often at all three stages of viewing were: the performer's intentional connection to the audience, the direction of gaze, the amount of effort being executed, the tempo of the performer and the balance within the body.

Each element is mapped to a variable. The mappings were assigned by viewing all the works multiple times and creating reference points for low, middle and high numbers. For the elements of intentionality and gaze there were only 3 states noted. This led to intentionality of performance being mapped to 1, 2 or 3 as internal, blank or projecting. Internal intention is when a performer's focus is fully introverted, blank intention is when a performer is present in their environment but not engaging in it and projecting intention is when the performer is actively engaging with the audience. Gaze direction is mapped to 1, 2 or 3 as low (focused on the floor), middle (focused straight ahead) or high (focused up at a balcony or the ceiling).

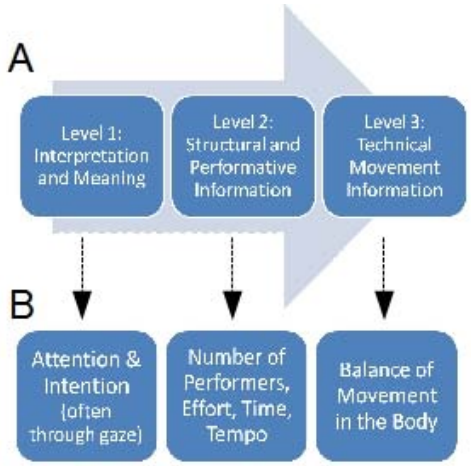

Figure 5. A) Levels of Viewing Dance and **B)** Variables Chosen from the Above Levels to Visualize in ActionPlot

However, the amount of effort used to execute an action had much more variability. Because of the ability to identify many different levels of effort, effort is mapped from 1-20 as low to high. Low effort is considered as fully relaxed (for example laying on the floor while fully relaxed), mid effort is considered active or attentive (jumping with intention) and high effort is considered as extreme execution (intense thrashing or references severe survival tactics). Tempo also has more variability and is mapped from 1-10. This encompasses a range from stillness to as fast as the body can physically move or shake.

Balance in the body is attributed to where the effort is acting *in* the body as well as how the body is actually balanced. Bartenieff Fundamentals is a movement analysis system for exploring movement pathways and spacial intent [H98]. Bartenieff movement patterns are utilized to categorize the balance of motion in our analysis. Pathways of homologous, homolateral and contralateral motion are analyzed by how they cross anatomical planes within the body. Homologous motion is movement of both arms or both legs (the top or bottom of the body). Motion in the top half of the body is mapped to the number 1 and motion in the lower half to number 2. Homolateral motion is movement of the arm and leg on one side of the body (the right or left sides of the body). Movement using the left side of the body is mapped to 3 and the right side of the body to 4. Contralateral motion is movement of the arm and leg on differing sides of the body (example: the right

arm and left leg). Movement crossing from top left to bottom right is mapped to 5 and movement from top right to bottom left to 6. We analyzed 4 choreographic works based on the identified criteria for the first (available) 5 minutes. Works chosen for analysis represent various dance periods in the 20th and 21st centuries: Doris Humphrey's 'Water Study' from 1928, Martha Graham's 'Night Journey' from 1947 Yvonne Ranier's 'Trio A' from 1965 and Diana Szeinblum's 'Alaska' from 2005. See Figure 6 for a data sample and Figure 7 for images of Graham and Humphrey's work.

Figure 6. Image from Szeinblum's 'Alaska'. (Retreived at http://centroculturalelsuplicante.blogspot.com/2009/02/pablo-lugonesun-bailarin-del-elenco.html).

This moment is mapped to the following values:

	Intention 1-3	**Gaze 1-3**	**Effort 1-20**	**Tempo 1-10**	**Balance 1,2,3,4**
Left Dancer	3	2	12	7	1
Middle Dancer	1	1	1	1	1
Right Dancer	1	3	8	5	1

5. System Design

Developed in Processing, ActionPlot visualizes dance analysis data. The system plots multiple attributes: number of dancers, time, effort, tempo, intention, gaze direction and body balance. Initial design considerations included the need to show change over time, to present clear levels of information facilitating pre-attentive processing and be viewed as a metaphor to the body in performance [S07][W04]. Aesthetically we were interested in building variables into complementary structures using inspiration from the Layer Braid system [CQ*08] and Synchronous Objects [FP*09] we designed a system to plot our analysis data (see Figure 9).

Figure 7. A) Graham in 'Night Journey' (Retreived from http://ann-lauren.blogspot.com/2010/05/19-20th-cent-martha-graham.html)
B) Humphrey's 'Water Study' (Photo courtesy of MOMENTA by Anne Bradley)

To support the metaphor of viewing a body in performance, attributes are layered as abstractions of the 3 levels of viewing movement. Intention and gaze are at the top as the most direct connection between audience and performer, which also supports interpretation of the entire work (level 1). Effort, time and tempo in the middle as prominent structural information (level 2). Body balance is at the bottom as the most detail information provided about the movements themselves (level 3). Intention and gaze variables are depicted as circles with intention mapped to diameter and direction to line weight on the edge of the circle. Gaze is filled with the same color as the matching line depiction for time, effort and tempo in order to identify individual dancers. The circles are placed relative to the line by keeping a constant distance on the y-axis.

As time is changing continuously and effort appeared to have the most variance in the data, these variables were chosen for the x and y coordinates. To address the fact that tempo is confusing to understand alongside time, yet is a performative element of the body, it was designed into the diameter of lines drawn between time and effort coordinates. The illustration of these lines has evolved from experimentation with drawing mirrored curves, ellipses, sin waves and line weight. The decision to use line weight simplified clutter and though occlusion was still an issue, allows the user to view many dancers at once. Dancers are defined by color in the following order: teal, aqua, yellow, purple, green, and red.

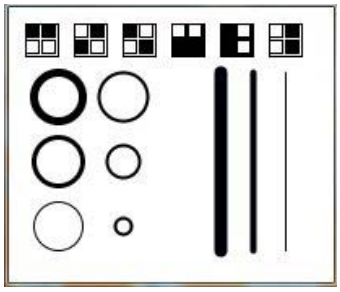

Figure 8. Glyph, Line and Circle Options

Body balance is depicted as glyphs to emphasize weight in the specified section of the body (See Figure 8). Glyphs take the shape of a box with four sections and highlight the most used section at that point in the timeline. For example, heavy use of arms highlights the top of the square, heavy use of the right side of the body highlights the right side of the square and heavy use across one body's diagonal highlights one top and one lower square on opposite sides of the square. When 'all' dancers are selected in the system only the first dancer's movements are illustrated in the balance glyphs. This design supports the traditional cognitive map of watching dance by bringing focus first to the overall complexity of action (level 1), to devise an understanding of the general structural components and action (level 2) then provides some simple elements of movement detail to illustrate positions of movement without precise specificity (level 3). This information is useful to extract relationships and pattern information through comparison to support deeper understanding of experiential elements in dance structure.

The user is provided with a multilist button that expands to first list the works and second provides options for viewing all elements of a work or just selected performers. When a dancer is selected they are highlighted by making all other dancers transparent.

This addressed occlusion while allowing the viewer to continue comparison of all performative elements while analyzing detailed information.

6. Visualization Explanation

Figure 9 is an example screenshot from the Action Plot system. The structure of dancers is initially prominent, with effort and tempo (mainly seen as the amount of action) next, intentionality following, balance and gaze direction at the very end. In this image, 'Alaska' begins with a solo dancer, adds in 3 more dancers and then shifts into 2 separate duets. The work begins in chaos, with spurts of fast motion that is countered by near stillness. Effort levels continue throughout the piece, but are slower. Intentionality shifts from projecting out to the audience to being internal.'Alaska' performs many movements with the top half or either side of the body, shifting continuously.

'Night Journey' begins as a duet, adds in a third dancer and eventually three more to create a group vs. the two leads (the initial duet). The work begins slowly with one dancer performing a phrase repeatedly with pauses in between. The second dancer is moving slowly with continuous effort and becomes active near the middle. Additional dancers

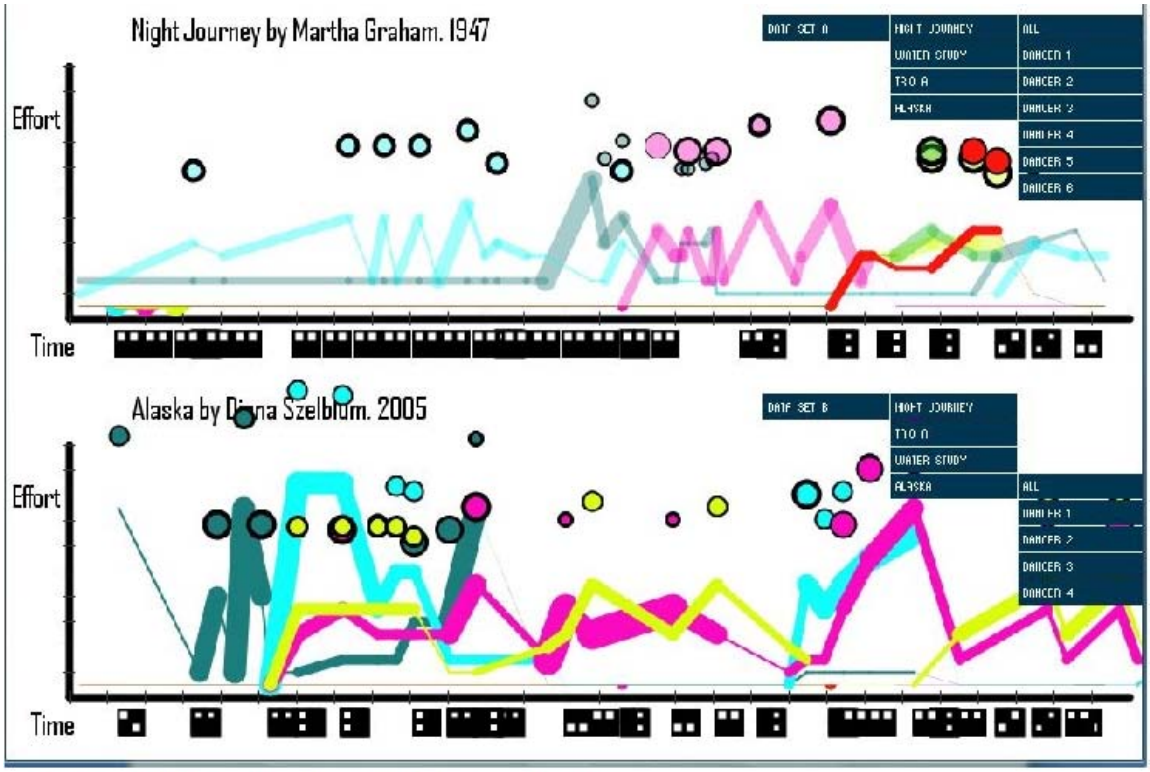

Figure 9. ActionPlot Illustrates Data from 'Alaska' and 'Night Journey'

join shortly after, and vary their movement between a moderate amount of action and stillness. 'Night Journey' begins with blank intentionality (present but not engaging with the environment or other dancers) but is projecting by the end. Balance in movement focuses on the top of the body in the beginning and shifts to the sides by the end. Though these selected works are similar in structure it is clear that 'Alaska' has a higher sensation of action and structured chaos in viewing while 'Night Journey' has a more calculated and formulaic structure.

The system is available online at:
www.metacreation.net/kcarlson/ActionPlot/applet

7. Results

A qualitative study was performed using open-ended interviews to evaluate the ActionPlot system. Four participants were evaluated using the tool, two dance experts and two non-experts with minimal dance experience. They were given the tool and were told that the system maps the experience of watching a dance with structural and performative components. After participants expressed their interpretations of the visualized information, they were provided with the legend. There were distinct differences between the experts and non-experts interpretation of the visualization. Prior to being given the legend, both experts interpreted the lines representing effort, time and tempo as the amount of action being executed. Glyphs were thought to depict body position or the active part of the body. Intention and gaze circles were thought to have something to do with performativity but were discarded as being hard to interpret. Non-experts viewed the lines as the height and steps of a dancer or a representation of the actual movements made. The glyphs and gaze circles were unknown. All participants viewed the different colored lines as different dancers. Structural components such as canons, counterpoints and group vs. solo were easily identified by all participants. The complexity of screen space was directly related to the level of action or energy and chaos onstage. One expert felt by the end of the session that there was lots of interesting information about the structure of the choreography in the visualizations that are not as apparent when watching choreography live. For example, the overview of a work illustrated structure that was choppy vs smooth. This referenced the flow of the dance and whether relationships between dancers were abrupt or consecutive. The two experts felt this would be a useful tool for analyzing choreography from a viewer's perspective while the non-experts were apprehensive.

8. Discussion

The strongest element of the system is level 2, or the lines depicting effort, time and tempo. Tempo supports a feeling of additional action when combines with effort (by taking up more screen space). While more exploration could be used for the depiction of body balance, the glyphs do seem to be fairly informative for the user. The weakest element is the use of intention and gaze circles. The choice to place them at a constant y-axis distance from the individual dancer's line worked for some images but many became extremely cluttered. Multiple dancers created additional occlusion. The use of the multilist buttons is helpful as a selection tool but also need to be refined. The color choices stand out and are better than different saturations of a single color (used in earlier versions) though the exact choices need to be re-evaluated.

While the details of the ActionPlot system can be further refined in future work, we feel that this system of viewing dance analysis is useful, especially to a practitioner. Because this information is so rarely available we feel that it would be an exciting contribution to understanding choreography for the dance student or movement theorist attempting to understand both the works of others as well as their own process.

9. Conclusion

This paper details a system for visualizing choreographic analysis from an expert viewer's perspective. Our results illustrate that the process of viewing ActionPlot provides information on the level of actions, energy, structural components and the overall experience of a dance to experts. This information is useful as an analysis tool while providing overall experiential information about specific choreographies. Further development is needed on the gaze component of the design as well as presentation for non-expert audiences. We believe this tool will be useful to the community of dance research while contributing to the exploration of a system for dance analysis and visualization.

Future developments of the system will include a deeper investigation into the depiction of intention, gaze, color and the integration of more interaction tools. Intention and gaze circles will be adjusted for coherence, transparency of information and location. Reference numbers will be added to the Effort and Time axis. The screen size will be extended so the multilist buttons will not occlude the presented information. Color choices will be reevaluated and reimplemented. Zooming and panning or brushing will be added to help to see more detail in chaotic areas. The ability to explode dense areas will also be developed to support analysis between dancers. Further investigations into the information desired for analysis as well as additional perspectives on what components are most apparent when viewing dance will aid in further development of the design.

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