Dance phrase onsets and endings in an interactive dance study

Andreas Bergsland
andreas.bergsland@ntnu.no
Norwegian University of Science and Technology, NTNU
Trondheim, Norway

ABSTRACT

The paper describes a work-in-progress exploring the expressive and creative potential of dance phrase onsets and endings in interactive dance, using an artistic research approach. It briefly delineates the context of the presented work, before describing the technical setup applied, both in terms of hardware and software. The main part of the paper is concerned with the specific mappings of three different sections in the performance that the project resulted in. Subsequently, the process and performance are evaluated, including both the dancer's feedback and observations by the author. The points from the evaluation are then discussed with reference to relevant research literature. Findings include that the dancer experienced an increased awareness of beginnings and endings in different sections of the performance, and that postural adjustments were necessary to make the interaction more robust.

CCS CONCEPTS

• **Applied computing** → **Performing arts**; *Sound and music computing*.

1 INTRODUCTION

The paper describes a project that has aimed to explore the expressive and artistic potential of onsets and endings within an interactive dance context, using an artistic research approach [6]. More concretely, it has aimed to find useful methods and technologies for tracking onsets and endings of dance phrases and to further process the movement data in relevant ways. Further aims have been to try out sound synthesis, processing, and spatialization techniques, and to explore how the movement data can be mapped to these in ways that highlight interesting qualities of the dance phrase onsets and endings, both from the audience and the performer's perspective. This paper reports on the initial steps of this project, presenting the most relevant aspects of the process, setup, and design, before elaborating on the evaluation and dancer feedback.

2 BACKGROUND

An interactive dance performance is usually taken to mean a performance in which dancers' movements and actions are tracked by some form of sensor technology and technological tools are further used to render this into some form of output (video projections, sound, text, graphics, robotic movement, etc.) that shapes the performance environment in real-time, in turn affecting the dancers' actions [5, 18]. In the literature on interactive dance, one can find several mentions or brief discussions of how stillness and movement are productive oppositions [3, 4, 9, 13]. And, when movement replaces stillness or vice versa, different forms of onsets and endings will happen. For example, in pieces like e.g. *Seine hohle Form* by Palindrome Dance Company[1], one can observe how in some sections dance movements are interspersed with stillness to create temporal incisions and accents. In many of the phrase onsets and endings that occur from this, one can observe a variation in temporal dynamics, e.g. whether the phrases begin or end gradually, abruptly or something in between, with or without accents, etc. Still, there seems to be a lack of research literature discussing these phenomena in greater depth, and this project is a response to this.

There are further research fields that have relevance to the topic of dance phrase onsets and endings in interactive dance. In another publication, I relate the current topic to the field of interactive sonification and argue how perceptual and cognitive phenomena like salience, attentional capture and segmentation are involved [1]. This will not be further discussed in this paper, though.

3 ARTISTIC PROCESS AND DEVELOPMENT

This project has been conducted in the belief that its creative and artistic processes will produce new insights, understandings, and products, in line with Borgdorff's notion of artistic research [6]. Moreover, my role in the project fits well with Grey's notion of the "practitioner-researcher": "The role is multifaceted - sometimes generator of the research material - art/design works, and participant in the creative process; sometimes self-observer through reflection on action and inaction, and through discussion with others; sometimes an observer of others for placing the research in context, and gaining other perspectives; sometimes co-researcher, facilitator and research manager, especially of a collaborative project" [11].

The latter point has been important since the work described in this paper was done in collaboration with Seh Yun Kim, who contributed as a dancer and choreographer. Kim has been a co-creator in the sense of giving me responses and opinions of how the interaction has worked for her, as well as coming up with ideas for sounds and ways of interacting with them, during the development and rehearsal phases.
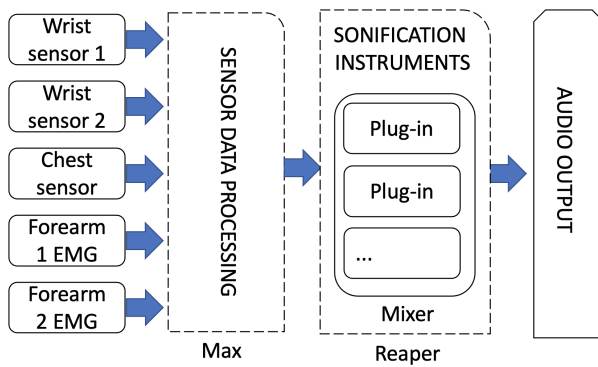
---

[1] https://vimeo.com/8895552

Figure 1: Technical setup

The development of the work had several affinities with an iterative design process [17]. It took place as an iterative cycle between technical and musical development, and practice sessions with evaluation, and took place over 10 weeks. The final presentation of the work was at the Konzertzaal 1 at the Zurich Arts University in November 2021. The full performance can be seen in **Video 1**.[2]

To bring forth insights and reflection related to the performer's perspective, I did an interview with Kim about the process and the performance. Although this ideally should be conducted shortly following the performance, it was conducted three weeks later due to practical reasons. The interview was conducted on Zoom, and subsequently transcribed and analyzed using thematic analysis [7]. The content of the interview will be discussed in more detail below.

4 TECHNICAL SETUP

A schematic representation of the technical setup as used in the final performance can be seen in Figure 1. Due to room constraints and having to move between different performance spaces in the rehearsal and performance phases, it was important to have a lightweight setup that was easy and fast to set up and pack down. Ultimately, the following sensors were chosen for the performance: a) two Myo sensor armbands[16] fitted on the upper forearms to register the muscular tension, and b) three NGIMU[3] inertial (IMU) sensors attached to wrists and chest. All sensors were considered both lightweight and relatively unobtrusive, low-latency, robust and reliable, easy and fast to set up, in addition to covering the required range for the performance area. The placement of the sensors and details about the hardware and software setup are discussed in more detail in [1].

5 MOVEMENT – SOUND MAPPINGS

The movement-to-sound mappings were designed with a special focus on the beginnings and endings of the dancer's movements, going to and from different degrees of stillness or pause. Three of the sections in the piece were thought as the most relevant to the topic of the paper and will be described separately in more detail in the following. These sections all used playback and processing

of sampled sounds. A full explanation of the technical issues in the implementation of these mappings would greatly extend the scope of this paper, so I will just give a brief explication of the most relevant points here. By following links in the footnotes one can access a web page where each mapping is demonstrated in a video and shown as a flow chart. The reader is advised to let the reading be accompanied by these charts and videos.

5.1 Section 2 – Discovering

This section was intended to focus on clear and sharp phrase beginnings, and relatively marked endings, based on EMG and inertial data from the Myo armbands. The idea was that the performer should gradually discover how she could make and modulate sounds with her fingers, hands, and arms, starting with short and discrete sounds, then gradually prolonging them, and finally modulating the intensity and timbre of the prolonged sounds.

Chart and video 2[4] shows the signal flow and structure of the mappings in this section along with a practical demonstration. The most relevant features were the following:

- Sudden muscle activation starting from a relaxed state will trigger a sound
- Rotation of arm decides the sound file
- Relaxing the muscle will end the sound
- Moving arm while playing a sound renders a "chorus" effect

The eight EMG data streams from each of the Myo armbands were LP-filtered to give a good tradeoff between smooth data and rapid response and then summed. By looking at when the second derivative of this value crossed a threshold, we got a relatively predictable way of triggering the sound files used in this section. However, to impose the performer to be still and relaxed before making a note, the trigger would only respond when the EMG sum was at a low value. The attack and sustain portion of the sounds were then treated separately and subsequently crossfaded, with a focus on giving an immediate attack and a smooth sustained part.

5.2 Section 3 - Imitating

In contrast to the previous section, this section was intended to have very smooth and gradual onsets of the sounds the dancer made. As a part of this, the section featured two groups each containing three layers of vocal sounds. In this section, only the two NGIMU sensors attached to the dancer's wrists were applied.

The mappings in section 3 are shown and demonstrated in **Chart and video 3**[5], with the most prominent features being:

- Activity of arm mapped to intensity vocal sounds
- Azimuth (horizontal direction) of arm mapped to time pointer in the sound file
- Salient movements bring forth a pitch modulation and spectral arpeggiation effect

This section used a generalized activity or intensity parameter that was the sum of absolute values of the delta quaternions from the sensors, subsequently noise-gated and smoothed. This created an activity value that responded very well to the low to mid-range of movement, something which turned out to be very

---

suitable to create very soft and gradual beginnings and endings. Moreover, a calculation of a rarity index [14] was implemented to give a data stream representing salient movement onsets. This calculation produces a high value when there is a big change, and a low value or zeroes when there is little or no change, thus emphasizing marked beginnings and endings. This value turned out to be a good expressive tool for the dancer's imitation in this section of the piece.

5.3 Section 5 – Metals

This section was intended to represent a big contrast in the piece since it contained a very different sound material (metal objects) than the preceding sections. A high number (ca. 250) of short audio segments were ordered according to spectral and morphological content and played back with a granular playback engine, much in the same manner as [2, 3].

The mappings in section 5 are shown and demonstrated in **Chart and video 4**[6], with the most prominent features being:

- Arm activity mapped to sound file triggering frequency and volume
- Direction of torso decides which sound file to be played
- Sudden jerks happening during low overall activity mutes the sound
- Sudden jerks happening during medium-high overall activity produces accent sound

It can also be mentioned that during the duration of this section, the metal sounds were increasingly processed going from a clearly identifiable metallic quality into a much more abstract type of sound with a sort of "squeaking" quality.

6 EVALUATION AND DANCER FEEDBACK

In the following, I would like to elaborate on some of the most interesting and relevant issues during the process and in the performance. I will draw on my own evaluation on the basis of documentation and notes from the process, as well as the most relevant themes that came up in the thematic analysis of the interview with the dancer: 1) using stillness in dance, 2) beginnings and endings, 3) understanding how things work, 4) thinking as a musician, and 5) being led by the sound. The themes were not mutually exclusive.

To invite Kim to use stillness more often the interaction in section 2 was programmed so that the muscle had to go from "stillness", i.e. a fully relaxed state before it could contract to trigger a sound. This was not always comfortable for Kim, who was used to avoiding periods of stillness and that she had to "do something" when she was in focus as a dancer. During the work with this project she gradually got accustomed to using stillness as a part of her artistic expression:

Theme 1: *[…] if I'm still, [the audience] is not really getting anything else, at least that's what I thought. […] And later on, when I was on purpose making the stillness, that was then a different thing. Then I felt that I was giving people a little break, or time to breathe. So, when I was aware of it, it was different than when I first approached it.*

From notes from the rehearsal sessions, it was evident how during the rehearsals Kim was often frustrated when the sounds weren't triggered when she flexed her underarms since she already had some tension in her arm muscle in the position that she was in. After trial and error, she found that the easiest way to achieve fully relax the arms was bending the torso slightly forward when standing with protruded shoulders so that the arms could hang straight down from the shoulders. In this position, small movements would very consistently trigger a sound. Thus, Kim's knowledge and understanding of the interactive system were integrated into her intentions of moving in a certain way. This also came up during the interview:

Theme 3 & 5: *I would never have rotated if I didn't know that rotation would make sound, you know.*

Thus, here Kim feels that the interaction and the sound, if knowing how it works, will affect the choices of which movements to do and that in this case, this choice is counter to her movement choices as an experienced dancer and choreographer. Kim also expressed something similar explicitly linked to the beginnings and endings of the sounds she generates:

Themes 2, 3 & 5: *It's not actually the sound that gives the beginning, it's the logic of making the sound that starts the beginning of the movement. It definitely shapes it - and the ending as well. I guess the sound comes as a result, but the understanding of how to make the sound and how to stop the sound, it actually makes what kind of movement is gonna happen.*

It was also evident that Kim became aware of her own shaping of the dynamics of the musical phrases she generated with her movements, and how she would more or less consciously start to think like a musician:

Themes 2 & 4: *Well I think, you know the most way of common music progression, you know coming up, and then slowing down, I think subconsciously I was trying to mimic it. Nobody told me to, but I was always starting slow, and then going up, and then slowing down a little, to go back to the place and finish it at the highest point, or sometimes going down and then closing it. Of course, I was paying attention to the sound before and what kind of sound I should make later, and how I should go on.*

The mappings with a focus on the beginnings and ends also seem to have made Kim more conscious about lower level structures, i.e. phrase and sub-phrase levels, of her dancing:

Theme 2: *Whenever I did some small movement, it was a new beginning for me, because the music is appearing with me or I am making it, so it was actually a slightly weird sensation that I have, that even though I know the whole beginning of the end of the piece, each movement felt like I was starting again, starting again. I think there were a lot of beginnings and as well as endings. But I guess that we did it in a way so that [...] each movement, each sound – there were a lot of beginning and ends, microscope-wise.*

A final observation from the interview is how Kim experiences playing the ending accents of section 5:

Theme 2: *I felt really cool actually in the last beat, […] in the very last section of Metals, it was a very cool feeling to do it, it was like hitting a tennis ball and really hitting it on the right place many times - it feels good.*

---

[6]https://tinyurl.com/4xrkmbwj

7 DISCUSSION

The focus on beginnings and endings in the work described in this paper was only to some degree reflected in the themes from the interview of the dancer. Mostly it was simultaneously related to other themes, like **3**, **4**, and **5**, which I will get back to in a moment. However, one interesting topic that emerged from **theme 2** was the increased awareness of onsets and endings in both sound and movement on a low level ("microscope-wise"). It would be tempting to draw parallels with perception research indicating that sound events will increase the perceptual salience of co-occurring visual events [15], although Kim's perception in our case involves probably involves more than vision, such as kinaesthetic awareness and proprioception.

Another interesting issue emerged from my own observation of Kim's strategy for finding a relaxing stance to be able to trigger the sounds in section 2. This can be seen as a variant of Godard's notion of *pré-movements*, denoting the preparatory postural adjustments taking place before a movement [10]. In this case, however, the dancer's knowledge and understanding of the interactive system (cf. **theme 3**), at least from an experiential and embodied point of view, is partly guiding her movement preparation and adjustment of posture (leaning forward, protruding shoulders). An important part of Godard's notion of pré-movement is the largely unconscious initiation and preparation of movement, but this, as we see here, might have additional conscious aspects in interactive dance.

We saw above how understanding and predicting the sound and the interaction would affect Kim's movement choices (**themes 3 & 5**). That interactive systems impose a restriction upon dancers might be seen in a negative light as something impoverishing for choreography. Conversely, it might also be seen as a creative possibility. Jung [12], who has applied fairly intrusive technology (Gametrak controllers) connecting dancers to one or several cables to control music and visuals in what she calls a *poetic of restriction*, sees restrictions instead as a way of escaping established habits and well-rehearsed moves, and thereby something that can introduce new kinds of movement into the dance [12]. Thus, even if there seems to be an inherent conflict between the purely choreographic concerns and a dancerly response to the workings of interactive dance systems, the latter also implies certain creative possibilities.

A similar conflict can also be identified in **theme 4**, "thinking as a musician". Mark Coniglio, when discussing his *MidiDancer* software, acknowledges that the software makes the dancer move like a musician when what he really would like is "a device that allows a dancer to be a dancer"[8]. Moreover, Wilson and Bromwich describe the transformation of a dancer in an interactive dance context into a musician or instrumentalist as something limiting to the understanding of the dancer's role which is both dehumanized and simplistic [19]. On the other end of the scale, choreographic directions can sometimes override the concern for the sounding output. For example, Masu and colleagues reported that the dancers, when playing one of the instruments in their interactive dance work, would ignore the sound and the interaction[13].

8 CONCLUSIONS AND FUTURE WORK

Both in the design of mappings and in noting the dancer's response to these, this work has brought forth insights related to phrase onsets and endings in interactive dance, both related to stillness, pré-movement as well as the onsets and endings themselves. Other findings resonate with familiar topics from the literature on interactive dance. Still, in the further development of the project one can hopefully enrich and inform the technologically and aesthetically challenging art form of interactive dance, demanding time-consuming close attention to details in a long chain from movement to artistic experience.

9 ACKNOWLEDGMENTS

REFERENCES

[1] Andreas Bergsland. 2022 Published. Designing interactive sonifications for the exploration of dance phrase edges. In *Sound and Music Computing, SMC2022*. 176–183. https://doi.org/10.5281/zenodo.6572982

[2] Andreas Bergsland and Robert Wechsler. 2013 Published. Movement-Music Relationships and Sound Design in MotionComposer, an Interactive Environment for Persons with (and without) Disabilities. In *re-new*. 56–62.

[3] Andreas Bergsland and Robert Wechsler. 2015 Published. Composing Interactive Dance Pieces for the MotionComposer, a device for Persons with Disabilities. In *New Interfaces of Musical Expression NIME2015*, E. Berdahl (Ed.). Lousiana State University, 20–24.

[4] Johannes Birringer. 2004. Dance and Interactivity. *Dance Research Journal* 35/36 (2004), 88–112. www.jstor.org/stable/30045071

[5] Johannes H Birringer. 2008. *Performance, technology, & science*. Paj Publication, New York.

[6] Henk Borgdorff. 2011. *The Production of Knowledge in Artistic Research*. Routledge, London, Book section 3, 44–63.

[7] Virginia Braun and Victoria Clarke. 2012. *Thematic analysis*. American Psychological Association, Washington D.C., Book section 4, 57–71.

[8] S. deLahunta. 2002. ISADORA "almost out of beta": tracing the development of a new software tool for artists. Part I: in dialogue with Mark Coniglio. http://www.sdela.dds.nl/sfd/isadora.html

[9] Cagri Erdem, Katja Henriksen Schia, and Alexander Refsum Jensenius. 2019 Published. Vrengt: A Shared Body–Machine Instrument for Music–Dance Performance. In *Proceedings of the International Conference on New Interfaces for Musical Expression*. Universidade Federal do Rio Grande do Sul, 186–191.

[10] Hubert Godard. 1995. *Le geste et sa perception*. Borda, Paris, 224–229.

[11] Carole Grey. 1998. *Inquiry through practice: developing appropriate research strategies*. Research Institute, University of Art and Design, Helsinki UIAH, Helsinki, 82–95.

[12] Jung I. Jung. 2019. *Choreographic Sound Composition: Towards a Poetics of Restriction*. Doctoral thesis. University of Huddersfield.

[13] Raul Masu, Nuno N. Correia, Stephan Jurgens, Jochen Feitsch, and Teresa Romão. 2020 Published. Designing interactive sonic artefacts for dance performance: an ecological approach. In *AM'20: Audio Mostly*. 445–129. https://doi.org/10.1145/3411109.3412297

[14] Radoslaw Niewiadomski, Maurizio Mancini, Andrea Cera, Stefano Piana, Corrado Canepa, and Antonio Camurri. 2019. Does embodied training improve the recognition of mid-level expressive movement qualities sonification? *Journal on Multimodal User Interfaces* 13, 3 (2019), 191–203.

[15] Toemme Noesselt, Daniel Bergmann, Maria Hake, Hans-Jochen Heinze, and Robert Fendrich. 2008. Sound increases the saliency of visual events. *Brain research* 1220 (2008), 157–163.

[16] Kristian Nymoen, Mari Romarheim Haugen, and Alexander Refsum Jensenius. 2015 Published. MuMYO – evaluating and exploring the MYO armband for musical interaction. In *Proceedings of The International Conference on New Interfaces of Musical Expression Conference*. 215–219.

[17] Andy Pratt. 2012. *Interactive design : an introduction to the theory and application of user-centered design*. Rockport, Beverly, MA.

[18] John Toenjes. 2007. Composing for Interactive Dance: Paradigms for Perception. *Perspectives of New Music* 45, 2 (2007), 28–50. http://www.jstor.org/stable/25164655 Empowerment, blurring of roles,.

[19] Julie A. Wilson and Mark A. Bromwich. 2000. Lifting Bodies: interactive dance–finding new methodologies in the motifs prompted by new technology–a critique and progress report with particular reference to the Bodycoder System. *Organised Sound* 5, 1 (2000), 9–16.