Interpreting notated works using the *Terpsichora* Pressure-Sensitive Floors

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ABSTRACT

The *Terpsichora* Pressure-Sensitive Floors are a new digital musical instrument which uses whole-body motion to control electronic music. The instrument continues the development of early models for pioneering dancer Philippa Cullen (1972), expanding its use as an expressive and versatile musical instrument. Two works by Australian composer Cat Hope were adapted for performance with this new instrument. *Delay Taints* (2018), for dancer, cellist and subtone, is an animated graphic score that provided an opportunity to freely assign sonic choices to the instrument, and read notated body movement to control those choices. This adaptation contrasts with that of *Majority of One* (2016), for four sustaining instruments and room feedback, where two of the notated parts were interpreted on the instrument. Methods to produce continuously controlled sound using limited movements of the body were developed to replace the instruments featured in the original performances of this work. This work explores the difference in the embodied connection of gesture to sound between acoustic and electronic instruments and explores the idiosyncrasies in the navigation of time elements in music for the Floors. In addition, methods of performing with the Floors produces a new form of communicating electronic performance to audiences using full body gesture. Interpreting these two compositions by Hope using the *Terpsichora* Pressure-Sensitive Floors contributes new strategies for adapting animated scores for electronics using direct body movement.

1. INTRODUCTION

1.1 The Terpsichora Floors and Cullen's originals

In the past three decades, the development of gestural controllers and digital musical instruments interfacing with digital audio workstations has rapidly expanded to bridge the connectivity gap in performance of electronic music with computers [1, 2, 3]. Philippa Cullen, a prolific Australian choreographer and dance artist working with sound, created a range of instruments in the early 1970s through collaborations with designers and technologists [4]. Cullen aimed to gain a new level of control of sound as a dancer,

freeing her movements from sounds created by a separate instrument or performer. Cullen's *Vernus* Pressure-Sensitive Floors, built in 1972, remain a distinct application of interaction design, as the movement of the entire body is required to control a single sensor underneath each of her four Pressure-Sensitive Floors, as seen in Figure 1. The Floors are made of individual platforms that fit together and can be used in anu number or combination. Most synthesiser controllers use many small sensors and control surfaces to allow for control of many parameters; in contrast, Cullen's floors use a large interactive surface for fine control of few sonic parameters. On this instrument, data is not directly observed from the body, and the platforms do not require specific physical movements such as tapping or a particular gesture of a limb to be activated. Rather, they respond to changes in pressure, applied via body weight, on each of the different floor platforms. The new instrument follows the original design principles: the *Terpsichora* Pressure-Sensitive Floors are a set of wooden platforms, sending control voltages, and respond to movement using a load cell; each of the floors have one sensor underneath them [5]. This more recent version of the Pressure-Sensitive Floors (hereon referred to as 'the Floors'), built in 2015, works as a MIDI controller by converting the control voltage signal, interfacing with Max/MSP and Ableton Live software. The design and implementation in a DAW is combined with the development of a gestural vocabulary for performance on the new Floors. This vocabulary is used to increase the expressivity of performance, toward the Floors operating primarily as an expressive instrument, rather than a performance interface [6].

Figure 1 Left: One of Cullen's four identical *Vernus* Pressure-Sensitive Floors, built in 1972. Right: The *Terpsichora* Pressure-Sensitive Floors, built in 2015. 7 platforms forming a tangram shape, each with one sensor underneath, responding to movement

With a new access to expressivity, the Floors have recently entered the space of navigating composition. The gestural vocabulary developed for the instrument and the instrument's performance affordances are still in an early stage of gestation. For their development, new compositions for the instrument, adapting existing works, and improvisation are all necessary components. Much of the

Sanadzadeh's performance on the Floors is not notated, and pieces which are notated are often done in a shorthand style specific to the performer. Thus, adapting existing scores for movement and sound was considered simultaneously a diagnostic tool about the instrument, a creative endeavour and a method for growing the performance and design of the instrument.

2. ADAPTATION OF CAT HOPE SCORES

Two works by Cat Hope were adapted to be performed with the Pressure-Sensitive Floors and acoustic instruments. The first, *Majority of One*, is an animated, scrolling timeline-based score with a playhead indicating the point of performance. Originally conceived for sine tone oscillators alongside acoustic instruments [7], a 2021 recording of the work performed by Hope's ensemble Decibel [8] features four acoustic instruments and feedback. The performance featuring the Floors on two of the four 'instrumental' parts, featured bass flute and double bass on the other two parts [9]. *Majority of One* notates sonic directions using different coloured lines that sweep up and down between 'highest and lowest point' markers. The accompanying instructions for the piece explain how the lines are read by different instruments, noting that the performances should "Follow your colour for the whole piece… the movement mut always be seamless and without interruption. Bend your note by whatever mechanism you choose, but it must be without steps [7]. Adapting two parts for the Floors required simultaneous interpretation of the differing pitch trajectories of each part, presenting a unique challenge for performance on the instrument. A way of compartmentalising the Floors for the purposes of this investigation was examining it as an electronic instrument and separately considering human motion in performance and notation. Rather than having a new piece composed for the instrument, which would be designed to work with its existing performance style, adapting two pieces written for an electronic oscillator (a fundamental element of electronic music) and a score for movement, would offer unique findings. In a performance examining these divided parts of using the Floors, the affordances of the instrument could be better contextualised. First, in comparison with a sine wave oscillator in *Majority of One*, the adjustments required to perform a fundamental element of synthesis directly were found; the freedom and sonic possibilities in interpreting notation for human movement, outside of the medium of dance, were examined in adapting *Delay Taints*.

Delay Taints, initially composed for dancer, cello and subtone is also an animated, scrolling score with the subtone embedded in the digital score [10]. Both works are presented in the Decibel ScorePlayer software on iPad [11]. In this performance of *Delay Taints,* the Floors read the 'dancer' notation, and a double bass read the cello part. The interpretation of the dance part for this instrument provided an avenue to explore the shape and limitations of

the connection between movement and sound when performing on the Floors.

In the adaptation of the dance part for the Floors, two factors were considered: first, the appropriate gestural vocabulary with which to adapt the action directions of the score; second, a responsive sound design to enable musical synergy to be achieved between the double bass and Floors part. The double bass actions can be more directly interpreted by the player, yet complex action shapes in the score present challenges to interpretation for the Floors part.

3. INTERPRETAITON OF *DELAY TAINTS*, AN ACTION SCORE

Delay Taints has two intersecting performance parts that use slow gestures, subdued dynamics, and small movements. On the score, the height of each line is an indicator of pitch for the cellist and height of the dancer's body in relation to the ground. Lines, circles and crosses are directed in the score instructions as "Crosses for a gentle, Bartok pizzicato, or hard clap/slap/hit; smooth round dots are gentle pizzicato or finger click/softer sound. Dynamics are soft unless the line is thicker" [10]. To interpret this action score, dancer movements were first interpreted in terms of their efficacy to create sound on the Floors. This adaptation involved considering the change in pressure exerted on the Floors by changing the positioning and height of the player. The sounds that were chosen for the performance mapping were intended to stay outside of the double bass' timbres, but allow for moments of unity where the two lines intersect on the score (see Figure 2). The score provides instruction for movement, and the Floors sonify that movement in unique ways.

Figure 2. A screenshot of the *Delay Taints* score in the Decibel Score-Player, showing intersection of the instrument in blue (double bass) with the dancer (the Floors) in red lines.

3.1 Adaptation of Dancer Part to Floors

As the Floors respond to movement, a dancer's body is the closest analogy to a performing body for the player of the Floors. However, whilst for dancers, the torso, arms, and the head can move expressively and independently from each other, for the player of the Floors, their movement affects the subtle shift of the entire body's weight, thus

impacting the sound as it responds to changes in pressure. Whilst independent movements of the arms and neck are inconsequential to the sound, movements of the torso strongly affect the sonic outcome; much of pressure distribution of the body is determined by the relative positioning of the hips and shoulders. The placement of feet on each platform, the relative weight on each foot, and the shifting of this weight across the instrument are the focal points of performance [12]. This anchoring of the body in the feet means the movements of the Floors player are more restricted than that of the dancer. Figure 3 shows stills from the movement of dancer Laura Boynes performing in the premiere performance of *Delay Taints* and that of the Floors performer in the 2022 adaptation.
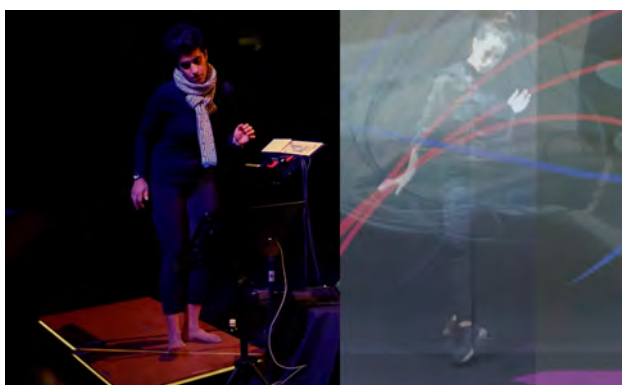

Figure 3. Comparison in movement adaptation and similarities between movement in Floors adaptation (left) and Dancer in the original adaptation (right)

Expressivity and the role of the performer are distinct between the dancer and the Floors performer. Watching a performance of electronic music with the Floors is more dance-like, as the entire body of the performer is the main mode of communication between audience and player [13]. This mode creates a point of connection between the electronically-generated sound and the gesture, thus bringing a new type of liveness to the performance [14, 15]. However, unlike a dancer, the individual shape of movement is not a priority for the Floors player. The sonic result is the focus of the performer, even when performing an action score. In performance with the Floors, the gesture is in service of creating sound, and the action score is interpreted as one intended to create musical meaning. This difference in priority changes how the score is interpreted.

Increasing height for the performer of the Floors does not always aid an accurate realisation of a score, as it can limit the control of individual placements of weight accessible for the performer. In this way, the original score's direction of height for the dancer needed to be adapted [10]. This height was translated to changing the amount of pressure on each platform. Much of the control of the Floors in performance is done with small gestures and minute shifting of the weight of the body. The larger gestures in the score for *Delay Taints* were thus interpreted as larger musical gestures, rather than larger body gestures. In the performance, the author tried to access new sounds by using larger musical gestures which often involved complex small movements across the Floors. Figure 4 shows the performer on multiple Floors for complex gesture and on toes with smaller contact for interpreting height.

Figure 4. Compilation of gestures from Floors performer to interpret complex subtle movements in the score. Movement on the floors is combined with changes of sound on the computer

3.2 Interpretation of Intersecting lines

Delay Taints features varying number of lines for performance that appear, disappear and intersect. They also 'fade' in and out (see Figure 2). These movements are interpreted by the dancer in the original performance as individual and independent layers of action. For performance on the Floors, this interpretation needed adjustments as individual movements of the limbs of the performer are inconsequential to the sound. Two actions were taken for this interpretation

1. Taking the number of lines to direct the number of simultaneous layers of sound
2. Interpretation of individual occurrences of unique shape combinations as one sonic gesture or sonic motif, which recurs.

In performances with the Floors, two types of sounds are used: those triggered by the Floors, and looping sounds that are shaped by the movement. Triggered sounds, used for staccato crosses, are used with each floor. Thus, layers of individual staccato sounds are performed separately. The small number of used Floors in this interpretation (three out of an available seven) means that beyond 3 layers of staccato sound, the interpretation must fall on adding simultaneous layers. Many layers of sound can be added which can be triggered using the same action. However, as they are triggered simultaneously, using the same small number of sensors, they cannot then be independently controlled.

Within the design of the Floors, each looping sound is enabled using the keyboard and its parameters controlled using all the available platforms. Whilst performance with more Floors could enable separating layers of sound, the limitation of the human body, in restricted distribution of weight across limbs and being able to have limbs available per floor, remains at 4-5 Floors (using the feet, hands and knee of the performer).

3.3 Sound Design and Mapping of Movement

In the original form of *Delay Taints*, the dancer's expression is a silent one, thus the action score is translated to a visual and kinetic medium. Adapting it to a sonic interpretation meant that the shape of the dancer's gestures would need to be translated into timbres and placement of the sounds in time. The score part for the double bass was taken as an interpretive guide for this adaptation. Samples of 'bubble-like' sounds, created using the granular synthesiser in SuperCollider [16], as well as small crackle and bell sounds, were used to interpret in the short circle and dot notations, with longer oscillators and looping bell samples as those used for the sustaining line notations. The lines in the score were interpreted using individual channels of looping sounds to follow the movement of the lines in the Decibel ScorePlayer software [11]. Individually triggered sounds correspond to specific floors, but looped sounds are triggered across the entire instrument, with each the parameter of a looped sound (duration, harmonics, effects, ADSR envelope, etc.) controlled by an individual floor. Whilst performing a gesture, multiple parameters of all enabled looping sounds are changing, whilst triggered sounds are added with the same gestures. Thus, the performance of all simultaneous lines is inextricably linked and cannot be actioned individually.

The larger, linear vertical notation in the score were challenging to interpret sonically, since time is represented horizontally and as a whole gesture, meaning a vertical (or steep) line would be 'instantaneous'. To do this, a combination of activating multiple loops briefly and combining them with short triggered sounds was used. In performance of *Delay Taints*, triggering and reshaping of these lines limited the Floors performer's ability to move freely.

3.4 Comparing The Floors with Acoustic Instruments

Three distinct differences between The Floors and acoustic instruments shaped the interpretation of the score: the Floors lack of immediacy or instantaneous sound, the complex nature of the Floors mapping and the way they obscure cause and effect, as well as the layering of sounds [5].

First, the Floors have a smaller range of available 'immediacy' in performance. This is due to the mapping design chosen for the Floors, which dictates a complex divergent mapping of musical parameters, tied to their nature as continuous controllers, which send data as a stream, detecting change, rather than MIDI triggers, which would respond to individual actions on them.

Secondly, the Floors' mapping is complex due to multiple parameters being controlled with a small number of sensors. Thus, whilst the body movement appears to communicate the score to the audience in these works, the connection between action and sound remains hidden. By contrast, the physical movement of the performers body with the acoustic instruments can be observed readily by the audience, by watching the player's fingers landing directly on different notes, or moving across a string instrument's fingerboard.

Finally, the Floors can layer many sounds simultaneously. Unlike acoustic instruments, the dynamic and timbral range immediately available at any point is broad on the Floors, enabling a wider interpretation of action scores. In combination with the lack of immediacy, this facet enables a wider sonic range in duo performances with the Floors player but simultaneously obscures the method of sonification [14].

4. ACTIONING SONIC DIRECTIONS IN *MAJORITY OF ONE*

Unlike *Delay Taints,* the adaptation of *Majority of One* was sonically clear. Two notated parts on the score were performed on the Floors. Each part is an expression of pitch at a relatively low and unchanging amplitude throughout, and with rests interpreted as amplitude of 0. The pitches of each oscillator were placed on two of the Floors. This meant that to raise the pitch of one oscillator, more pressure needed to be applied to the corresponding floor. Increasing the pressure applied to a floor is done by either moving to a more flexible part of the platform or by increasing the amount of weight the performer puts on the floor [5]. The performer has a finite amount of weight; in performance, adding weight to one floor involves removing weight from another. Since the parts are independent, at points in the score one oscillator is changing in pitch whilst the other remains still. To accommodate for performing these independent lines, a new element was devised in the gestural vocabulary for the Floors. If an oscillator's pitch is changing whilst the other oscillator was remaining steady, a counter level of 'pushing down' on the steady floor was used whilst transferring weight to the floor corresponding to the changing oscillator (see Figure 5).
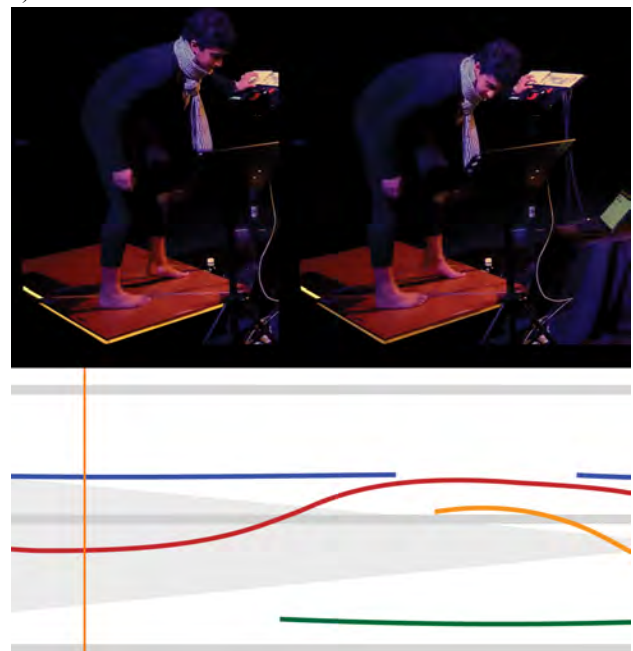

Figure 5 A screenshot (detail) of the score for *Majority of One*. The Floors performed the blue and red parts. Photograph shows the Floors performer in the corresponding moment pushing on left foot to compensate for weight distribution changing on right foot, which corresponds to red part. Movement of y-axis on trackpad facilitates silence in blue part.

Whilst *Delay Taints* allows for free movement of the performer, the sine-wave parts in *Majority of One* are precise in pitch, thus invite minute movements.

The amplitude of each sine wave part was controlled by the x and y position of the trackpad. This mapping strategy allowed for independently controlling the amplitude of each sine wave part. Executing the two parts thus became inextricably linked as four gestures of up/down for controlling the first sine wave part, left/right for controlling the second, and diagonally across in both directions facilitated amplitude changes to be executed. This mapping integrated with the movement of the timeline on the score in the slower sections of the piece. Yet in the latter parts, where oscillator entries and exits are rapid, this gesture did not facilitate the sharper entries and exits. This amplitude mapping inevitably gave a slower attack to each oscillator, which shaped the performance of these two parts.

5. OVERARCHING CONSIDERATIONS

Performing *Delay Taints* and *Majority of One* using The Floors revealed contrasts in the relationship between score, gesture, sound, and timbral range, as they present between the Floors and acoustic instruments.

In performance with the Floors, the relationship between action, sound and time, is different from acoustic instruments and from standard electronic instruments. Whilst the action can be quick, the Floors send a continuous signal, which broken up to create a trigger, means that an increased anticipation is required by the performer to 'ramp up' to the particular trigger, akin to sounding a large drum or bell. Simultaneously, the action of performance uses the shifting of weight, rather than a moment of contact with force, so unlike a mallet or clapper, the sounding action is akin to a heavy bow. This anticipation is distinct from latency since the instrument is sending out a continuous signal that is changed by the performer rather than individual triggers that are each enacted by the action of the performer. As the sounds are electronically generated instead of being activations of a resonant body, increased speed or force does not immediately translate to increased amplitude. These factors mean that the action and force from the Floors performer do not visibly reflect the sonic outcome. In addition, to change sounds, the use of the keyboard is required, which further creates a gap in the gesture; it also makes it harder for the audience to understand the relationship between action and sound.

Although the double bass has a longer anticipation time and attack for bowed sounds than other string acoustic instruments, it still retains a direct relationship between action of the player, sounding of the note, and resonance through the body. This inherent acoustical nature makes it a more immediate sounding body than that of the Floors, where parameters are shifted by moving weight. Mappings are complex and gradual to unfold, and there is no resonant body to sonify an action immediately. These differences meant that the faster reaction of the double bass part in *Delay Taints* did not immediately lock in with the sound of the Floors.

The nature of triggering sounds by shifting weight means that precise rhythms of movement and fast triggering of individual short sounds presents a challenge, as it requires a rapid movement of the entire body that is unlike the rapid movement of an arm and bow for the double bass; the bass player can instantaneously replicate individual small sounds (dots and cross notations), whilst the Floors performer must create a gesture that encapsulates a group of small triggered sounds together, as a cluster. Whilst the scores are linked, the action interpretation for the Floors player is temporally disjoint from the bass player where precise triggered moments are required [10].

The timbral range available to the Floors is far broader than acoustical instruments, as any sample can be programmed into the instrument. Enabling and disabling ranges of sound within *Delay Taints* thus considered two factors: time and cohesion. The enabling of individual types of sound for the Floors is done via a computer keyboard, affecting the movement by the Floors performer at the moment of enabling. To create the right sound when desired, timbral changes need to be enabled prior to action on the floor. This pre-selection is similar to the change in organ stops pulled for a timbral shift. Whilst this pre-selection is helpful to performance, its utility in rapid moments of shifting within the score or in response to improvised elements within a scrolling score prove challenging, and its preparation within a scrolling score is more difficult to program.

Similarly, in pitch, exactitudes are harder to achieve with the Floors. The range of the pitch change available needs to be calibrated to the needs of the performance and a very controlled lack of movement is required to avoid the pitch from changing. This consideration affects how the Floors interlink with the acoustic instruments in *Majority of One.* In the final section of this piece, where the oscillator pitches remain steady for some minutes, the corresponding floor values were 'frozen' to facilitate the requisite steadiness and allow the performer to breathe without affecting the pitch.

In the adaptation of *Majority of One*, the inclusion of two musical parts for the one Floors performer resulted in one complex interlinked part. One Floor platform was used for each notated part, connected to its own oscillator. The performer was linked to one or both parts simultaneously; natural required movements of the body had to be limited as they would affect the pitch of one of the two oscillators. In future adaptations of these two parts for one Floors performer, a new way to control amplitudes with two controllers can assist with the separation of the parts and freeing the body of the performer by creating a third contact point can help achieve more accuracy with the sine wave parts. For further accuracy of performance, amplitude mapping would need to be reconsidered in terms of facilitating faster changes with a new gesture for volume control and a way to centre the body of the performer.

The Floors provided the basis for the development of a unique technique for the gestural performance of these scores. Given the nature of the instrument and its response to weight and pressure, this technique is tied to the unique

body of the performer. Spatz considers technique as that which is "not tied to specific bodies and local contexts" [17]. The findings of this research, whist facilitating a specific performer's action, have found techniques that are not unique to the performer, but translate broadly as adaptation strategies for other electronic gestural instruments. The type of movements considered by the performer and the embodied understanding of weight and motion provide a template for the use of other gestural controllers as well as an embodied understanding of electronic sound control. The effect of this has been observed in the use of other gestural controllers by the author and the adaptations of her movement technique in other players' gestural vocabulary of movement. The movement techniques in relation to the Floors themselves is useful for building a language of performance on the instrument, allowing for adaptation of other pieces for it and for its use by other performers. Here, the transferrable skills of new techniques in training other players appear as existent issues in performance with electronic gestural controllers [18]. An instrumental facility is developed on a bespoke controller, often for its techniques to remain locked to the single user-developer-performer figure. Through adaptation of existing action scores, and discussion of the developed movement language, it is the aim of this research to illuminate embodied issues in electronic performance that can aid performers of other gestural instruments and bring additional connection between players of different bespoke controllers.

6. CONCLUSIONS

The adaptation of *Delay Taints* and *Majority of One* for performance with the Floors provided a new pathways and considerations for the interpretation of digitally animated, action scores. Through interpreting the two pieces, new minute body movements were found to enable a change in one floor with minimised effect on the other, and new forms of interpretation were developed for action scores. In this process, sound design choices, mapping of movement parameters, and gestural control were examined to create a cohesion between the individual musical parts, to enable a coherent final work. The scrolling timeline nature of the two works allowed for a stronger connection between immediate gesture and sound elements using the Floors, yet there remains room for interpretation and ability to perform longer phrases with more expressivity.

In addition, the Floors provided a more expressive gestural performance of the sustaining instrument part. Issues of accuracy in timing and achieving expressive cohesion between the parts were observed along with differences between instruments in the connection between sound and gesture. The movement of the Floors player is visible unless subtle gradations of sound are achieved by minute shifting of weight. Using the Floors requires an indirect control of sonic parameters which further changes the relationship between action and sound. On this instrument, subtleties of electronic sound control in these pieces have become accessible in new ways whilst enriching the performance strategies of this instrument and informing its design in response to animated scores.

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