

Agency in dialogue: how choreographic thought emerges through dancing with *Tools that Propel*

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Abstract. This paper discusses *Tools that Propel*, a digital interactive installation developed by Adam Russell and Sarah Levinsky, with reference to its impact as a choreographic development system, and to the performative skills and embodied knowledge that dancers bring to their relationship with it. It examines the different implications of two interrelated frameworks for understanding this relationship and how movement and the behaviour of the computational system shape each other. The first sees the system as part of the dancer’s ‘extended bodymind’, unpacking how the body’s choreographic thinking happens across both its embodied cognitive processing *and* that of the system. The second sees *Tools that Propel* as ‘other’, curiously *acting on* the dancer and vice versa. In this second proposition, the various ‘things’ that make up *Tools that Propel* act as agents in their own right, intervening on the dancer’s decision-making as much the skill and embodied knowledge she brings to the assemblage of distributed agencies acts on them. Finally the importance of sustained dialogue with *Tools that Propel* is emphasised, a long-term digital intervention through which new choreographic thinking emerges; an interplay between extensions of bodymind and indifferent digital interventions, in which movement shapes behaviour and behaviour shapes movement.

1 INTRODUCTION

Confronting the ‘interactor’ with a life-size projection of themselves and other bodies, *Tools that Propel* blends live ‘mirror-like’ video and recorded fragments from the recent past that resemble their current movement. The computational system compares what it sees in real-time with gestures/movements it has previously tracked, recorded, and categorised, and models the likelihood that the real-time movement might be a re-performance of any of these previous movements. If this likelihood is above a certain threshold then it plays the recorded footage (‘memory’) of that gesture/movement *instead of or blended with* the real-time live projection of the interactor on screen. The interactor improvises with ‘ghosts’ of themselves and others tracked by the sensor before them; the entanglement encourages breaking of habits and mining of memories, exploring subtle variations.

Tools that Propel was born out of a collaboration between Sarah Levinsky and Adam Russell, at the intersection of their interrelated but separate PhD research projects: one concerned with the potential and affordances of AI and motion capture technologies to intervene in choreographic practices in ways that disrupt habitual movement patterns in improvising dancers and catalyse the emergence of



Figure 1. Dancer Maria Evans improvising with *Tools that Propel*.

new movement material with its own choreographic agency; the other concerned with how digital tools can support processes of playing at not knowing what we are doing by interactively folding past time into co-incidence with present action. There are many potential applications of *Tools that Propel*. It has been shown as a gallery installation [21] which the public encountered with no prior knowledge and it could be optimised for this purpose. However, this paper discusses it with reference to its use in dance improvisation and for developing new choreographic thought-in-action. If, as discussed by Erin Manning and Brian Massumi in [22], ‘[e]very practice is a mode of thought, already in the act’ what are the possibilities for developing new modes of thought, within a new expanded practice, when we create dance in dialogue with the computational system that is *Tools that Propel*?

The arguments within this paper are based on observation and analysis of dancers and dance students using the system at sporadic intervals over the course of a year and a half, as well as semi-structured interviews with them and documented discussions during studio sessions. In a studio session on November 1st 2018, Yi Xuan Kwek, an undergraduate dance student from Falmouth University, remarked that *Tools that Propel* ‘[now it] feels like an extension of me... before we felt like it was an other’ [18]. This comment led to the examination of *Tools that Propel* in relation to ‘The Extended Mind’ thesis expounded by Andy Clark and David Chalmers in 1998.

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Through this theoretical framework this paper considers how the system becomes part of the ‘extended mind’ [4] of the dancer, and something that ‘change[s] the way we encounter, engage and interact with the world’, something that ‘change[s] our minds’, as David Kirsh discusses in [16]. Understanding the dancer’s interaction with the system in this way, this paper unpacks how the body’s choreographic thinking happens across both its embodied cognitive processing and that of the system. It examines how the dancer draws on the external information in the choreographic output on screen – the ‘memories’ which bring back ephemeral movement previously lost and which blend with or disturb the projection of their real-time self – and uses the system as an extension to the decision-making processes internalised in his/her bodymind. This comes about when the dancer opens themselves up to the perceptual shift that occurs through symbiosis with the system and the computational affordances which enable them to dig deeper within their habitual movement patterns and explore new movement possibilities affected by the reconfiguration of their previously internalised understandings of time and space.

Equally though, whilst Xuan Kwek’s comment suggests a shift in her embodied understanding of working with the system *from* ‘other’ to ‘extension’, the validity of seeing *Tools that Propel* as ‘other’ demands further interrogation. Here it is curiously *acting on* the dancer and vice versa. Examining this second theoretical framework with regards the interaction of the dancer with *Tools that Propel* this paper draws on the ideas discussed in Jane Bennett’s *Vibrant Matter: a political ecology of things* [1], to argue that the various ‘things’ that make up *Tools that Propel* act as agents in their own right, intervening on the dancer’s decision-making as much as the skill and embodied knowledge she brings to the assemblage of distributed agencies acts on them. This paper proposes that the ‘things’ that make up the encounter with and operation of *Tools that Propel*, including the material body and mind of the dancer, are part of an assemblage of distributed agencies that together allow new thought (movements, traces, decisions) to emerge. In a dialogue between them, new choreographic thinking unfolds; movement shapes behaviour and behaviour shapes movement.

2 TECHNICAL BACKGROUND

Extensive discussions between us took place over several months in Winter 2016/17 towards an imagined system, before any working code was written. This led to a proposal accepted for the Choreographic Coding Lab #8 (CCL8) in Amsterdam May 2017. A wide-ranging review of potential software frameworks led us to settle on Derivative’s *TouchDesigner*, which although limited to the Windows OS at that time (now also available for MacOS), provided an attractive hybrid of visual dataflow for sensor and video processing, with Python code on the backend allowing access to a wide range of machine learning libraries. Python is an extremely popular environment in data science for providing a lightweight rapid prototyping language for computationally-efficient but syntactically dense C++ code. A very early version of the system was shown in Amsterdam at the end of CCL8, running in *TouchDesigner* but using a very crude placeholder method to index the video recordings.

The fundamental technical concept of *Tools that Propel* was always to combine recording and playback of live video footage with a gesture recognition system that begins as a *tabula rasa* and adds new gesture classes to its model as the dancer(s) move, repeatedly switching the video display between the live feed and recent ‘memories’ when previous patterns are recognised. The motion data is currently provided by Microsoft’s Kinect 2 sensor, a markerless skeletal

tracker based on a structured-light infrared depth camera. This sensor also conveniently provides an RGB image feed for the video recordings and live projection³.

Most gesture recognition systems have two significant constraints which we wanted to overcome. They are typically trained *before* use on a number of known gesture classes (supervised learning), and then identify known gestures from a time-series of sensor data *after* they are performed (offline segmentation). As our aim was to confront the dancer(s) with footage of their own recent past while they were performing motions identified by the system as ‘similar’ to previous examples, we were particularly keen to achieve both *online unsupervised learning* and *online recognition* - meaning that the system trains itself during interaction, and continually estimates a ‘current’ gesture class from an incoming stream of sensor data. This latter feature is often termed *gesture following* as opposed to gesture recognition.

The second of these aims was satisfied by the XMM library developed at IRCAM Paris by Jules Francoise and others [2, 12] ‘a portable, cross-platform C++ library that implements Gaussian Mixture Models and Hidden Markov Models for recognition and regression [...] developed for movement interaction in creative applications [...] with fast training and continuous, real-time inference.’ In particular, the XMM library provides a Hierarchical Hidden Markov Model (HHMM) capable of estimating likelihood *and progress* within M gesture classes of mean length K using a sliding time window of length T in only $O((KM)^2T)$ time [11]. During continuous recognition, this provides a *constant* time cost, which in our case running on commodity PC hardware with 10-20 gestures each a few seconds in duration using 6 screen-space bone positions, gives an HHMM update time of ~50ms i.e. we can achieve interactive frame rates.

2.1 Probabilistic editing

The first of our aims, to achieve online unsupervised learning of gesture classes, had a more crude and unorthodox solution. We attempt no kind of clustering to form gesture classes from multiple examples. Instead each class is trained on only one example, formed the first time a movement is seen which is insufficiently likely to be produced by any prior classes. At initial startup, or after a manual reset, the HHMM is empty and we begin recording live video and storing frames of accompanying motion data. After a maximum duration parameter is exceeded (typically ~5-8secs), the recent recording is added to the memory as a new ‘phrase’ (i.e. HHMM class). At this point, we start recording another new phrase and at the same time receive a continuously-varying likelihood estimate (i.e. calculated per frame) that we are in an existing gesture class. As soon as the likeliest class likelihood exceeds some threshold parameter, we stop recording and begin playback of the corresponding memory video, continuously adjusting the playback position to follow the progress estimate for the current (i.e. likeliest) class. As soon as the likelihood falls below another threshold (lower than first to provide hysteresis), we stop memory playback and again begin recording a new phrase. There is also the possibility of switching directly from one memory to another if the likeliest class changes.

As shown in figure 2, both the live and memory states involve updating the HHMM filter, which updates the likelihood estimates of all currently-known classes. The only time we are not updating the model is when we lose motion tracking data e.g. if no body is in

³ There is no technical reason why the RGB camera has to be in the same viewing position as the motion tracking sensor, and future iterations may employ separate points of view

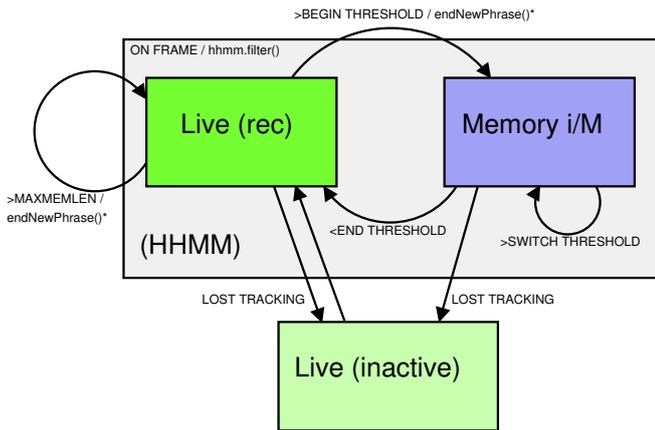


Figure 2. Unsupervised learning and video playback driven by HHMM gesture following (*: retrain model)

front of the Kinect sensor. In this case we can still show live video on the display, but are not recording. Finally, as indicated in figure 2 by the transition arcs exiting and re-entering the HHMM, when a new phrase is added we must retrain (very short live recordings below a minimum duration parameter are discarded). Since the model cannot be trained incrementally this step is far more expensive than the normal per-frame update, as we must reset and retrain the entire model from scratch on all recorded phrases of motion data, and can introduce a perceivable delay to the interaction of at least several hundred milliseconds.

Note that although the *dancer(s)* might consider subsequent new phrases to be similar to existing classes, as mentioned earlier the system does not and they are always added as new classes based on a single example phrase. This makes the total set of classes at any stage extremely history-dependent; different orders of introduction of movement material will result in different classifications. Furthermore because the new gestures are often formed by exceeding the maximum duration of just a few seconds, the classes are also extremely timing-dependent; slight variations in pace might result in very different ‘cuts’ between classes. As discussed later in section 5.1, although this deliberately *ad hoc* approach to unsupervised segmentation through probabilistic editing leads to some very strange decisions, this strangeness was found very valuable.

2.2 Screen space gestures

If the memory size were permitted to grow without limit, the system would gradually slow down to non-interactive frame rates as the filtering step time is quadratic in the number of classes. Furthermore the retrain time on adding a new phrase would become extremely disruptive, taking several seconds or more. The number of sensor dimensions is also a concern - IRCAM’s XMM was developed for gesture control of sound synthesis environments where there might typically be one or two 3D accelerometers (e.g. attached to a baton) providing 3-6 Degrees Of Freedom (DOF) per frame. Here by contrast the Kinect 2 skeletal tracking data can track up to six bodies simultaneously, each with 25 estimated joint positions (in both 2D camera space and 3D physical units) and 13 of these also offer joint orientation data, roughly 600 DOF which is far too many for interactive frame rates on commodity hardware.

For these reasons we limit the data size in several ways. Firstly by only recording a subset up to 6 bones from one tracked skeleton - typically the head, pelvis, hands and feet to sufficiently differentiate large-scale body pose variations (although the bone set can be reconfigured). Secondly we constrain the number of memories to some maximum, typically a dozen classes. To maintain a progressive dialogue with the system (see section 6), rather than stop adding new memories once we reach this maximum, we instead discard a previous memory when adding a new one. There are several possible discard policies in the system configuration such as most-frames-played, most-times-entered - typically we just select the oldest class based on when it was first added. Finally, to reduce the cost of each tracked bone, we used 2D camera space positions instead of 3D physical space. This choice was initially made for speed and convenience, with the expectation that we might at some stage switch to a set of more sophisticated derived parameters such as relative joint angles or accelerations. However the screen space gesture classes had unexpected benefits and so we stuck to this approach. In particular it meant that gesture classes were primarily differentiated by position in the visual frame, which strongly supported the ‘mirror-like’ quality of the wall projection. As discussed in section 4.1, this allowed dancers to use the screen space as an index into past configurations of the studio space, looking for traces of prior activity.



Figure 3. Dancer Katherine Sweet assisting system diagnostics (here showing console log, memory table, likelihood graph and current class)

3 PRIOR WORK

Framing this practice-based research in relation to antecedent computational systems for dance creation, it is important to note that using computers to generate and elucidate choreographic ideas is in itself not something new. The development of software designed to destabilise the choreographer’s or dancer’s habitual movement vocabularies, and historically-embodied thinking patterns, goes back at least as far as Merce Cunningham’s use of *Life Forms* [14]; and indeed Cunningham’s chance methods used a far more basic technology to bring about surprising choreographic ideas - dice. Through his particular way of using *Life Forms* Cunningham created choreographic phrases using key-frame animation that often defied the laws of physics and human physicality. His demands on dancers to realise sometimes near-impossible movement sequences, originally created

with the software, brought about unexpected, imaginative and novel solutions within his dance creation in the studio (where Cunningham did not take the computer). Other computational systems for choreography such as the *Choreographic Language Agent (CLA)*, created by OpenEnded Group for choreographer Wayne McGregor [9], expands the dancer’s physical imagination and acts as a form of interactive notebook. As Scott deLahunta discusses, ‘[w]ith its digital memory, the *CLA* uniquely documents aspects of [the dancers’] decision-making – making part of their choreographic thinking process available for revisiting and examination.’ [6]. DeLahunta compares it to William Forsythe’s CD Rom *Improvisation Technologies: A Tool for the Analytical Dance Eye* [10], which elucidates the dancer’s potential arcs, shapes and trajectories during improvisation through simple graphic lines and curves which overlay the dancer’s movements, stating that while Forsythe’s ‘dancers had to be holding sets of ideas in mind and problem-solve with them while moving, the *CLA* moves parts of this process to its computer canvas as a page for working out choreographic ideas interactively.’ [6].

3.1 Making live decisions

Yet, like *Life Forms*, both the *CLA* and *Improvisation Technologies* involve the dancers in a (mostly) retroactive translation of the digitally-revealed choreographic possibilities offered by each system (as tool, agent or otherwise). Conversely, *Tools that Propel* aims to reflect back and challenge the movement decisions of the dancer in a real-time interaction. In this, we have drawn on the learning from the *Reactor for Awareness in Motion* or *RAMDanceToolkit* [15], in which computation transforms the dancers’ tracked movement data into visual geometric outputs which reconfigure what they are doing (reorienting limbs to different joints, or making visual imprints of dancers’ movements in time, for example). These real-time visualisations act as external stimuli for the dancer to draw on in the creation of new rules – or mental imagery that dancers use whilst creating movement ideas [7] - conditioning their internal movement decisions throughout the course of the improvisation.

But *Tools that Propel* departs significantly from *RAMDanceToolkit* in its aesthetics and the visual rendition of the body’s movement after its digital transformation. In the interaction between dancer/choreographer and computation, the question of ‘body’ emerges frequently in terms of visual outputs and was a consideration in determining the ‘mirror-like’ aesthetic of *Tools that Propel*. With *RAMDanceToolkit* the geometric renditions of the body of the dancer require significant mental translation on behalf of the improviser. Thus interactive installations such as *Dancerroom Spectroscopy* [24] and Klaus Obermeier’s *Ego* [26] provided as much of a framework for the development of *Tools that Propel* as choreographic software, in particular with regards the feedback loop developed between the interactor and the visual output of their computationally-manipulated movement. In both installations, albeit in very different ways, the virtual rendition of interactors’ movement data went from the familiar (reflecting the shape of a human body) to the unfamiliar, ‘other’. *Dancerroom Spectroscopy* offered participants a meta-physical, almost spiritual experience through the exploration of the nanosphere, with their virtual selves often transitioning from ‘extremely literal, “personshaped” energy fields to more abstract energetic representations’ [24]. *Ego* catalyses physical play in interactors by rendering their virtual reflections as a stickman/woman doing longer, stretchier, bouncier versions of their live movements. The tacit understanding of the gap between their real and projected selves reverberates in the gap between the movements they feel themselves

doing and those that they see simultaneously reflected, feeding disinhibition and a playful exploration of their bodies in motion. *Tools that Propel* attempts to take learning from how interactive installations catalyse embodied play and to develop an *evolving* feedback loop between the dancer and the system that increases embodied knowledge, heightens compositional awareness and focuses performative intention.

4 EXTENDED BODYMIND

In terms of embodied cognition and the expansion of the dancer’s mind through the computational tool, the emphasis is perhaps on the augmentation of the dancers’ capacities. If we take the notion of ‘*active externalism*’ expounded by Clark and Chalmers which is ‘based on the active role of the environment in driving cognitive processes’ [4] we have to assume that encountering new sources of information that offer perceptual shifts in our understanding and experience of the world will bring about new cognitive processing. This means that an encounter or movement exchange with *Tools that Propel* can bring about new choreographic thought-in-action, at least in the moment of the interaction.

‘Bodymind’ might often be thought of as the site and source of internal physical decision-making. This paper understands ‘bodymind’ as also encompassing a relationship - mental, physical, conceptual - with external sources of information, imagination, and impulses to move and think through moving. With regards their work with Wayne McGregor’s company of dancers in the development of the *Choreographic Thinking Tools*, Scott deLahunta, Gill Clarke and Phil Barnard discuss the way that dancers use mental imagery – visual, sensorial, aural, kinaesthetic – in the improvisational and creative tasks that lead to the development of dance phrases and performances. They acknowledge how dancers are ‘[n]ow embraced as creative contributors to the generation of a work and its movement language’ meaning that ‘skills of attention, imagination and curiosity ‘thought through’ the body become tools as essential for the dancer to develop as their physical proficiency.’ [7]. The notion of ‘attention, imagination and curiosity ‘thought through’ the body’ underlies the use of the term ‘bodymind’ in this research. We can also understand ‘bodymind’ through Merleau-Ponty’s discussion of the ‘body’s unity’ as a ‘lived integration in which the parts are *understood* in relation to the meaningful whole’. Here the ‘body-mind in all its parts “perform(s) a single gesture”’. [23]. Crucially, for Merleau-Ponty bodily engagement with the world is part of what constitutes its consciousness.

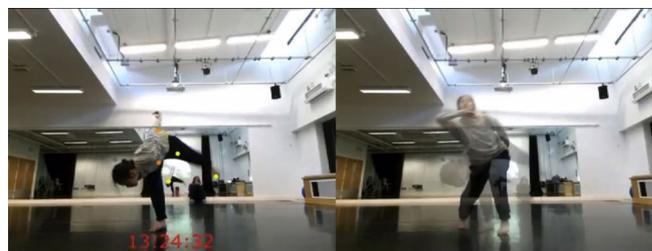


Figure 4. Dancer Yi Xuan Kwek in a ‘session video’ which records a continuous side-by-side comparison of the live camera input (with tracking data and timestamp) and displayed video out for later analysis

4.1 Extension of imagery

Mental imagery in dance creation is just that – mental – but it is derived from the dancer’s experience of external stimuli. Dancers have to hold that information in their bodyminds as they move around it, through it, and with it in the creation of new movement. As deLahunta et al. state ‘[w]e can draw on well-drilled habitual pathways and movement patterns in choreographic problem-solving, where thinking remains detached, somehow ‘thought-alongside’ or we can skilfully pay attention to and through the passage of the movement whilst it is in process, whether in response to internal environment or external image, intention or ‘affordance’, allowing the movement to become ‘thought-filled’, itself the instrument of cognition.’ [7]. When thought is done ‘alongside’, or at ‘one remove from the moving’ they argue ‘the solutions suggested by the body are likely to stay within the limits of our habitual movement patterning.’ *Tools that Propel* could be thought of as an aide-memoire, bringing into being another mental architecture as an expansion of the dancer’s own. It gives reminders of movement and motifs that the dancer has explored before, brought back for more complex and nuanced exploration. Sometimes it brings back movements half way through the trajectory the dancer might usually associate with that movement, breaking into the flow of another movement, disrupting the train of physical thinking and habitual movement patterning. As such, it also offers a set of visual rules with which to inform and provoke the improvisation and new ways of moving. Reflecting on an improvisation with *Tools that Propel* during a studio session held on 18th October 2018, Yi Xuan Kwek reports that she was walking around looking for spots that were trigger points for memories; then became interested in blending people together; then transitioned into finding free space and uncharted territory, which after a while got quite saturated and led her to look for old memories of people and explore how long she could hold them there whilst subtly changing their movement. She also commented on the incidental capturing of other dancers in the memories and stated that she had enjoyed ‘holding the space’, bringing back and holding memories which had people moving elsewhere in them, filling the room with their presence. She remarked to the other dancers ‘your heat signatures are left there’ [18]. Through its affordances *Tools that Propel* is triggering the creation of these creative rules, acting as part of her cognitive apparatus, and informing her physical thinking; it is extending her bodymind.

4.2 Extension of habit

Perhaps, however, it could be argued that *Tools that Propel disembodies* the act of thinking, separates it out from the bodymind. In materialising the computational decision-making on screen, seen in the blending of bodies performing real-time and past movements, the overlaying of people and time, it displaces the thought to being ‘alongside’ the dancer; and thus, perhaps it encourages movement generation along the lines of dancers’ habitual movement patterns. Indeed, in a workshop delivered with Company Van Huynh on December 4th 2018 at Centre 151 in London two dancers suggested that it actually brought them back to their habitual movements rather than enabling them to escape them [19]. It is important to consider this further with regards the impact of the system across a greater range of dancers, of course, but it was noticeable in the Company’s warm-up that their practice was somatically-driven and it is possible that the requirement to feed off external information in the moment of improvisation was not something that they were necessarily used to or personally drawn to. In contrast to these dancers, two others

at the workshop suggested that working with *Tools that Propel* had opened them up choreographically, making them think about space and composition more in their improvisation. The interplay between following internal movement impulses and maintaining a compositional eye can be difficult and it has been observed that dance students who have used the system over a sustained period of time, improvising with it in numerous studio sessions go through a process whereby they learn to succumb to it. As one student said in interview, ‘I got frustrated a lot, so I would go from frustration to more curiosity...then that would change “Oh it’s not going how I want it to go”, so it’s kind of discovering... that it’s not about working out how it does it, just enjoying how [*Tools that Propel*] works with you’ [20].



Figure 5. Group improvisation during a live-streamed performance

It is clear that some dancers discover new possibilities within their own habitual movements re-presented in front of them; they enter a dance in dialogue with them. We might consider here Deleuze’s statement in *The Logic of Sensation* that the artist has to ‘enter into [the cliché] precisely because he knows what he wants to do, but [...] he does not know how to get there.’ [8]. As an extended bodymind *Tools that Propel* brings a dancer’s habits back to them and through the intriguing way those habitual movements are re-presented through the folding of time and layering of bodies, for example, it encourages the dancer to engage in a deep process of digging into the cliché to find more within it. *Tools that Propel* works to train, or slowly seduce, dancers into practising the vital skills of ‘attention and imagination’ [7] through engagement with the overlaying of, and fitting inside, their movement, their own and other people’s bodies, editing and evading the projected footage through embodying it, giving it kinaesthetic empathy [13, 27] through the movement of their real bodies on the studio floor, and allowing the perceptual disruption of linear time to open up new possibilities.

4.3 Performing *Tools that Propel*

Expanding the capacities of the dancer through this extended bodymind might suggest a one-way direction of travel. But by examining the displacement of formerly non-machinic functioning within the

dancer (memory, mental imaging and peripheral vision, for example) to the functioning of this computational system, and in relation to this, the expanded capacity and skills we see within the dancer in return, we can get a clearer sense of the performative skills going into the creative act of thinking in dance. We can see that in turn these shape the machine's behaviour (and its choreographic output): some of these inputs by the dancer might be understood as compositional awareness, intention, attention, movement articulacy, kinaesthetic energy and empathy - the same skills and qualities it is helping to elicit in them. Through these, dancers generate an interplay with the system, inventing new movements, manipulating old ones, and testing its decision-making; they are keeping it 'on its toes' by moving the visual output, its choreographic decisions materialised on the screen, by inhabiting the 'ghosts' and by offering up movement for its tracking eye in order to keep it in play. If we are looking at *Tools that Propel* and the dancing bodymind as what Andy Clark calls 'human-technology symbionts', that is 'thinking and reasoning systems whose minds and selves are spread across biological brain and non-biological circuitry' [3] we might argue that the decisions made by the thinking body, the bodymind, as part of this 'human-technology symbiont' are perhaps made in the acquisition of new performative skills, knowledge, and articulacy, ever-evolving with and inseparable from the system itself; that new movement awareness, thinking patterns, and processes are *made with* the system, and shape its behaviour from within the extended bodymind that is made of both.

5 A DANCE BETWEEN 'THINGS'

But what different insights does a consideration of the system as an 'other' offer? Practical use of *Tools that Propel* also yielded the idea that all the components (dancers, Kinect sensor, projector, computer, algorithms, room, mirror, space, time, body, memories...) form a distributed agency acting to catalyse the discovery and recognition of the choreography 'as "not ours" but rather "animating" us' [29], unfolding with its own logic. *Tools that Propel* appears to look back at the dancer and to be making decisions. It feels uncanny: reflecting the 'reality' of the room but presenting the dancer's body as estranged and housed within another's; projecting their current self in their previous movements and those of others before them; offering a collapse of the linear trajectory of past and present; and blending matter and memory in both the virtual and physical realms. But *who* or *what* is doing the moving? W.J.T Mitchell writes that 'Things... [signal] the moment when the object becomes the Other, when the sardine can looks back, when the mute idol speaks, when the subject experiences the object as uncanny...' [25]. Here, rather than seeing the 'agent' (the dancer) 'spread[ing] into the world' [4] we can understand the objects of the system themselves as having agency. We might conceptualise them as Bennett does when she writes about '[a]ctant[s]... Bruno Latour's term for a source of action', as neither objects nor subjects, but 'interveners' akin to the Deleuzian 'quasi-causal operator' [1]. Here we would see that the components of *Tools that Propel*, as 'actants' or 'interveners' impact on the dancer's bodymind as much as the dancer *acts, intervenes, operates* on them, through the 'things' that make up her own performative skill and embodied knowledge. In collapsing the hierarchy between subject and object, human and machine, we begin to understand the dialogue that takes place - the 'dramaturgical conversation' as Mark Coniglio calls it [5] - between them, and that the new thinking (materially traced as choreography unfolding on the floor and on the screen) emerges out of this, also a 'thing' with its own sense of agency.

5.1 Indifferent to dance

In her elaboration of the ways in which dance communicates kinaesthetically, Mary M. Smyth discusses motor theory in terms of its 'view that the ability to perceive depends on the ability to articulate', before stating that this is 'inappropriate for understanding dance communication.' [28]. She states that '[t]he important part of the message in dance is not "what was that movement?"' and goes on to argue that 'for the spectator who is not a dancer, being able to discriminate one movement from another is not the problem.' But in developing *Tools that Propel* that was a vital problem to overcome. What is a movement? How do you distinguish one gesture from another? What is the beginning and end of a gesture? As discussed earlier in section 2.1, the system determines the end of a gesture in one of two ways - either on the first frame at which the estimated likelihood that the current motion is produced by one of the 'known' classes exceeds some threshold, or on the frame at which the duration of the current recording exceeds some defined maximum (typically 5-8 seconds). It has nothing to do with how we perceive meaning in the movement; its expression, its energy, its arc or trajectory. It is, as Adam Russell has termed it, quite 'psychopathic' in its decision-making and flagrant disregard for meaning. But this very refusal (or inability) to apply any other more multimodal sense to the movement - unlike the 'practical multimodal experience evidenced in dance expertise' in all its richness and nuance [7] - is part of what makes it 'other' and warrants curious appraisal of its qualities, affordances and agency from a non-subject-oriented perspective.

As Sofie Hub-Nielson, dance undergraduate at Falmouth University, commented in a studio session on October 10th 2018, *Tools that Propel* encourages dancers to use what she termed 'human movement', which is movement that is not normally used in dance but at the same time portrays and uses the human body [18]. It is its indifference to meaning, narrative, and prior relations that shifts what is perceived as dance. The dancer can offer whatever he or she wants to the system, to the tracking eye, but the factors by which it determines value do not adhere to either representational, historical or embodied conceptions of what constitutes dance. Hub-Nielson stated that she found it interesting that a computer could push the natural human body forwards towards our frame of reference as we are dancing, rather than a non-natural or technological rendering of a body. We are faced with material reality, however indirectly we reach it. The recognition of the agency of the technological components involved in the assemblage that makes up dancing with *Tools that Propel* - seeing them not as objects to be used or overcome or extended out into, by and from our subject-oriented perspective, but able to act on us, even from their withheld, indifferent existence in the space - actually allows the interactor to journey deeper into the human rather than farther away. The dance between 'things' opens up new perspectives, possibilities, and intrinsic insight into and understanding of the nature of our material being. An undergraduate dance student has described how *Tools that Propel* will 'do something unexpected and it's an invitation, it's an opening'. Another describes how a memory of yourself or someone else on screen leads 'not so much [to] sensing the physicality but just listening to your own mental process [...] it's enough stimulus to make you think differently'; and a third, describing the reflection of the room as 'raw' talked about going on a 'journey [...] together [...] a relationship we were moving on together.' She said 'I think it helped me accept myself more [...] just kind of accept the way I move in a strange sort of way.' [20]. It is this 'opening up' of the centre of the moment and place we are in, coming about through the distributed agency between the dancing body and

Tools that Propel that builds compositional awareness, attention and intention within the movement decisions carried out in the dancer's bodymind; and as these skills and qualities are applied by the dancer to their improvisation with the system, the 'opening up' gets deeper.

6 AGENCY IN DIALOGUE

When the OpenEnded Group and Wayne McGregor developed the *CLA* the aim was to create an 'independent dance agency [...] an entity that could respond to and solve the kinds of choreographic tasks that [McGregor] set for his dancers. [17]. *Tools that Propel* is less of an agent than the *CLA* in that sense; it cannot generate choreography on its own or respond to choreographic tasks. It needs the bodies of the dancers interacting with it to come to life at all. But therein lies its specificity too. In this interaction it can respond to the dancers and what they give it in *real-time*, and it can also surprise them. It can take them into themselves and deeper into the moment of improvisation. In its ability to dialogue, challenge, and reveal, it sustains dancers' engagement over long, evolving, improvisations and inspires them to improvise with it over and over again.

6.1 Digital intervention in real-time

Of course, there have been countless installations created over the decades that respond to interactors in real-time, and numerous digital dance performances in which visuals and sonic outputs are controlled by dancers' movements. Many of these installations and digital dance performances would fall under the banner of what Mark Coniglio calls 'digital reflection'. This he defines as being when technology acts as the protagonist in the performance and is used to empower and augment the performer, expanding the space of their performance, through interactive systems, for example, that use performers' gestures to trigger sounds and video. But the development of *Tools that Propel* was inspired by Mark Coniglio's arguments for what he calls 'digital intervention' a modus operandi he positions in opposition to 'digital reflection'. [5] Whilst often producing spectacular visual performances, Coniglio believes that the work he defines as 'digital reflection' is never really memorable or profound because it has not earned what he calls the ecstasy of great art through any sense of conflict. He also argues that whilst the body as an instrument 'is incredibly high-resolution and responds very dependably to the commands sent to it by their brain [...]he] can think of no digital gesture-sensing system that offers anything near the same level of resolution and responsiveness.' In contradistinction, Coniglio cites *Life Forms* as an example of 'digital intervention'; an approach to using technology in creating performance in which the technology acts as an 'antagonist' to the human performers, challenging rather than expanding their capabilities, and thereby producing new forms that would not have come about otherwise. *Tools that Propel* uses computation to *intervene* in the dancer's decision-making in *real-time*. It explores digital intervention as a mode of stimulating and producing new choreographic thought-in-action *as the dancer improvises* and *as the computational choreography unfolds* in relation to, and propelling, new emergent movement.

6.2 Negotiating bodies

The *CLA* might indeed be described as an 'extended mind'; James Leach has called it a 'kind of prosthetic dancer's brain' and 'an extended digital notebook' [17]. It was built on the foundations of extensive, invaluable research into how the choreographic process

works and is designed to produce choreographic possibilities that are different from those of McGregor's company of human dancers, inspiring them to explore and investigate new terrain. Leach states that the 'agency' of the *CLA* 'was a function of having some degree of autonomy, tightly coupled with choices the user would make' and discusses how it was not the 'choreographic entity that had been envisaged'. This revelation led to a further investigation into the need for the agent to have a 'body' and what that meant for McGregor and his dancers; following this came the creation of *Becoming*, a more recent iteration of the *CLA* which McGregor described as an 'eleventh dancer' [17]. *Becoming* was designed to give 'body' to the computational tool, reflecting McGregor and his dancers' desire for something that had a sense of matter, energy, presence and movement.

But it is the description of what McGregor and his dancers said about bodies in relation that is most important to a recognition of the contribution that *Tools that Propel* might also bring to this field of research. Leach writes that '[m]aking movement material with others, or with others in mind is about the relational aspects of movement. When articulating the qualities of working with others in a studio, or in tasking situations, dancers said that they are aware of a constant negotiation of feeling and presence, of desire, shame, imposition, power, politeness, domination, or facilitation. These are qualities *felt and worked with* in making movement material.' [17] As such *Becoming* was developed to be a bodily presence in the studio with the dancers, 'an aesthetically and kinaesthetically compelling presence', designed to 'elicit a kinaesthetic response' in dancers working with and alongside it. It still does not explicitly respond to what they are doing, however. It is not in 'constant negotiation' with them even if it is constantly present and constantly negotiating its own body.

Tools that Propel though significantly different in aesthetic to *Becoming* also has such presence and also brings out kinaesthetic responses in people working with it. It too has body, despite its visual output being projected on a flat screen or wall. But where it differs from *Becoming*, beyond the programming and computation informing its particular mode of bodily thinking of course, is that it challenges and responds to dancers; it negotiates with their bodies. It has been described by undergraduate dance students as 'predictable but also unpredictable'; as something that 'takes what your offering and offers back, whether that's [by] breaking your offering or developing your offering' and that 'makes you conscious of what you're doing [...] helping you to retain that sort of clarity in your thought'. It is acting on the dancers and they are able to act on it. Describing *Tools that Propel* as being '[l]ike one of those dynamic abstract paintings where you don't really know what's going on but you have to stand there for a long time and figure it out' one dance student stated that 'some people might want to just challenge it and others might want to kind of like use it, and live in it almost'. One student said that it 'supported me and pushed me to break my boundaries more with my movement and open my mind a bit more' and others spoke of having 'a fluid kind of conversation', 'like a relationship, a conversation, communicating with each other', 'just bouncing off each other', 'adopt[ing] the mindset of like looking at her as a performer' and having 'days when we did not get on' [20]. *Tools that Propel* is *digital intervention happening in real-time*, and the movement that emerges with agency of its own and in dialogue with all the bodies in the system could not have pre-existed this relationship.

7 CONCLUSION

This paper interrogated the experience of the dancers improvising with *Tools that Propel* with reference to two apparently oppos-

ing critical frameworks, exploring whether the movement emerges within the dancers' own extended bodymind, that is through human-technological symbiosis, or in dialogue with the system's 'otherness' as part of an assemblage of distributed agencies acting on each other, embroiled in a dramaturgical conversation. It concludes that it is in the interplay between both conceptualisations of the relationship between the human-body-in-movement and the computational decision-making that new choreographic thought-in-action occurs. This interplay might be understood as being between computation as an expansion of the dancer's capacities and computation as an unpredictable, surprising and sometimes disturbing intervenor.

Through examining the relationship between the dancer and *Tools that Propel*, this paper has also explored the performative and embodied know-how that the dancer is revealed to bring to the interaction and suggests that this know-how might also be specific to the interaction itself. Whilst movement does indeed shape the system's behaviour, this very behaviour shapes the movement too; in this entanglement it is not always clear who or what is doing the moving.

If there is a sense of agency perceived in *Tools that Propel* and/or brought about by improvising with the system, this is not because of an intentionality on the part of the programming. Agency is felt in the feedback loop evolving between the dancer and the system; expanding, ricocheting and pulsing *with* and *because of* all the collisions that occur between the mode of thinking enacted by the fleshy dancing matter and the mode of thinking enacted by the computational system.

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