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# Virtual relationships: the dancer and the avatar

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**ABSTRACT**

People might assume that dancing with a digital avatar would be a relatively distant, dehumanizing or disembodied process. However, in this article we propose that effective and creative choreographic practice can be achieved by working with a virtual representation of a dancer, and we offer two case studies to evidence the practical application of motion capture technology within this context. We observed that the virtual model quickly and naturally becomes an extension of the dancer's interiority and that a dynamic affective attunement between dancer and avatar spontaneously develops. We describe how the relationship between the physical and the virtual dancing body raises several practical, theoretical and even philosophical questions for choreographic approach, style and process. Building from Susanne Langer's (1953) germinal conception of the 'virtual powers' of dance, we articulate a practice-led research opportunity to critically reflect on conventional choreographic practices through the affordances of a specifically digital virtuality, in ways that can open out the kinds of affective, emotional and phenomenological frameworks within which creation occurs. The unique affordances of recent motion capture systems, offer naturalistic three-dimensional environments with an increased improvisational interactivity that simply cannot be achieved with video-based media.

In this article, we propose that effective choreographic creative and research work can be achieved by working with a virtual model/avatar, and we offer two case studies to highlight the practical application of motion capture technology within a choreographic environment. In each of these research scenarios, the dancer engaged with a virtual representation of themselves as a digital avatar while performing or devising dance work (as a projected screen image, or in Augmented Reality). We found that the virtual relationship between the physical and the digital body raises many practical, theoretical and even philosophical questions for choreographic approach, style and process, and can either reveal new kinds of knowledge or simply disrupt existing habits and routines in creatively exciting ways. It also opens a practice-led research opportunity to critically reflect on conventional methods of dance creation and the kinds of affective, emotional and phenomenological frameworks within which choreography occurs. Drawing on the

germinal concept of the 'virtual powers' of dance from aesthetic theorist Susanne Langer (1953, 169–188), we interrogate how digital technologies tap into, enhance or augment the inherent, non-verbal, virtual expressivity of dance. We then propose that in-depth collaborative explorations between dancers and researchers can support this enquiry into embodied knowledge and choreographic process, where the relative (inter)disciplinary positionality of the collaborators productively informs the research. The first case study reflects on the development of a collaborative digital dance performance, *Malta Calls*, for Valletta 2018, European Capital of Culture, where the researcher was engaging with a choreographic creative process from a participant observational standpoint. The second case study describes the EU-Funded Horizon 2020 *WhoLoDancE* project, where the researcher was also the dancer within the work, fully embedded within a practice-led research methodology.

A conventional dance audience might believe that dancing with a 'machine' (an automaton, computer or other digital apparatus) would be a relatively distant, dehumanizing or disembodied process. On the surface, dance seems to be a primarily physically embodied, fleshly experience, engaging in a kinetic expression of amorphous, subjective emotional and affective states, and as a primal form of non-verbal communication from human to human. The idea that a synthetic, animated expression of bodily movement could be capable of this same communicative expression of emotion or transmission of affect seems unlikely, even when it is directly programmed to do so by a human agent. Within aesthetic theory, and since the influential 1970 article by Masahiro Mori (2012) which first introduced the term, there has been a persistent discourse that there is always an uncrossable 'uncanny valley' that prevents true connection or affinity with humanoid objects. This evocative discourse has extended from its original context in robotics to more recent human-computer interface (HCI) and motion capture fields in a very common-sense way, simply stating that there is an eerie and unsettling sensation that undermines any natural attunement with a technological avatar. In this article, however, we suggest that recent iterations of motion capture technology (emerging within the last five to ten years) used in conjunction with visualizing software such as games engines, and with increasingly immersive screen interfaces from Virtual and Augmented Reality (VR and AR) to projection-mapped landscapes might be able to finally bridge the gap to permit a fluid emotional and affective communication. In doing so, it might also *go beyond* simply duplicating, or substituting for direct human interaction. This is to say that this technology introduces certain elements of difference and discovery into choreographic interaction, which have the potential to reveal new insights and new sensations. Motion capture is thus not simply a 'second-best' option for those who cannot find the time or space to have a direct physical interaction, nor is it only a technological novelty for a niche digital choreographic practice. Dancers and choreographers who work with motion capture know how precisely it can catch nuances of bodily gesture (such that even with relatively abstract representations of a body in motion you can often identify a person through their unique movement style); yet it is the way that physical attributes of proportion, gravity, muscularity and force, as well as mental attitude and the *vitality* of a dancer, are then digitally and aesthetically *recomposed* into the virtual avatar that can become revelatory. This process can render the imaginative interiority of the dancer into extended space in ways that generate new perceptions of connection, interaction and empathetic communication.

Most of us who grew up with a fondness for children's animation are familiar with many brilliant expressions of humanoid dance movement, from the early Betty Boop's *Minnie the Moocher* (1932) through Disney's *Fantasia* (1940) and *Mary Poppins* (1964), right through to very recent expressions of dance on gaming platforms such as with *Fortnite*'s 'Emotes'.[1] These media images see real human movement expressed synthetically, sometimes with direct human interaction with and between anthropomorphized animals and objects (penguins in *Mary Poppins*, mushrooms in *Fantasia*). However, these are recorded dance performances, photographed and then animated, first through rotoscoping techniques,[2] and then, for the last 40 years, also through the digital motion capture of human performance. As cinema, they are essentially fixed, linear images that are treated in post-production to be aesthetically pleasing, and while they are enormously entertaining to view, there is no true interactive engagement here between the live dancer and the virtual animated image – the performer does not see what we, the viewer, sees. While in *Mary Poppins* we see human and penguin dancing 'together', the performer merely gives the appearance of live interaction through careful staging and choreographing, and this practice of *pretending* to react to, or interact with, invisible entities is still fundamental to contemporary green-screen computer-generated imagery (CGI) filming practices. But how would it be if the performer could see this animated figure in the real space before them, moving around them, with them, and with a real-time mutual communicative interaction? We suggest that this has only recently become possible with a combination of new digital technologies of real-time motion capture and generative animation.

As a recent example of this kind of work, acclaimed choreographer Bill T. Jones collaborated with Google Labs in 2019 on the work *Dancing with Machine*, using the AI motion capture system Posenet to generate a genuine interaction with a virtual image. The live dancer's movement triggered images and words on a screen that surrounded and followed their form, expressing their interiority through a verbal-visual exteriorization of thoughts and feelings.[3] With this work, the machine is reactive to the human, and the choreographic creative process is fundamentally altered through the way the technology is responding to the motion capture data. However, it seems that the dancer here is still simply pre-learning and rehearsing the movement that is most visually effective in this context. They do not directly respond to the visualization that they generate in an interactive, open-ended sense. Furthermore, the communication seems mono-directional, from dancer towards audience, and the virtual aspect is a flow of words in space, rather than a more figurative expression of the human body.[4]

While this is a fascinating shift towards an interactive relationship with a virtual model, as a next step we propose a system by which a dancer can truly respond to a computer-generated image or avatar of another humanoid dancer in real time, as an emergent form of dance communication, expression, creation and performance. We propose that dancing directly with the virtual model – that is, reacting to and moving with (a capture of the dancer themselves, another performer in a different location, or even a simulated AI dancer) – has the potential, in several circumstances, to replace or augment the kinds of conventional uses that are given to the mirror and video recording in dance training, creation and rehearsal. It can then extend to exciting new telematic, distributed and hybrid choreographic performance work.[5] This potential would be due not only to the technological affordances of three-dimensionality and increased capacity for improvisational interaction with the animated image of movement data, but also due to

the *augmentation* of dance movement, in the way that (as pure data) it can be altered, manipulated or abstracted to be 'other'. Indeed, we can already see interesting examples emerging of dancers working with bodily movement as pure extended expressions of form, shape and colour, or with visualizations of other non-corporeal forces, flows, trajectories and connected points in space.[6]

Beyond describing and analysing the striking visual aesthetics of much recent digital dance work, can we also ask what kinds of new or altered knowledge and insight these new technologies and practices might be able to generate? As evidenced by the dance work of Bill T. Jones and others such as Alexander Whitley, there are clear creative and aesthetic applications in the devising of new hybrid media forms of choreographic performance and installation. There are also other practical applications in the revision and reshaping of technical and efficient processes of learning, teaching and rehearsal – through three-dimensional capture and replay of choreography, remote interactivity, and other modes of motion data analysis.

However, our focus is on the use of motion capture systems to generate an interactive virtual dance partner and investigate their potential as choreographic *research* tools for investigating the habitual kinds of affective, emotional, imaginative and phenomenological frameworks within which movement expression and creation occurs. These technological apparatuses allow us to critically think about how to reshape, extend or augment the practices of dance creation to productively challenge the dancer. As Bill T. Jones notes of his 2019 project, 'it's a whole other learning curve – it's hard on the ego' (in his 'making-of' video; see endnote 3). We further suggest that a practice-led research, or interdisciplinary praxis, of dance with virtual models and in digital spaces can extend into theoretical and even philosophical realms, offering a transformative or *technoetic* potential to give new perspectives on the intensive lived experiences of the body and their expression in dance. This approach considers, for example, how the sensory modalities of kinesthesis and proprioception are deeply related to the way that consciousness develops through fully-embodied experience, and how this process is then influenced and disrupted by technological augmentation and prosthetics.[7]

Though abstract philosophical debates and more scientific and technical questions might seem to demand qualitatively different approaches and modes of operation within the dance field, abstract constructions of theory can directly influence the practical realities of a dance research environment. Within the choreographic arts specifically, philosophical curiosity has always encouraged practical experimentation. Susanne Langer's work from the mid-20th century initially challenged how we define and use the term 'virtual' and helped reimagine how dance can both nurture discussion and be a form of agency. More recently, her claims that the moving body and 'vital gesture' are ways that whole-bodied agency is possible are directly influencing ways of critically engaging with the body and dance practice in digital environments. Langer's germinal work on virtuality (developed under the supervision of Ludwig Wittgenstein and A. N. Whitehead, and influenced by Henri Bergson's process philosophy and dynamic ideas of creative evolution) in fact seems to foreshadow much later philosophical work on new media virtuality.[8] Indeed, from authors such as Mark Hansen and D. N. Rodowick, contemporary conceptualizations of the way that digital works of art are not fixed and stable but rather constantly *becoming* and changing as they are engaged and interacted with, were already present in Langer's work. Now, Langer's concepts directly influence a new

generation of theorists of dance's 'vitality dynamics' who explicitly connect physical 'analogue' practices with new digital choreographic expression.[9] For instance, re-reading Langer's theory, researchers Vincs and McCormack designed an interactive dance performance system that 'touches' space, digitally revealing 'the subtle, poetic, embodied dynamics of dance; trajectory, velocity, acceleration – the "how" of movement, rather than the utilitarian "what" of task-based gestures such as pointing or clicking' (2010, 360). They call this 'a literal realization of Langer's theory, made using a technology that reinterprets her idea of virtual force as extended physical agency', and, moreover, a poetic and aesthetic rendering of that agency (ibid.).

Informed by Langer's approach, in this article we first offer some theoretical/philosophical frameworks that build on the work of Langer, followed by practical/methodological reflections on dance and virtuality. We start with concepts of affective kinetic attunement with virtual models, of kinetic synaesthesia, and with Langer's understanding of the phenomenological virtuality of dance experience as it manifests at the interface of digital expression. We then offer two case studies to discuss how a practical application (praxis) of motion capture technology within a choreographic creative or research environment can enhance the inherent imaginative, virtual elements of dance towards a natural and intuitive embodied relationship with the virtual model. While these cases primarily respond to our first hypothesis of the productivity of working with virtual models as a meaningful form of creative practice, we also use them to reflect on the second, more speculative hypothesis on the potentiality of such practices to be creatively transformative.

## Vitality forms, virtual powers, and affect attunement in dance

Key to our analysis of the productivity of working choreographically with a virtual model or avatar is the notion of 'affect attunement' with dance movement, or more precisely, with the 'vitality forms' of human gesture as they are expressed in dance. Vitality forms are defined by psychologist Daniel Stern as abstract, phenomenal sensations of intensity which incorporate time, force, movement, space and intentionality, but which are not only expressed through the movement of an actual physical object or body, but also synaesthetically through sound, shape, colour or any other aesthetic experience, or indeed any 'happening' which expresses 'energy, power or force in motion' (Stern 2010, 7). Expressions of vitality do have a discrete *actual* form (i.e. a sound, a movement, a rhythm), but these forms flow into each other affectively and synaesthetically. In attuning with vitality forms, we mentally simulate them, subconsciously mirroring them as if we were participating (in an imaginary sense, but also at a corporeal and *neural* level).[10] We suggest, then, that the vitality forms of dance can be digitally captured, augmented and extended into space in ways that can mirror and actualize our interior, synaesthetic modes of mental simulation and affect attunement.

Aesthetic theorist Susanne Langer, in her influential book *Feeling and Form*, postulated that the essential purpose of choreography as an artform is to express 'virtual gestures' and 'vital forces' as part of the 'virtual powers' of dance (1953, 169–188). Drawing on this evocative idea, we hold the position that the medium of dance is, essentially, the work of harnessing vitality forms for the purpose of sharing emotion and affect. As Stern explains, a new mother affectively attunes with her baby by mimicking the vitality

forms of the child's expressions, for instance the length and timbre of a squeal, or the force and speed of a gesture. This happens intuitively and subconsciously in a direct inter-action requiring close physical contact and two-way communication, and contributes to the emotional and affective bond that develops between mother and child. Stern explains that if the mother does not respond accordingly to the child's motion and expression – for instance with an expressionless face or without appropriate matched movement – the child becomes distressed within seconds (2010, 41–42). We are, in a way, developmentally hardwired to attune to the movement of another, and doing so releases positive affects.

Of course, when watching a dance performance, there might only seem to be a one-way flow of communication. The dancer does not usually *see* the audience other than as an amorphous blob, and as spectator, we do not physically respond to the dancer, for instance by duplicating their movement with our own bodies. Furthermore, if we are watching a digitally animated simulation of a dance in the form of a virtual avatar, it might seem as if this would encourage even less reciprocal attunement, as we are not even looking at another human being but rather an abstraction thereof. However, these assumptions can be challenged both theoretically and from practical observation, and in the case studies provided below, we suggest that we easily mentally simulate and *attune* with any dancing figure, from a simple stickman to totally abstract forms. Dance theorist Marc Boucher (2004) calls this experience 'kinetic synaesthesia':

> When we view dance or moving images, we can experience kinesthesis without being our-selves in motion by virtue of sympathetic communication, that is to say that kinesthesis is not only a somesthetic sense, but one that allows a form of corporeal communication or psycho-kinesthetic influence […] Kinetic synaesthesia refers to visual and proprioceptive interconnections, and to how visually perceived movement vectors can be experienced as kinesthesis. (Boucher 2004, section 4)

In this sense, we feel as if we are part of the dance, even if we are assuming a roughly static or passive viewing stance. It is, as Boucher notes, a synaesthetic complex of sensory experience 'in a constant state of flux' (2004, section 6).

Indeed, we do not even necessarily need another human bodily presence to experience this sense of kinetic attunement, and we seem to easily invest in non-human vitality forms *as if* they were generated with clear creative or emotional intent. Like the famous playful dance of the plastic bag in the film *American Beauty* (1999), we affectively attune with and anthropomorphize movement, whether it is human or otherwise.[11] Similarly, when a Boston Dynamics robot is kicked over, we empathetically feel concerned for it, though we know full well that it doesn't experience discomfort or pain,[12] and dance-circus company Motionhouse has even choreographed a piece, *Traction*, with a mechanical JCB digger, playing with the anthropomorphic poise and grace of its movement.[13] With great facility, and most likely as an evolutionary response, we readily read human emotion from the movement of anything from the most basic to more complex and abstract objects.[14]

This speaks to Langer's observation carried through to the work of her contemporaries, that dance is already virtual – at a foundational level, an expression of virtual forces and tensions between dancer and dancer, and between figure and ground.

> In a *pas de deux* the two dancers appear to magnetize each other; the relation between them is more than a spatial one, it is a relation of forces; but the forces they exercise, that seem to

be as physical as those which orient the compass needle toward its pole, really do not exist physically at all. They are dance forces, virtual powers. (Langer 1976, 81)

For Langer, the dancer calls upon virtual powers of memory and imagination to *actualize* physical movement, but our own perceptual experience of that *actual* movement is again already virtual, and in a way *imaginary*.

> Everything a dancer actually does serves to create what we really see; but what we really see is a virtual entity. The physical realities are given: place, gravity, body, muscular strength, muscular control, and secondary assets such as light, sound, or things (usable objects, so-called 'properties'). All these are actual. But in the dance, they disappear; the more perfect the dance, the less we see its actualities. What we see, hear, and feel are the virtual realities, the moving forces of the dance, the apparent centers of power and their emanations, their conflicts and resolutions, lift and decline, their rhythmic life. (Langer 1976, 78–79)

This virtual entity, for Langer, is the essence of all *art work* (as a form of labour) that is involved in the symbolic expression of life, balance, tension, flow and rhythm, and channelled through the maker's intuitive knowledge of such feelings and their discipline of expression.

## Digital virtuality

Accepting the virtualizing perspective on dance-as-art, it is useful to position and understand how digital audiovisual technologies specifically are being used to capture, reflect or refract virtual flows and forces. What is their unique *productive* role in the channelling and expression of the virtual powers of dance, and in what way do they either serve or advance the aesthetic and communicative functions of choreographic arts? If the human body itself is the first technology for dance expression, this body is already a virtual body within the performance. Langer notes that the dancer's reflected image in the mirror is also virtual, visible to our eyes, but with no physical presence. Then, when captured on film, the cinematic dance image is again virtual. Reflecting on this same point, Marc Boucher notes how the famous early-cinema dance film, *Serpentine Dance* by Loïe Fuller, is already a virtual technological display in which the actuality of the body evaporates.

> As Fuller animated yards of silk on stage, the audience perceived luminous kinetic forms, dancing light shapes, such as butterflies, flowers or flames. The interplay between electric light and fabric generated a virtual display insofar as the perceived shapes were ephemeral and immaterial in spite of the presence of a body more or less hidden by the fantasmagoria it created. (Boucher 2011, section 1)

Considering Boucher's insight into the contemporary digital apparatuses for the capture of movement data and the expressions of that data as graphic animated forms, we realize that there is nothing radically new in calling these technologies virtual. Instead, we are invited to think about the relative capacities of new technologies to tap into the essential virtual powers of dance, and to act as an effective channel and conduit for a natural and spontaneous affect attunement with choreographed movement. Motion capture may be particularly suited to this purpose in creating an aesthetic expression of kinetic synaesthesia that could not be achieved in the more literal and indexical media forms of film and video. Indeed, a level of abstraction from the actual photographic representation of motion allows a distillation of the primacy of movement, so that we are not instead absorbed in the other 'realisms' of the capture of dance (the face, the space, ambient

noise, etc.). As Boucher describes, motion capture simply surpasses other technologies in terms of a realism not of photographic likeness, but of naturalistic motion:

> With motion capture, we can sometimes recognize the identity of a motion captured individual through the kinetic likeness of the virtual dancer […] where the realism of image, image resolution, or even morphological likeness matters less. As E. de Aguiar writes: 'Motion is a fundamental visual cue in human perception and slight inaccuracies are directly noticed. Hence, even if the rendering is perfect, the motion will still tell you that it is an artificial scene'. (Boucher 2011, section 3)

As Boucher traces through works by pioneers Nadia and Daniel Thalmann, Jeff Kleiser and Diana Walczakm, prior to the application of motion capture technologies in the arts (and in pretty much all CGI animation before *The Lord of the Rings* in 2001–2003), our affinity with digital avatars as animated virtual humans always fell deep into the uncanny valley, failing to offer us motion that felt appropriately human-like. While motion capture has a long history in military, scientific and clinical applications, it was not until the Vicon system developed the technology into mainstream audiovisual entertainment culture in the 1990s, notably in James Cameron's *Titanic* in 1995, that we could begin to see more naturalistic human movement. However, due to very high studio costs, this technology was still largely inaccessible to individual artists, and it was only in 2010 with the launch of the Xbox Kinect camera that, for the first time, artists and performers, including dancers, could realistically access and use a low-cost, real-time, motion capture system. This unleashed, in many ways, a new aesthetic paradigm of the digital expression of bodily movement. Despite the many limitations of the system (as a mono-directional infrared projector and camera sensor device, there are many well-documented problems with movement tracking, occlusion, and a relatively small detection range; see Strutt et al. forthcoming). Now, overcoming these issues of high cost and limited functionality, a new generation of motion capture has emerged in the last five years. Both inertial sensor (IMU) suits and Machine Learning systems such as Posenet operate without the requirement for wires, body-markers or even a studio, operating simply through a local WiFi network, and in the case of Posenet, even without specialist hardware. This democratization of the field of access has allowed an explosion of digital and motion capture dance and performance work, fuelling a whole new genre of digital dance.

Within this emerging technical field and in a rapidly developing aesthetic paradigm of digitally enhanced, dynamic modes of knowing and discovering through movement, we can start to see a transformative potential within the affective, emotional and phenomenological frameworks of the practices of dance. Daniel Stern notes in his *Forms of Vitality:*

> When vitality forms can be evoked, a whole experience can tumble out […] An obvious key is to stay with direct experience at the local level, not abstractions about experience, and moreover to stay with dynamic events such as movements that unfold in time, not mental states conceived of as static entities. […] The goal is to evoke a vitality form that will pull into consciousness some aspect of the whole lived experience. (Stern 2010, 128)

What Stern describes here is that the performance of movement as an evocation of lived experience, rather than, for instance, the verbalization of recalled memories, can trigger a much more dynamic, complex reconstruction of phenomenal, affective experience. Stern then notes that various techniques of *difference* can be strategically used to change our perspective, and to draw us away from static mental models towards the dynamic and virtual.

In short, mental models and neural networks can be reshaped by doing something differently, imagining it differently, seeing another doing it, or by hearing about it in words. The walls separating modes of experience are starting to come down as we realise that all has to pass by way of imagined movement. (Stern 2010, 135)

We thus arrive at a point where we can see that in digital dance, and specifically with the use of motion capture, one's own movement is already visualized differently, and in a way more vitally, or virtually, by stripping away certain recognizable, realist elements of one's own body. We see instead an avatar, simultaneously both self and other, that we can move with in a real time, dynamic and processual mode – within a *flow* of experience. With these digital channels for the essential virtuality of dance, and within an emerging techno-aesthetic paradigm for choreographic practice, we achieve a new experimental field for the symbolic expression of Langer's phenomenology of life, balance, tension, flow and rhythm.

## Practice-based research with choreography in digital environments

Marc Boucher, reflecting on Langer, describes how virtuality is indeed a very broad concept as it is applied in the dance field, and in fact it can too often be simply conflated with interactivity, even though 'the term "interactive" is often used in lieu of the more suitable "reactive," that is to say when reciprocity, mutuality, or feedback are not involved' (2011, section 5). Interactivity, however, is a key factor within the motion capture technological assemblage in the sense of true reciprocal feedback. Though physical touch may not be a sensory modality within it, it is wrong to say that it is purely visual, as we can for the first time articulate a fully physical relation of agency with and within an image, which affects our proprioceptive, kinaesthetic, orientation and balance senses. We may experience our own body as physically different – our sense of weight, gravity and balance, and our proprioceptive sense of the length, position and form of our own limbs.

What we can see within these technological configurations is a profoundly different articulation of the relationship between the physical actualities of dance practice and the more virtual realms of aesthetic experience from the position of both dancer and spectator. Motion capture inserts itself within this balance as a tool which is apt for investigation and exploration of the technologically altered sensory flux, where touch becomes 'virtual', and expansion of the synaesthetic dimension, which, for Langer, already structures much of the felt experience of dance. Its use, therefore, becomes an effective research methodology for the exploration of sense, intention and action through choreographic practices, an observation speculated upon already by dance researchers Vincs and McCormick in 2010, but now made reality.

Touch in digital environments has been 'virtualized' – distanced from being, agency, sensation, by the abstract, utilitarian nature of most human-computer interfaces. Dance might provide a means of exploring ways of reinserting the complexity of whole-bodied agency – the nuance of physical sensation and action – within virtualized digital interfaces. (Vincs and McCormick 2010, 360)

Bridging the gap between the disciplinary practices of dance-as-art and computational, gaming or motion capture practices can, however, be difficult, and requires the kind of experimental lab or workshop type environments that are often hard to achieve within the financial and spatial imperatives of the average arts organization. Innovation thus

often occurs within open-ended, interdisciplinary research environments where existing technologies can be put to use in novel theoretical or praxis scenarios that are not explicitly functionalist or goal orientated (such as, for instance, towards game-play, or the creation of discrete aesthetic outputs as 'works of art'). Art practices can, within these scenarios, be strategically used to challenge traditional approaches to research, through their emphasis on collaboration, and in the integration of theoretical concepts and experimental practice. We aim here to discuss the use of the technologies of motion capture in digital environments and with virtual models within this open-ended choreographic research context, and in an improvisational, interactive and intersubjective mode, as a productive way of observing, reflecting on and producing new embodied knowledge (about the body, held by the body, or interpreted through the body).

Drawing on Sayal-Bennett's (2018) definitions of the difference between *practice-based* and *practice-led* research, it's useful here to reflect on how the two terms can often be used interchangeably while they are essentially different. Sayal-Bennett, drawing on work by Barrett and Bolt (2007), Gray and Malins (2004) and Sullivan (2005), suggests that 'practice-based research refers to a form of research in which the originality of the study and its contribution to knowledge are demonstrated through a creative artefact or outcome, such as images, music or performance'. She then explains: 'Practice-led research is that which focuses on practice itself, leading primarily to new understandings about practice' (2018). Through practice-led research, specific forms of knowledge and insight may not only be observed but also actively produced as a mode of knowing-through-making. This knowledge is understood as a complex dynamic structure, where tacit and explicit or intuitive and intellectual ways of knowing interact on a single continuum. For Lawley (2017), brain, body and environment dynamically influence one another to produce embodied knowledge, and in this sense, the spatial and movement-based medium of dance becomes a privileged mode of exploration of the dimensions of embodied experience for the production of dynamic and processual forms of discovery.

Within the specific context of dance research, the idea of knowing-through-making references Maarit Mäkelä's (2017) practice-led research, as well as that of dance scholar Anna Pakes, who uses choreographic scores to reflect on dance epistemologies. Pakes (2017) says that choreography has a specific potential to generate new knowledge that is not solely tied to artistic outputs, but which can lead to innovative ways of thinking about embodied practices and processes themselves. Specifically, improvisational decision-making within a dance environment can reveal a physical and imaginative engagement with body and space. Pakes further suggests that alongside the dancer's subjective and intuitive discovery purposes, a choreographer is also primarily 'interested in the impact her work may have on a potential audience' and thus their work is always intersubjective (2017, 19). The collective nature of creating a work, through a nuanced and imaginative consideration of the circumstance in which the work will live, who the intended audience is, and the emphatic dynamic processual relationship between choreography and audience, allows for choreography to be a particularly effective tool to develop a practice-led research praxis. Choreography is a form of practice that can be productively used in exploratory and open-ended contexts of bodily, spatial and intersubjective modes and lends itself to more diverse and open research environments.

Another dimension of intersubjectivity is within the dancer-choreographer relationship. This is inherently interactive and interdependent, but may also be unstructured, with an asymmetrical power dynamic between the two which can at times hinder choreographic outputs and creative process. Within a digital virtual environment and when a dancer is dancing alongside themselves as both dancer and choreographer, there is cooperation and co-dependence that bolsters a new way of engaging and creating. While this might tend towards a more egoistic, solitary practice, without the moderating influence of another human dancer, the addition of a complexity of other creative agencies and co-dependencies – of digital visual artist, technicians and technical systems – means that the creative dynamic is even more of a journey of discovery, with a need for new languages of interdisciplinary communication.

Sarah Rubidge (2002) has in fact questioned whether digital technologies should even be seen as discrete 'tools', devices and techniques for the augmentation of the discipline of dance, or if should they be considered as altogether a new 'medium' for choreography, a distinctly new milieu for rethinking practices and for engaging with the materialities of body and space on a more philosophical level. She asserts that interactive or virtual dance is, in fact, the latter – not a tool used instrumentally towards a specific goal, but rather a transformed mode of practice altogether. She notes that 'an interactive, or responsive environment is by nature improvisatory' (2002, 4), as the interaction will *necessarily* open a non-predetermined path.

Rubidge continues with this dichotomous framing to suggest a complexity of visible and invisible components within the virtual environment. The visible components consist of the *actual* video imagery, digital animations, VR environments, and electronically generated sound that is corporeally sensed. And yet behind this, the invisible components within an interactive environment, such as the software, algorithm and code, are equally important, and can drive choreographic work to stimulate a non-linear, non-predetermined dialogue. The invisible components are inherently virtualizing in this sense.

> The interactive system is an open-ended system. Because its network of triggers and rules for responses are non-linear in form, at any point in the process of generating a work-event in an interactive environment a choice as to what to do or see or experience next is available to the performer or viewer. (Rubidge 2002, 5)

The exploratory confrontation between the dancer and the technical system allows for a dynamic, unscripted encounter, becoming a productive tension between practice and research through its ability to generate emergent insight. Moreover, rather than making creation more opaque and 'magical', dancing with digital systems can *make visible* or *demystify* many of the decision-making processes, mediating the space of interaction between the choreographer and the environment through the capture of discrete data for the purposes of analysis, or by graphically representing a dancer's *virtual* interiority in exterior space. While still appearing to the user/spectator as virtual, one can trace the *actual* lines of creation through the data. In Langer's terms, this opens up the liminal microcosm between actual movement and virtual gesture in new ways, and the digital interaction encourages a production of knowledge that has the capacity to elicit a new choreographic language and process. What we can understand is that while dance has always an inherent potential to explore the flux between actualizing and virtualizing tendencies, this potential can be augmented by complementary virtualizing

technologies such as motion capture. This observation is corroborated by Marc Boucher, who also notes the liminal complexity of motion capture systems.

> Motion capture virtualizes dance; physical modelling and character animation actualize it. We can only perceive actualized instances of virtual dance, [but] virtual dance as a product of digital technology must be understood both in technological and philosophical terms, and in relation to other multimedia forms where embodiment is a major issue. (2011, section 9)

To summarize, and to position the case studies that we now offer, we can say that digital tools and environments have the potential to play to and enhance the inherently virtual, imaginative and intersubjective experiences of dance. Through creating exploratory, interactive and improvisational scenarios in which space and body can be altered, we can see new forms of dynamic, practice-led and processual choreographic activities emerge. As either a technique of difference with regard to the knowing of one's own body's kinaesthetic or proprioceptive sensory flux, or as a form of communication and discourse with other bodies and space, we see forms of relational and intuitive embodied 'knowing' emerge, alongside more discrete and actualized fixed patterns of data, either of which can reinvigorate, or simply disrupt, dance practice as a mode of creation and research. In the following case studies, we thus consider both the technological apparatus (both tools and framework, with visible and invisible components) and then the kinds of experiences, observations and 'intuitive outcomes' of the situations.

## Case study 1: devising a performance improvisationally with motion capture

This first case serves as a reflection upon the natural, intuitive and spontaneous kind of dynamic, affective attunement that can occur when working with a virtual model. It occurred as an instance during the production of the collaborative digital dance project, *Malta Calls*, for Valletta, European Capital of Culture 2018, with Zfin Contemporary Dance Ensemble, Studio Aszyk, Prickimage, and choreographer Mavin Khoo. The researcher here was a participant observer, dialoguing with the performer about their experience within the moment, and later in interview.

Our team decided that, for this technologically enhanced performance concept in Malta, we would use an inertial sensor motion capture suit system (the Rokoko Smartsuit) to generate animated visualizations of the dance within the games engine Unity. In several motion capture sessions over a development period of several months, the choreographer improvised movement to an original musical score. For the final performance, the captured motion data was animated in Unity, and pre-rendered for projection on screens behind the live dancers. The performance itself, though aesthetically pleasing and with many 'virtual' interactions between the live dancers and projected image, was by no means truly interactive and was merely choreographed to appear so. However, more interesting, perhaps, in terms of practice-led-research, were the capture sessions themselves (Figure 1), in which Khoo was able to explore movement freely and experimentally in real time with an almost life-size model/avatar of himself.

Khoo initially experienced this as a kind of detached sensation of 'puppetry' where he was merely controlling the image as if by invisible strings. While this in itself was interesting in terms of his novel exploration of movement, he actually found himself thinking less about
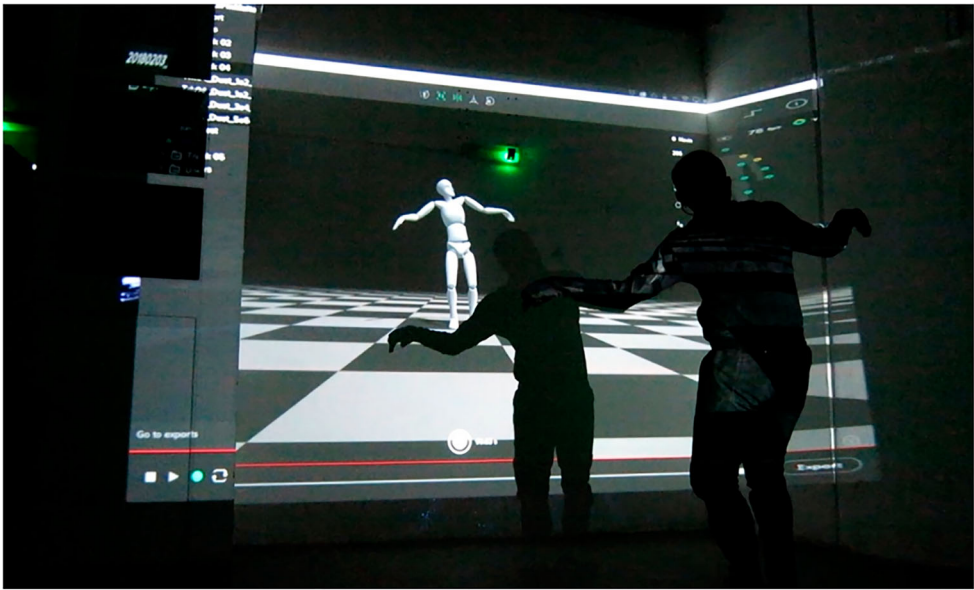
**Figure 1.** Choreographer Mavin Khoo dancing with his virtual avatar within the Rokoko software. Photo: author.
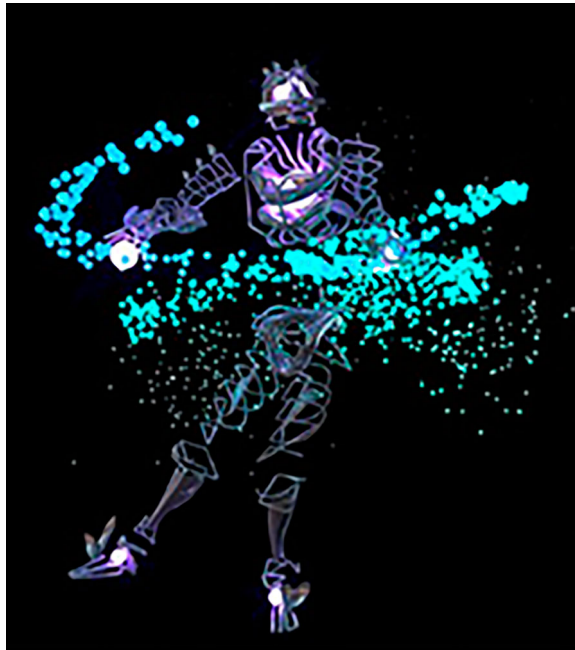


**Figure 2.** The appearance of the digital avatar in the performance *Malta Calls* (2018). Image by Studio Aszyk.

the articulation of movement within his own body – within his (virtual) internal space – and more about this external and objective actualization of his movement. He reflected:

> Being made to creatively work differently is always a good thing. As a choreographer, one is always concerned about generating movement vocabulary first. For me, it has always been a more internal space that I have had to engage with to articulate my body organically. In this instance, I am reliant on observation. As a maker, there is a huge benefit in being able to negotiate aspects of the body in real time as a kind of shadowing partner. It allows for a kind of objectivity to take hold in choices you make, particularly in relation to the body in time and space. 3D capture impacted the creative process through the instant playback of my movement. (Interview with the author, 2019)

An unexpected experience then emerged within the capture session. We discovered almost by accident that within the Rokoko software visualization, we could instantly replay the previous capture while simultaneously making a new recording. What resulted here was a very tangible and intuitive improvisational interaction between two dancers on screen, where one was a capture of Khoo himself from only seconds before. It was essentially a duet with himself, creating an exhilarating 'poetic' experience of spatial and temporal flow within the interaction. Khoo described his excitement at this discovery:

> As a choreographer, I am usually drawn to the 'intuitive outcomes' of improvisation in the studio. My work in itself is usually heavily driven by a narrative thread and so, those intuitive outcomes are framed by task-based sessions linked to clear emotional strands. I was genuinely concerned that the presence of motion capture in my process would be problematic in generating a kind of emotive human ownership to the work. That it would be replaced by a technological imprint and that this would deliver a sensationalist element to the work instead of a poetic one. I was excited when I started to discover the opposite. (Interview with the author, 2019)

In our understanding, this type of experimental and open-ended dance practice, a duet with the technical, virtual system, simply evidences the strength of such systems to permit an intuitive and poetic, dynamic and flowing mode of exploration. We could see Khoo playing with the sense of weightlessness within his jumps, and flexing and contorting his physical body to see the effect on the avatar, with a seemingly immediate affective attunement occurring. Later, and more objectively, he could re-watch and analyse his movement, and later still he could see his movements spawn colour, lines and shapes across the projected screen space as particles emitting from the avatar's hands and feet (Figure 2). This radically different way of working permitted new narrative threads to develop through the work, reflecting back into the final choreography that he later devised with the Zfin ensemble dancers, and which was performed in front of the projected image.

In subsequent and ongoing research, we have continued to experiment with these modes of live interactive engagement with the virtual avatar and the relative relations of embodiment and telematic or tele-immersive connection and communication. This has led to some truly fascinating moments through experimentation with abstract visualizations of points of connection between dancers in different locations (where, for instance, a line connects the hands of the dancers' avatars), expressions of force and trajectory (where brightness and scale of digital objects reflect the motion of the dancer), and of dance communication in three-dimensional virtual spaces.[15]

## Case study 2: 'Choreomorphy' and 'similarity search engine' in WhoLoDancE

WhoLoDancE[16] was a practice-led research project that brought together a team of technologists, designers, artists, dancers and multi-dimensional model designers to develop a set of digital tools that could facilitate and enhance choreographic processes of learning and creating dance. The project team explored the use of both high-end (the previously mentioned Vicon system) and low-end motion capture devices within a dance environment, and through a series of lab days and workshops with artists, educators and technologists, they were able to develop prototype models, test systems and feed back insight directly to the research team. The project thus created several ways to consider questions about where movement initiates, how movement propagates, how movement habits generate or limit dance, and wider concepts that are fundamental to dance, such as corporeality and perception. The digital tools were tested and evaluated through lab sessions with experienced dance practitioners, as well as in a series of public dissemination events designed to serve as a formative evaluation of user experience and interaction, providing insight and feedback about the diverse features for the interface and avatars (for instance, between human and non-human shape, human and non-human articulation).

One of the tools that was developed and tested during the three-year project was Choreomorphy, an interactive system that supports a reflective dance improvisation process within an educational, choreographic context. The tool requires that the mover wear a motion capture suit that interacts with the Choreomorphy interface to allow the dancer to visualize their movements on screen in real time (Figure 3). The Choreomorphy tool gives the option of customizing the visualization of the dancer's body and movement by switching among different avatar appearances, parameters and settings in real time, facilitating self-reflection and experimentation. The visualization enables users to experience themselves as different entities and shapes, as well as to focus on specific aspects of their movement, such as traces, trails or volumetric spaces (see El Raheb et al. 2018). Choreomorphy is not a system that asks the dancer to imitate specific movements and provide a score; rather, it aims at offering a variety of choices in visualizing movement based on imagery examples used in dance practice. The tool facilitates choreographic processes of learning and creating new movement scores, as its imaginative components and playful imagery encourage an exploration of the space and the body that is pushing boundaries. The improvisational dynamics and the compositional process is non-linear and offers the dancer a unique experience of flexibility and ability.

Another tool that was developed was the real-time movement 'similarity search' mobile phone application. The application, built on machine learning principles, allows the user to record movements and perform similarity searches within the WhoLoDancE movement library through any mobile device, such as a smartphone or tablet. In the simplest terms, the user points the mobile phone or tablet towards a moving person, and the application returns a stream of images corresponding to similar movements from pre-captured ballet, contemporary, flamenco and Greek folk dance steps and phrases that were stored in the repository (Figure 4). The dancer enters into a form of call-and-response conversation with the tool, and has a choice to pause and observe the feedback of movements or to continue moving to elicit another set of images and avatars.

**Figure 3.** Artist-researcher Rosa Cisneros in the WhoLoDancE Choreomorphy suit. Photo: Rosa Cisneros.
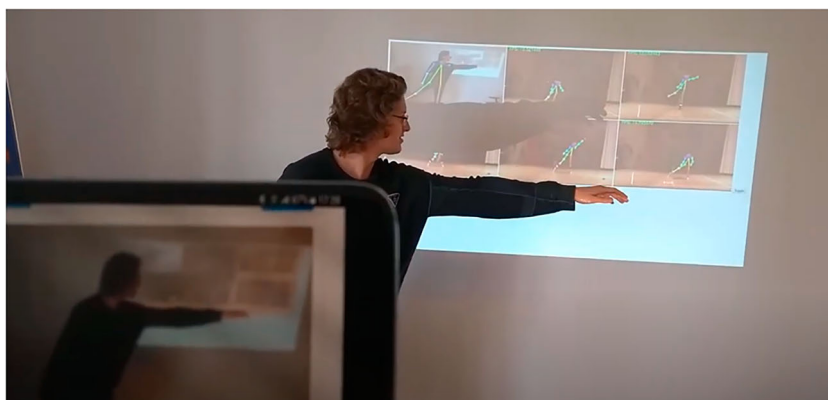


**Figure 4.** The PeachNote developers test the WhoLoDancE 'similarity search' phone application. Photo: PeachNote for WhoLoDancE Project.

In different but interesting ways, both of these tools informed the experience of dancing and choreographing within mediated environments and facilitating a 'duet' with a virtual model. The intuitive interfaces allowed for experimentation and play, facilitating a natural intimacy with the avatar and the augmented corporeality of the self. Such a relationship encouraged the physical body to sensorially reach and dance with the virtual body, while real-time feedback allowed the dancer to renew their choreographic process and their corporeal imagination. This imagination played out within the moment and became a flowing compositional loop between the dancer and their virtual self.

In this second case study, the mediated environment reveals a productive confrontation between the dancer's own intellectualizations and self-perceptions, and the exteriorized visual representation of themselves as avatar. The improvisational mode drew on embodied knowledge and agency while also prompting reactions to new visual stimuli, and this experimental approach led to finding a dynamic way of dancing within a flow of consciousness. Rather than the technology creating feelings of disembodiment, estrangement or alienation, the conditions encouraged tacit knowledges to become explicit and provided a productive framework for re-examining choreographic patterns. As with the first case study, a different arrangement of narrative and choreographic structure positively challenged and creatively engaged the dancer to explore new intimacies with the self, blurring the ego of the dancer with a virtual alter ego who 'speaks back'.

## Conclusion

We have established that dance expression functions in a virtual, imagined and mentally simulated mode as much as it does in the actual physicality of the dancers, and that this can, in interesting ways, be enhanced or augmented through the use of new digital tools and systems. In the two case studies we have offered, we explored how interactive triggers within each environment occur, arguing that there is a dynamic, improvisational duet as a form of affect attunement with the virtual self that can productively inform the decision-making process towards novel choreographic effects and new forms of knowing. In both case studies, the movement of the dancer is shown back to them in real time but in an altered, augmented and 'processed' mode. In both cases also, a dialogue developed between the dancer and their avatar, which exists on the boundary between being subjective and intersubjective – with both self and other. However, despite the technological interface that mediates this dialogue in each case, it was found that a simple and easy communication, affinity and emotional connection developed between the dancer and their avatar.

Interestingly, despite the relative fluidity of communication, the dynamic role of the choreographer themselves becomes blurred, precisely because of the extension of the dance into the external space (where it might normally be contained within their interiority). In Khoo's words, 'It's unclear if the technology is working for the dancer, or if the dancer is working for the technology' (interview, 2020). Thus, the environment and the tool start to play an important part in the choreographic process, framing the decisions made in the performative moment. This yielding of some level of choreographic *control* within a practice-led research methodology allows for emergent collaborative reflections to emerge, and each case study allowed for researchers to respond to the dancers, and for dancers to inform the research. The practice-led method thus facilitated an embedded

and embodied iterative learning, and ultimately informed the direction of the case studies. However, produced knowledge should not claim to have universal applicability, and our case studies merely aim to open up constructive questions on choreographic processes in relation to the multidirectional uses of new motion capture technological assemblages.

We thus suggest that motion capture systems used together with real-time generative graphic systems such as games engines Unity and Unreal, or indeed custom tools such as Choreomorphy, and in conjunction with increasingly accessible immersive VR and XR interfaces, have the capacity to shift the performative interface, creating new practices and insights. While these pose a challenge to conventional choreographic practices, they are not, in our experience, in any way dehumanizing or disembodying. Rather, they are creatively challenging in a positive sense, encouraging one to explore and engage in new intimacies with the self and other in a liminal zone between virtual and actual bodies, spaces and audiences. Such an intimacy requires the dancer to be in the space in an attuned manner, where the brain is responding to an interface and the body is engaging with a virtual externalized version of their self-expression. This creates a kind of feedback loop that moves away from paradigms of control and efficiency, and towards collaborative and complexified co-creation. The real-time choreographic process opens up an improvisational exploration where the machine and the dancer are in a tug-of-war, informing each other while also relinquishing power. As choreographers Bill T. Jones and Mavin Khoo both note, it is a creative challenge to work in these kinds of technical environments, and to negotiate with the affordances and limitations of both machines and their operators in ways that are a challenge to the discipline and the ego of the choreographer.

For this reason, Sarah Rubidge speculated in 2002 that virtual dance is perhaps best thought of as a new choreographic performance or installation-based medium, rather than as within the traditional discipline of 'dance' per se. However, with these new motion capture tools, we would rather see it as an evolution or emergence within the medium of dance, one that can inform, augment, extend and even enhance existing practices in an intuitive way, and not something that is wholly detached from the existing experience of the choreographer and dancer. Perhaps a more constructive perspective is to understand that these technologies can broaden the practices of dance into accessible realms of explorative research into new phenomenological, epistemological and even technoetic realms. The transformative, interactive and improvisational potential of the virtual interface relies solely on the dancing body and the dancer's embodied, intuitive knowledge to inform the process. The dancer must set aside the choreographic ego in the mediated environment, attuning instead with a virtual body and with virtual powers in ways that allow for new knowledge to emerge.

## Notes

1. Emotes are short, avatar-animated, choreographed dance moves that allow players to express themselves within a game space such as in *Fortnite*. These dance moves are sometimes trademarked and are often available to be purchased within the game, causing some ethical and legal issues for Epic Games, as recognizable choreography is divorced from its original context, commoditized, and the work of the original artist is erased. See Robertson 2019.
2. For background on the technological development of rotoscoping as the 'original' form of motion capture, see Bedard 2020.

3. The excellent 2019 making-of film 'Body, Movement, Language: AI Sketches with Bill T. Jones' can be seen at https://www.youtube.com/watch?v=RVyh1ewep84, with a dedicated site including a live collaborative experiment: https://experiments.withgoogle.com/billtjonesai.

4. Other good practical examples that are using motion capture technologies within a creative context include *Asphyxia* (2015), an experimental film project by Maria Takeuchi and Frederico Phillips that explores human movement through motion capture technology. The project uses performative dance captured with two XBox Kinect sensors, presented in an abstracted yet recognizable and fluid form. In Taiwan, the media art performing project *The Inheritance* (2014) combined many elements such as story, dance, 3D printing, real-time motion capture, stereographic projection, 3D interactive image, and architecture into a performance.

5. See Strutt et al. (forthcoming) for a survey and analysis of recent telematic and distributed choreographic work.

6. In 2020, dancer and choreographer Alexander Whitley produced his *Digital Body* project in response to the Covid-19 pandemic, offering dance in a purely virtual form. For this work, Whitley created an open repository of motion captured dance data and has built a community of digital artists, designers and composers to make use of and respond to the data. See https://www.alexanderwhitley.com/digital-body.

7. According to influential cybernetics and telematics artist Roy Ascott, the founding editor of the journal *Technoetic Arts*, 'technoetics is a convergent field of practice that seeks to explore consciousness and connectivity through digital, telematic, chemical or spiritual means, embracing both interactive and psychoactive technologies and the creative use of moistmedia' (on the journal's website at intellectbooks.com). A technoetic line of embodiment research is already being achieved with the VR experience *Isness*, in which researchers use simple motion capture technology to create what they describe as elevated, intersubjective 'mystical-type experiences' within a group environment (Glowacki et al. 2020).

8. See, for instance, the recent book *The Philosophy of Susanne Langer: Embodied Meaning in Logic, Art and Feeling* by Adrienne Dengerink Chaplin (2019).

9. Of the theorists who make use of Langer's ideas, not least is psychologist Daniel Stern himself (writing on dynamic experience in music, dance, theatre and cinema while noting how Langer directly inspired his work [2010, 37]). Her concepts have also influenced many eminent theorists and philosophers writing on dance, from Ramsay Burt (2009) to Pierre Lévy (1995) and José Gil (with André Lepecki, 2006).

10. Noe (2004) suggests that the same areas of the brain are activated whether imagined or executed actions are performed. Similarly, Stern writes about 'imagined movement', which he describes as a virtual simulation in the mind of imagined movement. This is in the realm of 'mirror' neurons, where verbally described, or purely mentally visualized movement triggers a neural and then electro-physiological pre-activation of the muscles – though not necessarily any actual movement. In this way Stern says that 'imagined movement is not disincarnated – it has the flesh of a virtually embodied vitality form' (2010, 134).

11. This famous movie scene can be seen at www.youtube.com/watch?v=Qssvnjj5Moo.

12. See *The Verge* article, 'That Video of a Robot Getting Beaten Is Fake, but Feeling Sorry for Machines Is No Joke' (Vincent 2019) for an analysis of this phenomenon. Fascinatingly, Boston Dynamics has just trained their robots to actually dance, as shown in this December 2020 video: https://www.youtube.com/watch?v=fn3KWM1kuAw.

13. See the Motionhouse site for details of this production, which they describe as '6 dancers and 3 JCB diggers dancing together with acrobatic partnering, animaline strength and unison phrases': https://www.motionhouse.co.uk/production/traction/.

14. The evolutionary and phylogenetic approach to dance as expression is pursued by the phenomenological theorist Maxine Sheets-Johnstone in work such as *The Primacy of Movement* (1999) and 'From Movement to Dance' (2012).

15. See this short video for detail on an ongoing AHRC-funded research project under the UKRI Covid-19 fund: https://youtu.be/SX5f3kvVxxA.

16. WhoLoDancE (2016–2019) was a three-year project and received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no.

688865. It was run by Lynkeus (Italy), and Coventry University (UK) was a consortium partner. See http://www.wholodance.eu/.

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