Towards Socializing Non-anthropomorphic Robots By Harnessing Dancers' Kinesthetic Awareness

Petra Gemeinboeck[1] and Rob Saunders[2]

***Abstract*— This paper discusses a novel approach towards socializing non-anthropomorphic robots, which harnesses the expert knowledge of dancers to develop abstract robot morphologies and their capacity to move in affective and expressive ways. We argue that movement offers a key to socializing non-anthropomorphic robots. Our Performative Body Mapping (PBM) method investigates the possibility of teaching a non-humanlike robot to move and interact by human movement experts. The paper outlines the conceptual framework of PBM and discusses an ongoing pilot study that engages professional dancers to study the relationship between abstract, simple morphologies and their potential to move in expressive, socially encoded ways.**

I. INTRODUCTION

Robots are increasingly presented as 'social actors', designed to assist humans in therapy, eldercare, education and domestic tasks [1], [2], [3]. A 2013 study of the Japanese Ministry of Economy, Trade and Industry forecasted that by 2035, 50% of total robot sales will be of service/personal robots that directly interact with humans [4]. Hence, the stakes for developing a better understanding of how to design socially competent machines are compellingly high.

Currently, the majority of research in Social Robotics and Human-Robot Interaction (HRI) focuses on anthropomorphic (humanoid) and zoomorphic robots [1], [5], [6]. The most well known example, emerging from MIT in the early 2000s is Breazeal's *Kismet*, a humanoid with controllable eyes, ears and lips that engages people in face-to-face interaction [7]. The underlying assumption is that robots that appear human– or pet–like are easier for people to relate to [1], [7]. Yet, humanoid or humanlike robots are technologically challenging and expensive to build [1], [5], and studies consistently show that it is problematic if a robot's appearance and a person's expectation don't match. For example, the more humanlike a robot appears, the more people expect it to manifest human–level cognitive and social capabilities, leading to disappointing or frustrating interactions [1].

In this paper, we argue that movement can provide a key to socializing non-anthropomorphic robots. Studying the expressive qualities of movement and their potential to generate affect and empathy, rather than a robot's expressive physical features, opens up a much wider range of possible robot morphologies to design social agents. Furthermore, designs that don't imitate naturally existing agents allow for the robot's behavior to be the predominant factor for determining a person's attitude towards the machine without being biased by "preconceptions, expectations or anthropomorphic projections ... before any interactions have occurred" [1].

A key challenge when designing alternate robot morphologies and movements is to understand how an abstract or alien robot body can move and express itself in ways that humans can relate to. In the following we will introduce our research project that develops a novel approach to tackle this challenge by enlisting dancers to harness both their movement expertise and embodied, kinesthetic understanding of how movement produces meaning and empathy.

The project is situated within the emergent cross-disciplinary area of Creative Robotics, which looks at human-robot interaction from a broad, culturally embedded perspective. The approach discussed here aims to open up uncharted territory with regards to a machine's kinesthetic abilities and how it can engender new aesthetic and affective experiences. The project is currently in its first development stages, and this paper will outline the conceptual framework and discuss the process of a pilot study that engages professional dancers in a series of workshops to experiment with abstract machine morphologies and their potential for expressive movement.

II. BODY MOVEMENT

Movement as a key element for developing a machines expressive qualities has been explored by artists for more than 50 years. Important examples include pioneering works such as *The Senster* by Edward Ihnatowicz (1970) and Simon Penny's *Petit Mal* (1993). Discussing the latter, Penny talks about the "construction of a seemingly sentient and social machine ... an agent interface utilising purely kinesthetic or somatosensory modes which speak the language of the body and bypasses textual, verbal or iconic signs" [8]. Contemporary works that explore the affective potential of machine behaviours include Bill Vorn's *Hysterical Machines* (2006), Golan Levin's *Double-taker (Snout)* (2008), Mari Velonaki's *Fish–Bird* (2009) and the authors' *Accomplice* (2013).

Movement produces the kinesthetic sensations without which human agency, as characterized by action, cannot exist [9]. Far more than a matter of locomotion and physically interacting with the world, movement embodies culture and carries social meaning. According to Noland, it may require movement practitioners, expertly attuned to "the performing body's proprioceptive, kinesthetic, even affective experience

*Research supported by University of New South Wales.

[1]Petra Gemeinboeck is Deputy Director of the Creative Robotics Lab, National Institute for Experimental Arts, Faculty of Art and Design, University of New South Wales petra@unsw.edu.au

[2]Rob Saunders is Senior Lecturer in the Design Lab, Faculty of Architecture, Design and Planning, University of Sydney rob.saunders@sydney.edu.au

of moving in prescribed ways", to understand to what extent movements and gestures "literally transform the bodies that perform them" [9].

As we will discuss in more detail below, at the core of our approach is the idea that, working with dancers, we can develop a deeper understanding of how to cultivate kinesthetic relations between humans and non-familiar, abstract robot bodies. Our research, in particular, explores the two concepts of corporeal literacy [10] and kinesthetic empathy [11], [12]. The concept of corporeal literacy affords a perspective that recognizes the novelty of new embodied experiences while understanding that our bodies are cultured to both perform and perceive "in some ways rather than others" [10]. The interdisciplinary concept of kinesthetic empathy explores the affective potential of movement and, with it, our innate capacity to kinesthetically perceive other bodies. It is "a movement across and between bodies, which, in an artistic situation, can have affective impact with potential to change modes of perception and ways of knowing" [11]. This powerful connection has also been explored in interactions with objects and environments [11], [12].

III. THE PERFORMATIVE BODY MAPPING METHOD

Our project addresses two core open questions in HRI: (1) how should a sociable robot behave, and (2) how should it appear? Doing so, the research tackles two fundamental assumptions, namely, that a robot should interact with humans 'naturally' (i.e. in a recognizably 'human' manner), and that this is best facilitated if it appears humanlike [1], [5]. Our hypothesis is that the expressive, dynamic and empathic qualities of movement can compensate for unfamiliar appearance in a robot's capacity to convey social agency. It is worthwhile noting here that, depending on the application, sociable robots may have very specific tasks that then define the main aspects of their appearance and behaviour. At this stage, our research responds to these questions and assumptions as a principle guiding our design and thinking about sociable robots and their affective potential. If movement is key to relating to and interpreting a robot, it could open up a much wider range of possible robot morphologies that are more cost-effective and adaptable to a changing social landscape than humanoid or pet-like morphologies.

At the center of our project is the development of the Performative Body Mapping (PBM) method for mediating between human and robot bodies. PBM places the robot's tactile–kinesthetic body and its movement at the center of meaning–making and eliciting affect to explore how non-humanlike robots can be taught to move and interact by human movement experts. The objective is for the robot to move according to its own abstract machine embodiment, whilst being 'encultured' with sensitivity for the nuances, rhythms and textures of human movements and gestures.

At the core of PBM is an autonomous robot with a non-humanlike, non-animal–like morphology with a capacity to learn how to move and a full–size, non-mechanical prototype of this robot body that serves as a 'costume' to be inhabited and animated by a dancer. The costume becomes the instrument for mapping between these two different bodies and their movement capacities, and for the robot to learn in a social, corporeal manner. It allows (1) for the dancer to learn embodying the machine body and to move with this unfamiliar body, and (2) for the robot to learn from the dancer by imitating the recorded movements from the dancer, disguised to mirror the robot's body.

A. Movement and Social Learning

In this project, the robot becomes the nonhuman apprentice of dancers who masquerade as the robot. Movement is at the center of social learninglearning from others. Dancers, for instance, 'sketch in dance' by "copying in real-time the movements of another dancer–the referent" [13]. The term 'sketching' also highlights that the copied movement will inevitably be a variation, due to differences in skill and body shape. In HRI, the most common type of social learning is imitation learning [14], [15], used to teach robots humanlike skills and behaviors. Not surprisingly, a robot learning to copy a human requires mapping between entirely different embodiments, including different body shapes, sensorimotor capabilities, and movement repertoires [14], referred to as the *correspondence problem* [15]. Rather than focusing on learning a specific task, this project will deploy imitation learning to capture the socially encoded, dynamic qualities of the dancers' movements. Using a costume that resembles the robot's body, a large amount of the morphological mapping between bodies is offloaded onto the dancer.

B. Computational Creativity

In addition to imitation learning, the robot will learn to explore and expand its movement abilities using a computational model of curiosity. The model is central to Computational Creativity, a sub-field of Artificial Intelligence that explicitly engages in questions of creativity. While its most common aim is to develop computational models of creative processes to study and support human creativity, it also makes possible the creation of autonomous systems capable of creative behaviors. Computational curiosity makes it feasible for a robot to become an embodied curious agent, intrinsically motivated to explore its own embodiment as well as its environment, whereby its reward is its learning as a result of this exploration [16]. This permits the development of artificial agents capable of proactively engaging with and learning to adapt to changing social scenarios [17].

IV. MACHINE MOVEMENT LABS: A PILOT STUDY

In the following we discuss the progress of an ongoing pilot study, entitled Machine Movement Labs (MML), which engages professional dancers in a series of ten workshops to experiment with abstract machine morphologies and their movement capacity. The focus at this early stage is on challenging assumptions and preconceptions with regards to possible shapes and movements, rather than designing a robot with a specific social purpose in mind. More specifically,

Fig. 1: Textile costume, inhabited by a dancer.

Fig. 2: Spiral tube costume (on the right) and textile tube with stiff plastic rings (on the left), both inhabited by a dancer.

MML aims to explore how far we can push the relationship between abstract, simple morphologies and their potential to move in expressive socially-encoded ways. This open, exploratory approach allows us to explore a wide range of possible forms, materials, movements, and dramaturgical scenarios without the constraint of the robot design needing to fulfill a specific requirement.

A. *Movement Strategy of BodyWeather*

The pilot study engages three dancers from the De Quincey Company, including its artistic director, choreographer and dancer Tess de Quincey. De Quincey Co trains in BodyWeather, a practice founded on Butoh dance, which draws from both eastern and western dance, sports training, martial arts and theatre practice. BodyWeather uses images for the body to work from "to shift it out of its known, habitual pathways" [18]. The images, i.e. of external forces and their trajectories like wind or a pressure cooker, allow the dancer to escape the habitual and 'find' movements they wouldn't do otherwise. The body essentially moves in response to these imagined forces, sometimes multiple forces at once. De Quincey says "the whole point about BodyWeather is to go beyond the biomechanics through images [that is] we recruit the biomechanics to find new, unfamiliar ways to move" [18]. BodyWeather's kinesthetic empathy revolves around the body's sensitivity to and connectedness with its environment. Thus, while still bound to the human and socially encoded, BodyWeather dancers are already experts in finding other, non-habitual movements.

The objective of the workshops then is to develop machine costumes that get activated by the dancers, whereas it is now the strange robot costume that provides an external force for them respond to and 'find' movements with. In the field of performance, the use of costumes to literally shape the performer's performance is not new. For his 1993 production of Tristan and Isolde, Heiner Mueller asked Yohji Yamamoto to design costumes for the singers "that would impede on the movement they are used to" [19].

B. *Experiments (in progress)*

Our starting criteria for the nonhuman morphology were: no obvious front and back, no head or face, no limb-like structures. Another enabling constraint for developing the costume is that it can be reconstructed as a mechanical prototype capable of moving on its own and able to imitate the dancers' movements to re-enact their sensitivity and connectedness.

In the first two labs we experimented with soft, textile structures, inhabited by the dancer, and surfaces with fiberglass rips to form architectural, parabolic shapes when bent, twisted and pulled by the dancers. However, the relatively soft shapes, requiring the dancer to give them a body [Fig. 1], turned out to be problematic: while the inhabitable forms could be richly animated with subtle movements, they were too reliant on the human body providing them with contour. The architecture-inspired, textile shapes, supported by elastic rips, produced interesting evolutions of geometric volumes but didn't allow for smaller, subtler expressions. It also seemed likely that the mechanical prototype would require large-scale mechanisms, external to the robot's body, to create the expressive shapes produced by the dancers.

Hence, for the third and fourth labs, we decided to work with simple costumes that formed a body on their own based on their material structure, but that could be transformed through the movements of a dancer inhabiting the structure. The first series of experiments also made clear that the simpler the shape, the more we could focus on the dancer's transformation of the body and its meaning, without being distracted by too many potentially moving parts. We experimented with a range of shapes and materials, and in the following will take a closer look at our experimentation with two of the most interesting 'objects'.

1) Vertical Tube: The first 'object' we discuss is a spiral tube, 190cm high with a 50cm diameter, coated with a strong nylon fabric [Fig. 2]. The tube acted as a relatively stiff spring that, by default, stood upright on its own, however

Fig. 3: Spiral tube costume, showing multiple articulated planes pivoted along its core.

Fig. 4: Box costume, tilted onto one edge.

could be compressed to a height of only 30cm.

At first, the dancer physically engaged with the object and its materiality, exploring, testing, seeing and feeling what it can do and learning to negotiate its structural integrity. This included learning to apply less force to move with the force provided by the structure, rather than moving the structure. Soon the dancer (inside) began to improvise with the object, exploring different movement shapes, rhythms and their expressive qualities based on the feedback they received both from the object itself and the observers (a choreographer, another dancer, and the authors). The tube started swaying, barely noticeable and then with force, contracted in different parts, bent, crunched and twisted. The helical structure allowed for simultaneous contractions and expansions along the vertical axis of the object, as well as being bent as to produce multiple differently articulated planes pivoted along its core [Fig. 3]. Both, flexible and responsive, it enabled the dancers to effectively express themselves through tiny movements, a small swivel, teeter, twitch, or a crinkle here and there. Together with bigger gestures, either sustained or suddenly brought to a halt, this produced a very rich and affective performance.

We also built a 200cm tube out of stiff plastic rings, strapped into an elastic scaffold and covered with a textile tube [Fig. 2], which produced a very different movement quality from the spiral tube. The springy spiral-shaped scaffolding proved more interesting, however, as it provided both a strong and flexible structural integrity. With an innate force to return to its default shape, it also allowed the dancer to apply force to transform the structure and, with it, its shape and expression. This play of tension proved to be very popular with the dancers.

2) Box: We also experimented with perhaps the most obvious simple, abstract form, yet not the most apparent in terms of its evocative capacity—the box. The dancers were asked to inhabit and bring out the expressive potential of a 150x55x45cm cardboard box [Fig. 4]. The stiff box shape got immediately interesting when it balanced precariously on edge or the dancer (inside) tipped it onto one corner. Tilting the box allowed for it to loose its stability and gravity and, with it, its ‘boxiness’, and turned it into a strange, potentially fragile box-shaped character. To see the box move, sway and teeter as the dancers applied different strengths of force and subtle variations of rhythm affirmed our belief that it is interesting and productive to have an expert dancer inhabit the strange body, rather than simulate the behaviors using a software-based model.

V. DISCUSSION OF EXPERIMENTS

Not surprisingly, many of the affective qualities of movement, particularly with respect to their dynamic expression don’t lend themselves to be captured in words, they exceed linguistic signification [20]. The affective power of movement, how it activates our body, happens before the cognitive process of language [21]. The empathic potential of this kinesthetic communication [21], [22] is at the heart of our Performative Body Mapping approach as it aims to unlock the social potential of abstract non-anthropomorphic machines.

In one experiment, for example, we asked the dancer inside the cardboard box to attempt to express the abstract imagery of the question mark glyph. When the dancer responded to the prompt, to us observers, the box took on a posture, overlaying notions of hesitation, inquiry and alertness. To be precise, however, rather than a posture, we had experienced the ‘finding’ of a movement, starting off with a hesitating twist that accelerated upwards, with a slight inclination, before it came to a sudden halt. This was not a visual representation of a question mark, but rather the bodily processing of what a question mark does, thus enabling us to feel the affective charge embedded in the box’s gesture. Movement quality in dance concerns its dynamic, affective and expressive characteristics and always involves intentionality “articulated in and through” the movements. “Intentionality here does not refer to some kind of idea pre-existing the execution of the movement but rather describes the directionality and the distribution of intensity embodied within the movement and crucial to the quality" [23].

A. Animation vs. Performance

Parallel to performance, animation has a long and rich history of animating familiar but life-less shapes and objects and imbuing them with behaviors, disposition and intent. Similarly to our experiments, these objects can be surprisingly simple, as demonstrated in the classic example of Chuck Jones's *The Dot and the Line* (1965) or John Lasseter's *Luxo Jr.* (1986), which features two desk lamp characters.

These animations are so successful because they commonly aim to anthropomorphize the object, imbuing it with a human character. Often, animators refer to the "personality of a character", conveyed through emotion, whereas the emotion is defined by the story. The 'readability' of the characters' actions relies on timing but also staging and anticipation. For example, "[i]n Luxo Jr., it was very important that the audience was looking in the right place at the right time" [24].

While animation techniques can be a very useful tool to develop a robot's movements, they have evolved in a very different medium, defined by its visual focus and the emotional impact of story telling. In contrast, robots are embodied objects, able to share and interact with our social environment in bodily ways. We can thus rely more on our kinesthetic sensitivities, without the need for the robot to be perceived as a humanized character. Our research aims to push this notion by investigating how we can utilize and train a machine's kinesthetic abilities for them to be readable by humans, without imbuing the machine with human personality. In particular, this pilot study investigates the affective kinesthetic abilities of different morphologies and materials.

Another important difference between animation and dance is in the aforementioned movement quality. Animation is about controlling the movement of a character, rather than 'finding' a movement or gesture and articulating intentionality in and through the dancer's body. Most computer animation systems use key frames to animate a character's movements. The animator defines poses, whose values are stored in key frames for the articulation controls of the character model, and the software interpolates between the values of these poses to render the full movement sequence [24].

Movement here doesn't emerge from the dancer embodying directionality and distribution of intensity but from externally defined, static poses, whose in-between is numerically interpolated rather than sustained, intensified or re-directed. We can find an example in MIT's Interactive Theater, which deploys anemone-like robots capable of movements and behaviors that are ostensibly readily apparent to the audience. As the theatre contains no dialogue, MIT's approach to animating the robot 'actors' was to transition between a set list of poses [25], rather than movements per se. Yet, much of what movement quality does happens in-between and gets lost in an approach, which favors positionality over movement [26].

B. Concluding Reflections

This research into the potential of dancers enacting and training abstract, non-anthropomorphic robots is still at an early stage of development. However, after only four workshops of our Machine Movement pilot study, we have been able to experience three professional dancers moving, activating and transforming very simple objects, which, in turn, were able to trigger a range of affects and empathic responses. We are yet to develop autonomously moving mechanical prototypes and evaluate their kinesthetic performance in public settings to involve non-expert participants. However, already at this early stage, as observers we found ourselves responding empathically to moving objects as abstract as a featureless tube or as stiff as a box [Fig. 5]. They caused us to unwillingly lean our bodies with them, feel their subtle twitches, and to tense up when they threatened to fall. Based on these experiments, we found that kinesthetic empathy is not only a matter of us projecting onto the robot but also is a force that the moving robot body, despite it being radically different to our body, can actively transfer to us—make us feel.

The success of these first workshops attests to the potential of movement to turn an abstract object into an expressive, empathy–inducing social actor. While we can't speak to the costume's potential in the robot's imitation learning process yet, we found that the costume plays a vital role in supporting the dancers to map between the two bodies and to develop an embodied understanding of what the robot body can do. Future workshops will focus on the development of a high-fidelity costume in collaboration with a costume designer to build up a repertoire of encultured, meaningful movements and gestures from within the robot's body and with its specific material context. The findings will support the next stage of the research, the development of PBM, whose first stage will be the development of a fully articulated costume that can form the basis for modelling and building a robot prototype.

Interestingly, engaging with dancers in this Creative Robotics project not only provides us with insights into kinesthetic empathy and the material affect of movement. The dancers' approach and its deep entanglement of biomechanics, and socio-cultural codes and empathy towards other, material agencies also expand our views of potential human-robot configurations. We believe that this research into the affective kinesthetic potential of abstract robot morphologies can not only lead to a novel approach for socializing abstract, non-anthropomorphic robots but can also provide a fertile ground for exploring new, culturally significant human-robot interactions.

ACKNOWLEDGMENT

The pilot study discussed in this paper is funded through a University of New South Wales (UNSW) Research Grant.

Fig. 5: Interaction with spiral tube (inhabited by dancer).

References

[1] K. Dautenhahn, "Human–robot interaction," in *Encyclopedia of Human-Computer Interaction*, 2nd ed., M. Soegaard and R. F. Dam, Eds. Aarhus: Interaction Design Foundation, 2013.

[2] N. Sharkey and A. Sharkey, "Living with robots," in *Close Engagements With Artificial Companions*, Y. Wilks, Ed. Amsterdam: John Benjamins, 2010.

[3] A. Weiss and M. Tscheligi, "Evaluating social acceptance and societal impact of robots," *International Journal of Social Robotics*, vol. 2, no. 4, pp. 345–6, 2010.

[4] S. Lechevalier, J. Nishimura, and C. Storz, "Diversity in patterns of industry evolution," in *Proceedings of the 25th Annual EAEPE Conference*, 2013.

[5] R. Pfeifer and J. Bongard, *How The Body Shapes The Way We Think—A New View Of Intelligence*. Cambridge: MIT Press, 2007.

[6] C. Castaneda and L. Suchman, "Robot visions," *Social Studies of Science*, vol. 44, no. 3, pp. 315–341, 2013.

[7] C. Breazeal, *Designing Sociable Robots*. Cambridge: MIT Press, 2002.

[8] S. Penny, "Embodied cultural agents: at the intersection of art, robotics and cognitive science," in *Socially Intelligent Agents: Papers From The AAAI Fall Symposium*, ser. Technical Report FS-97-02, MIT. AAAI Press, 1997, pp. 103–105. [Online]. Available: http://simonpenny.net/texts/embodied.html

[9] C. Noland, *Agency And Embodiment*. Harvard University Press, 2009.

[10] M. Bleeker, "Corporeal literacy: New modes of embodied interaction in digital culture," in *Mapping Intermediality in Performance*, S. Bay-Cheng, C. Kattenbelt, A. Lavender, and R. Nelson, Eds. Amsterdam University Press, 2010, pp. 38–43.

[11] D. Reynolds, "Kinesthetic engagement: Embodied responses and intersubjectivity: Introduction," in *Kinesthetic empathy in creative and cultural practices*, D. Reynolds and M. Reason, Eds. Intellect Books, 2012, pp. 87–90.

[12] J. McKinney, "Empathy and exchange: Audience experiences of scenography," in *Kinesthetic empathy in creative and cultural practices*, D. Reynolds and M. Reason, Eds. Intellect Books, 2012, pp. 219–236.

[13] D. Kirsh, "Running it through the body," in *Proceedings of the 34th Annual Cognitive Science Society*, 2012, pp. 593–598.

[14] K. Dautenhahn, C. L. Nehaniv, and A. Alissandrakis, "Learning by experience from others," in *Adaptivity and Learning*, R. Kühn, R. Menzel, W. Menzel, U. Ratsch, M. Richter, and I. Stamatescu, Eds. Berlin: Springer, 2003, pp. 217–421.

[15] A. Billard, S. Calinon, R. Dillmann, and S. Schaal, "Robot programming by demonstration," in *Springer Handbook of Robotics*. Berlin: Springer, 2008, pp. 1371–94.

[16] R. Saunders, "Towards autonomous creative systems: A computational approach," *Cognitive Computation*, vol. 4, no. 3, pp. 216–225, 2012.

[17] P. Gemeinboeck and R. Saunders, "Creative machine performance: Computational creativity and robotic art," in *Proceedings of the 4th International Conference on Computational Creativity*, M. Maher, T. Veale, R. Saunders, and O. Bown, Eds. Australia: University of Sydney, 2013, pp. 215–219.

[18] T. de Quincey, "Unpublished," 26 March 2015, video recording.

[19] S. Suschke, *Müller macht Theater: Zehn Inszenierungen und ein Epilog*. Berlin: Theater der Zeit, 2003.

[20] E. Manning, *Politics of Touch: Sense, Movement, Sovereignty*. Minneapolis: University of Minnesota Press, 2007.

[21] D. Reynolds, "Kinesthetic empathy and the dance's body: From emotion to affect," in *Kinesthetic empathy in creative and cultural practices*, D. Reynolds and M. Reason, Eds. Intellect Books, 2012, pp. 121–136.

[22] S. L. Foster, *Choreographing empathy: Kinesthesia in performance*. Routledge, 2010.

[23] M. Bleeker, "What if this were an archive?" *RTRSRCH Journal*, vol. 2, no. 2, pp. 2–5, 2010.

[24] J. Lasseter, "Tricks to animating characters with a computer," *ACM Siggraph Computer Graphics*, vol. 35, no. 2, pp. 45–47, 2001.

[25] C. Breazeal, A. Brooks, J. Gray, M. Hancher, J. McBean, D. Stiehl, and J. Strickon, "Interactive theatre," *COMMUNICATIONS OF THE ACM*, vol. 46, no. 7, 2003.

[26] M. Bleeker, "Martin, massumi, and the matrix," in *Anatomy Live: Performance and the Operating Theatre*, M. Bleeker, Ed. Amsterdam University Press, 2008, pp. 151–164.