Performative Body Mapping for Designing Expressive Robots

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Abstract

This paper explores the challenges and opportunities of skill acquisition for creative robotics, where the required knowledge is highly embodied. We present Performative Body Mapping (PBM) as a suitable methodology for harnessing the movement expertise of trained professionals. We describe the results from a series of workshops to design and train a non-humanlike robot through embodied explorations of possible forms and movements. In addition to the PBM methodology, we propose a method for evaluating expressive robot performers by adapting the Godspeed questionnaire, commonly used in social robotics, which gathers audience feedback on the perception of five properties of interest in creative robotics; anthropomorphism, affective agency, intelligibility, perceived intelligence, and perceived originality. We report on some preliminary results from a first audience study of an early prototype of our robot and discuss the implications for our research.

Introduction

The field of creative robotics lies at the intersection of computational creativity and social robotics, it is concerned with both the development of embodied creative systems and the application of creative practices to further human-robot interaction (Koh et al. 2016; Gemeinboeck 2017). The project described here straddles these approaches by exploring the role that movement experts, e.g., dancers and choreographers, can play in the design and training of non-anthropomorphic robots and the ability for trained robots to improvise novel movements. Using the design of a non-anthropomorphic robot as a platform, we address questions of skill acquisition across different embodiments, i.e., human and robotic, in a domain where knowledge is tacit, unstructured and resistant to formalising due to its embodied nature (Csikszentmihalyi 1988). Our focus in this paper is on the capture and reproduction of improvised movements from experts, the engagement of an audience through movement, and the perception of agency when a robot performs.

Embodied, Enactive and Distributed Creativity

Computational creativity, like many other scientific fields of creativity research, has tended to emphasise the thinking over making, i.e., ideation over the craft-like activities that support creativity (Glăveanu 2017). Unsurprisingly for a subfield of AI, computational creativity draws extensively on representational theories of creativity from cognitive science, e.g., the highly influential work of Boden (1990; 1994a; 1994b). Malafouris argues, however, that representational theories of creativity, like those of Boden, tend "to reduce the rich ecology of the creative space to some internalised 'problem space' that can be mentally manipulated and transformed to produce some creative result" (Malafouris 2014, p.145). Where the 'rich ecology of the creative space' that Malafouris laments is composed of the material, technical, social and cultural milieu that human creativity both exists within and continuously transforms.

Theories of embodied, enacted, and distributed cognition provide alternative perspectives on notions of creativity (Varela, Thompson, and Rosch 1991; Lakoff and Johnson 1999; Clark 1996; Noë 2004). Some have begun to explore approaches to computational creativity based on enactive cognition, e.g., see Takala (2015). Guckelsberger, Salge, and Colton (2017) argue that *enactive AI* (Froese and Ziemke 2009) provides the most suitable framework for developing autonomous creative systems, while conceding that such systems may not be recognised as creative due to the *embodiment distance* between computational system and human audiences. The challenge of bridging the embodiment distance is significant but building computational systems that are grounded in, and can engage with, the ecology that human creativity constructs and relies upon, may be key.

The overarching aim of the our project is to explore pragmatic methods for producing situated, embodied actors that balance the needs of grounding and evolving creative skills based on its (1) material, social and cultural situation, and (2) machinic embodiment. Our approach relies on working closely with experts, who provide the material, social and cultural situation that inform the design and training of a robot. Contemporary dance deliberately and systematically cultivates movement for its own sake (Stevens and McKechnie 2005, p.243), making it an ideal domain of expertise to draw upon, especially, given its practitioners willingness to engage with questions related to the bridging of human and non-human forms of embodiments through movement.

This paper presents a methodology for the design of creative robotics that focuses on the analysis and design of movements based on the kinaesthetic expertise of choreographers and dancers. We begin by exploring the perception of agency based on the movement of non-anthropomorphic robots within a specific social context by examining notions of agency in robotic art and performance. We look at the challenges faced in robotics of producing movements that convey affect, in particular the *correspondence problem*, i.e., the mapping of movement between humans and robots with different embodiments. We propose a methodology, called Performance Body Mapping (PBM), as an approach for bridging between different embodiments by leveraging the ability of movement experts, e.g., dancers, to inhabit and animate non-human forms. To study the capacity for our cube-like robot to elicit affect, we have developed an instrument for conducting audience surveys, based on the Godspeed questionnaire, widely used in social robotics. We report on a first audience study of an early prototype of a cube-like robot, and discuss implications for future work.

Background

Researchers in social robotics often rely on an underlying assumption that anthropomorphic or zoomorphic appearance assists the formation of meaningful connection between humans and robots (Duffy 2003). A number of projects have explored different machine learning methods for teaching humanoid robots how to move based on the recording of humans dancing (Ros, Baroni, and Demiris 2014; Özen, Tükel, and Dimirovski 2017) and recently the creation of novel dances for humanoid robots based on motion capture data has been explored (Augello et al. 2016; 2017), as well as, the potential for co-creativity with humanoid robots (Fitzgerald, Goel, and Thomaz 2017).

Building robots in our own image, however, deliberately blurs the distinction between organic and mechanical bodies, cognition and computation, to elicit human investment based on superficial and often false social cues. Studies in Human-Robot Interaction (HRI) illustrate the difficulty of the underlying assumption, by highlighting the frustration and disappointment experienced by humans when the social capabilities of a robot fall short of their expectations based on its appearance (Dautenhahn 2013). Non-anthropomorphic robots, on the other hand, permit human–machine encounters that aren't restricted by "preconceptions, expectations or anthropomorphic projections...before any interactions have occurred" (Dautenhahn 2013).

The Perception of Animacy

The challenge for developing non-anthropomorphic robots for performance is to design the affective potential that is inherent in movement such as to elicit desired responses in the viewer. The potential for simple movements of geometric shapes to be perceived to indicate high-level properties such as causality and animacy has been studied for over 80 years (Scholl and Tremoulet 2000). The phenomenon first documented by Michotte (1963) and Heider and Simmel (1944) is often illustrated with Michotte's "launching effect" where one small object (A) moves until it is adjacent to another item (B), at which point A stops and B starts moving. Different spatial and temporal relationships between the movements of A and B, result in different causal relations being perceived by viewers, regardless of cultural background.

Beyond causality, the principle of animacy also appears to be perceived in the movements of abstract shapes. Studies of perceptual animacy typically involve the perception of a simple shape being alive and often gives rise to the perception of goals, e.g., 'trying to get over here', or mental states, e.g., 'wanting to get over there' (Heider and Simmel 1944). Recently, building on theories of the perception of animacy, Levillain and Zibetti (2017) proposed a theoretical framework for understanding the agency ascribed to 'behavioural objects', such as robotic artworks.

Artists have long understood the power of movement in non-anthropomorphic machines to elicit audience responses. For example, Simon Penny created *Petit Mal*, an autonomous wheeled robot that would interact with gallery visitors, to produce 'behaviour which was neither anthropomorphic nor zoomorphic, but which was unique to its physical and electronic nature' (Penny 2000). Experiments with choreographing robots can be traced back to 1973 and the pioneering work of Margo Apostolos (Apostolos 1990). A number of choreographers have experimented with robots in their performances since, including Pablo Ventura, Thomas Freudlich and Huang Yi. In many of these works, the movement expertise of the choreographer transforms non-anthropomorphic robots into expressive bodies that can be read by human audiences. They have relied, however, on the ability of the choreographer to program a robot to reproduce movements exactly as instructed.

The Correspondence Problem

In HRI, a range of methods have been developed to specify a robot's movements, from a programmer "imagining a movement executed by the robot's body" to produce a sequence of instructions (Alac 2009), to *programming by demonstration* (Billard et al. 2008) where the movements of a human are captured for a robot to learn to imitate. The former is challenging because it requires the programmer to translate the (imagined) movement into a precise algorithmic representation. The challenge of the latter approach is the translation between different physical embodiments, known as the *correspondence problem*, i.e., the problem of mapping between a human body and a robot with a different morphology, movement repertoire and sensorimotor capabilities (Dautenhahn, Nehaniv, and Alissandrakis 2003).

To overcome the correspondence problem, researchers construct complex mappings between the movements of a human and the corresponding movements of a robot. In non-anthropomorphic robots this is particularly challenging and often results in engineers making a series of assumptions about the mapping that may or may not be informed by expertise in movement. Despite this challenge, programming by demonstration or *demonstration learning* is a popular approach, because it makes it possible for robots to learn behaviours and skills without every action they perform needing to be explicitly and painstakingly programmed (Dautenhahn, Nehaniv, and Alissandrakis 2003). The following section discusses Performative Body Mapping (PBM), which builds on the core ideas of demonstration learning but delegates much of the difficult morphological mapping to movement experts (Gemeinboeck and Saunders 2014).

Methodology

Performative Body Mapping has been developed to harness the ability of performers to map between different body morphologies. It is comprised of four stages; *bodying*, *grounding*, *imitation*, and *improvisation*. Here we focus on the first stage, which includes form finding, motion capture and the prototype construction, for more information on the complete process see Gemeinboeck and Saunders (2014). Bodying is concerned with the design of a robot's form in tandem with its movement capabilities. Often the design of a robot's physical form is dominated by functional requirements that manifest humanistic assumptions about the ways a robot can or should move (Ziemke 2016). Even in social robotics, where interaction with humans is paramount, movement is often a secondary concern to appearance. In contrast, the PBM requires that form and movement be designed in concert using an iterative approach.

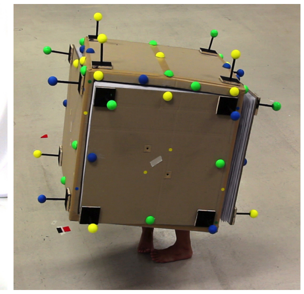
Designing through Movement

To iteratively 'find' and refine the robot's form, PBM involves the use of a wearable object, or 'costume', resembling a possible robot form, that can be inhabited and animated by a dancer. Costumes have been used by choreographers and dramaturgists to co-shape and transform dancers' movements, see Schlemmer's Bauhaustänze in Birringer (2013) and Heiner Müller's Tristan and Isolde in Suschke (2003). In PBM, involving the bodily imagination (DeLahunta, Clarke, and Barnard 2012) and kinesthetic empathy (Reynolds 2012) of dancers, allows the costume to become an efficient instrument for mapping between very different embodiments. In particular, the use of a costume; (1) provides dancers with an embodied insight into the material and morphological characteristics of a robot, (2) supports the development of a repertoire of movements and movement qualities, and (3) allows movement data to be captured that a robot can learn from, with little or no translation. The shape of the costume was not fixed during this stage and was redesigned in response to the movements and bodily relations the dancers could activate. The dancer's movements, in turn, were co-shaped by the affordances of the costume, so that distinct movement qualities could emerge from a material interdependence between the two.

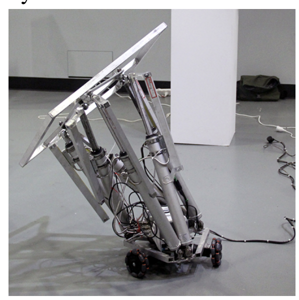
We collaborated with the De Quincey Company[1] and its artistic director and choreographer Tess de Quincey. The De Quincey Company practice *BodyWeather*, which draws from both Eastern and Western dance traditions, sports training, martial arts and theatre practices. BodyWeather practitioners are well attuned to the task of bodily thinking through 'other' body-forms, in Tess de Quincey's words, "the whole point about BodyWeather is to go beyond the biomechanics through images, [that is] we recruit the biomechanics to find ways to move, which are not normally positioned as human movements" (De Quincey 2015).

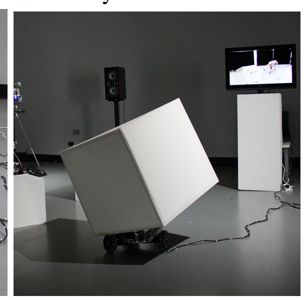
During the early movement studies the dancers inhabited a wide range of materials and objects to narrow the scope of possible robot forms. Our goal was to find forms that foregrounded movement over appearance and avoided analogies

[1]http://dequinceyco.net



(a) Cardboard box inhabited by Linda Luke. (b) Costume with markers inhabited by Kirsten Packham.





(c) Robot motion testing. (d) Robot as 'plinth'.

Figure 1: Evolution from costume (a,b) to prototype (c,d). Photos © Petra Gemeinboeck

with living 'things'. Enabling constraints for the exploration included that the form should be without a front or back, head or face, or limb-like structures, and that it should be technically possible to construct robot capable of imitating the costume's movements. This process quickly filtered out forms that, when activated, either relied too heavily on the dancer's body, would be impossible to construct, or were perceived as relying too heavily on its novel appearance.

As dancers experimented with geometric forms, it became apparent that the simpler the form, the more our focus shifted towards the movement of the costume. Ultimately, this lead to using the most obvious abstract form, yet not the most apparent in terms of its evocative capacity—a box. The dancers started by inhabiting a 150x55x45cm cardboard box, see Figure 1a. Iterations on the design reduced the height of the box until it became a cube, further distancing it from human proportions and focussing attention on the movement. The dancers noted that the box became particularly interesting when it balanced precariously on an edge or was tipped onto one corner. Confronting our notions of weight and gravity through tilting, swaying and teetering allowed for the box to lose its stability and, with it, its 'boxiness'. The ability to reproduce these types of movements became a primary goal for the design of the robot prototype.

Motion Capture and Machine Learning

The motion of the activated costume was tracked to (1) inform the model for a mechanical prototype that resembles the costume and its capacities to move as closely as possible, and (2) provide data for the robot to learn from. The cube's movements were captured using a video-based motion tracking system by attaching coloured targets to the cube's surfaces, as can be seen in Figure 1b. Activated by a dancer, the movements of the cube were recorded using two HD cameras arranged to ensure that all sides of the cube, except the base, could be seen at all times. The video recordings were analysed using custom motion tracking software and the resulting tracked 3D points were used to extract the cube's position (x, y, z) and the orientation (yaw, pitch, roll).

In total, we captured approx. 15 hours of movement data from three dancers over a period of five days. From this dataset we initially extracted five hours of motion capture data that represented the types of movement sequences that we wanted to test in the Re/Pair exhibition, see Results. To reduce ambiguity in the interpretation of the captured data, an inverse kinematic model of the robot was developed based on two joints, one to represent the (x, y, z) position of the base of the robot and one to represent the (yaw, pitch, roll) orientation of the top, relative to the base. The motion capture data was processed using the inverse kinematic model to derive the position and orientation of the two joints, the resulting data set consisted of 360,000 joint positions.

We applied a mixture density LSTM network, previously used to successfully synthesise handwriting (Graves 2014) and choreography (Crnkovic-Friis and Crnkovic-Friis 2016). The inputs and outputs of the neural network were 6-dimensional tensors (x, y, z, yaw, pitch, roll) and the architecture consisted of 3 hidden layers of 512 neurons, a total of approx. 5.3M weights. The synthesised movement sequences were subjectively assessed by experts against the original performances of the dancers before adding them to a catalogue of possible movement sequences. In addition to expanding the repertoire of movements, the aim at this stage was to produce a baseline result for future comparisons with the 'grounded' approach outlined later, see Discussion.

Robot Prototype

The video and motion capture data were analysed to determine the degrees of freedom required to replicate the movements of the dancers. To achieve these requirements, the design of the robot combines two main subcomponents; (1) a 'Kiwi Drive'—an omni-directional wheeled base (Pin and Killough 1994) that provides 3 degrees of freedom (x, y, yaw), and (2) a 'Stewart Platform' (Stewart 1965) that provides 6 degrees of freedom relative to the base (x, y, z, yaw, pitch, roll). The former allows the robot to turn on the spot and move over the ground plane without first having to turn to face the direction of travel. The latter allows the robot to shift, tilt and rotate by smaller amounts, relative to the base.

The use of omnidirectional wheels ensures that the robot design maintains an important initial criteria of the movement studies because the resulting robot has no front or back, a necessary condition for replicating some of the movement sequences recorded where the dancer quickly changed the direction of travel. The Stewart platform provides the flexibility necessary to reproduce the range of angles recorded for pan, tilt and yaw as well as the speed to produce some of the smaller, sudden or subtle movements produced by the dancers. Figure 1c is a photo of the robot prototype without its outer cover being tested for range of movement.

The robot prototype was shown in the Re/Pair exhibition, part of the Big Anxiety Festival[2] at the University of New South Wales, Sydney, Australia. The Re/Pair exhibition brought together five robotic works in different stages of development. Figure 1d shows the completed robot with its outer cover that was designed to mimic the plinths used in the gallery setting, while also maintaining the shape of the original costume. The main goal for exhibiting the robot at this early stage was to survey audience members regarding their perception of the robot's agency and originality.

Evaluation of Affective Agency

Several methods have been used to evaluate the perceptions and impressions of social robots (Walters et al. 2013; Vlachos and Scharfe 2015). The Godspeed Questionnaire Series (GQS) is one of the most frequently used and influential tools for evaluating social robots (Bartneck, Croft, and Kulic 2009). The GQS addresses five key concepts: *Anthropomorphism*, *Animacy*, *Likeability*, *Perceived Intelligence*, and *Perceived Safety*. These concepts are particularly significant for social robotics where the safety and the ability of users to relate to a robot are of paramount concern.

For a performance based on the movement expertise of contemporary dancers our primary concern is whether the "[m]ovement material that is created, performed, or observed engages motor and kinaesthetic processes and leads to cognitive and affective reactions" (Stevens and McKechnie 2005, p.1570). Consequently, we developed a questionnaire based on the GQS to address key concepts more appropriate to the evaluation of our research questions, i.e., *Anthropomorphism*, *Affective Agency*, *Intelligibility*, *Perceived Intelligence* and *Perceived Originality*. The choice of these concepts was driven by our desire to understand how the movement of the robot prototype is perceived in terms of affect, and how this perception is related to the perception of anthropomorphic qualities. The other perceptions we were interested in relate to computational creativity, such as, the perceived intelligence and originality, as well as, the intelligibility of the robot's movements.

To confirm the internal consistency and the validity of our data, an internal reliability test was conducted. The results showed that the *Anthropomorphism* and *Affective Agency* indices had the highest reliability with a Cronbach's alpha of 0.84 and 0.82 respectively, followed by *Intelligibility* and *Perceived Intelligence* indices with a Cronbach's alpha of 0.75 and 0.74 respectively, and *Perceived Originality* had a Cronbach's alpha of 0.70, meeting the standard 0.70 threshold (Nunnally 1978).

Results

During the Re/Pair exhibition we collected a total of 48 questionnaires. The majority of the participants were between 21 and 55 years old. As with other "in the wild" experiments, context plays an important role in evaluation, consequently we sought to maintain the gallery context until

[2]https://www.thebiganxiety.org/events/repair/

participants were asked to fill in a questionnaire. Participants were not made aware of the research components of this study ahead of time, rather, they were asked to fill out a questionnaire only after being observed interacting with the robot. The majority of the participants (81%) reported that they engaged with the robot for more than 2 minutes, and half the participants reported that they engaged with the robot for more than 5 minutes.

Participants were given a list of possible reasons for what attracted them to engage with the robot in the gallery, from which they could choose multiple items. The responses were grouped into 5 categories: the sound of the robot, the appearance of the robot, the movement of the robot, the project description, and other. 36 (75%) of the participants responded that the robot's movement attracted them, 23 (48%) reported that the project description drew their attention, while 17 (35%) cited the appearance of the robot and 5 (10%) the sound the robot made. 10 (21%) of the participants gave other reasons for being attracted to the robot.

Figure 2 illustrates the questionnaire responses as box plots of the participants' ratings for each of the five indices, using the Tukey convention with the median values and the box indicating the first and third quartiles, the whiskers indicate the lowest and highest datum within 1.5 IQR (interquartile range) of the lower and upper quartile, outliers are indicated with crosses (Tukey 1977). Detailed analysis of the results of the questionnaire is depicted in Table 1 and shows that the robot received high ratings for *Affective Agency* ($M = 3.43$), moderately high ratings for *Perceived Intelligence* ($M = 3.06$) and *Perceived Originality* ($M = 2.95$), moderately low ratings for *Anthropomorphism* ($M = 2.02$), and varied responses for *Intelligibility* ($M = 2.56, SD = 1.21$).

Discussion

The goal of our first evaluation was to examine whether the 'bodying' stage of the PBM methodology would permit movement experts to design and train a non-humanlike robot to perform in ways that are expressive and engaging. The results indicate that the primary reason for people to engage with the robot was movement ($n = 36$), significantly more than appearance ($n = 17$), while audience members were clear that the robot was non-anthropomorphic ($M = 2.02$). While this is not surprising, given the simple appearance of the robot and the environment it was placed within, it suggests that movements like those performed by the robot can be a significant attractor, without the need for an overtly anthropomorphic appearance. This aligns with Levillain and Zibetti's observations of the attraction of robotic artworks as 'behavioural objects' (2017), although it may also suggest an attraction to the novelty of the object given that, despite the robot being unable to create significantly novel movements, participants rated the perceived originality of the robot relatively high ($M = 2.95$). The effect of novelty is something that we will investigate further in future studies when we explore how the ability to improvise novel movements affects audience perception.

Participants rated the ability of the robot to produce affect highly ($M = 3.43$), suggesting that the robot was able to sufficiently reproduce some of the qualities of the dancers' movements to elicit an affective response. They also perceived the robot to have higher intelligence than we might have expected ($M = 3.06$) given that this early prototype could not interact with visitors, this may have been a consequence of the unexpected complexity and nuance of the movements. We observed, however, that visitors often adapted their own behaviour to accommodate the robot and this may explain a higher than expected perception of intelligence. In future studies we will explore how the perception of intelligence is affected as we add the ability for it to sense its environment through the addition of sensors.

Future Work

This study involved an early robot prototype and has investigated only the first stage of PBM, i.e., bodying. The ability of the robot to engage gallery visitors through movement and the audience perceptions of affective agency and intelligence suggest that, even at this early stage, PBM supports the ability of movement experts to embody a non-anthropomorphic form and map from their embodiment to that of the robot. The remaining stages in the PBM methodology are concerned with the *grounding* of the robot's movement, *imitation* through sequence learning, and *improvisation* using intrinsically motivated learning.

The motor controller used in the robot prototype decomposes the problem along functional lines between the Kiwi Drive and the Stewart Platform. The *grounding* stage will use 'active motor babbling' (Saegusa et al. 2009; Baranes and Oudeyer 2013) to derive a controller that bidirectionally maps between the motor and sensor data of the robot. The resulting forward and inverse mappings will provide a richer model for the application of sequence learning (Graves 2014; Crnkovic-Friis and Crnkovic-Friis 2016) in the *imitation* stage to take advantage of redundancy in the movement capabilities of the two subcomponents, i.e., for small movements in x, y and yaw, and the spatiotemporal context within movement sequences, e.g., to anticipate future movements. Finally, the *improvisation* stage will use intrinsically motivated learning (Baranes and Oudeyer 2010) to expand the repertoire of movements, beyond the generalisations produced by the *imitation* stage based on the grounded sensorimotor mapping.

The movement centric approach to the design and training of a non-anthropomorphic robot, which is at the core of PBM, provides another method for tackling the *correspondence problem* frequently encountered in demonstration learning. We will continue to apply PBM to robots' performance in theatrical, artistic and social situations but future applications of PBM could include the acquisition of other embodied skills that support creative activity across a range of domains, e.g., traditional crafts.

Keith Sawyer distinguishes between the study of 'product creativity' and 'performance creativity'; where the former studies what remains after the creative act, e.g., scores, paintings, sculptures, while in the latter "the creative process and the resulting product are co-occurring" (Sawyer 1998, p.11). Much of computational creativity, like psychology, has focussed on product creativity but Sawyer observes

Table 1: Analysis of Questionnaire Responses

Attribution	Attributes	Mean (M)	Standard Deviation (SD)
Anthropomorphism	Mechanical — Organic	2.13	1.18
α = 0.84	Machine-like — Human-like	2.07	1.16
M = 2.02	Non-human — Human	1.75	1.24
SD = 1.21	Artificial — Natural	1.79	1.23
	Machine — Performer	2.36	1.19
Affective Agency	Bland — Expressive	3.51	0.81
α = 0.82	Forgettable — Memorable	3.34	1.08
M = 3.43	Dull — Evocative	3.64	0.93
SD = 0.97	Trivial — Meaningful	3.03	0.99
	Boring — Engaging	3.63	0.94
Intelligibility	Unintelligible — Intelligible	3.14	0.96
α = 0.75	Enigmatic — Understandable	1.95	1.03
M = 2.56	Opaque — Readable	2.51	1.19
SD = 1.21	Ambiguous — Obvious	1.81	1.04
	Unconvincing — Believable	3.39	0.98
Perceived Intelligence	Incompetent — Competent	2.94	1.17
α = 0.74	Unintelligent — Intelligent	2.91	1.07
M = 3.06	Aimless — Deliberate	2.92	1.15
SD = 1.14	Indifferent — Curious	3.61	0.95
	Scripted — Imaginative	2.94	1.21
Perceived Originality	Simple — Puzzling	2.84	1.33
α = 0.70	Predictable — Surprising	3.31	1.10
M = 2.95	Scripted — Imaginative	2.94	1.21
SD = 1.22	Rehearsed — Spontaneous	3.09	1.20
	Rigid — Elastic	2.58	1.16

performance creativity "may actually represent a more common, more accessible form of creativity than privileged domains such as the arts and sciences" (Sawyer 1998, p.12). One of the challenges of this view for computational creativity is the development of creative systems capable of enacting a constructive dialogue with the world (Schön 1983). Performative, embodied approaches like PBM may provide a fruitful approach to the development of such systems. If we succeed it may tell us more about the lived experience of being creative than representational theories of creativity.

Conclusion

This paper has briefly made the case for creative systems, and creative robots in particular, to acquire embodied, craft-like skills as an alternative to following representational theories of creativity. A significant challenge in acquiring traditional embodied skills is the mapping between the embodiment of a human and that of a robot. We have proposed Performative Body Mapping as a methodology for the design and training of robots for the purpose of acquiring embodied skills. This paper has described the application of the 'bodying' stage of PBM to the design and training of a non-humanlike robot by movement experts for the purpose of performing in a gallery context. The audience survey suggests that this process of dancers inhabiting and animating abstract robot forms, successfully harnesses their embodied skills to design and train a non-humanlike robot with a capacity to be perceived as an affective agent.

Acknowledgments

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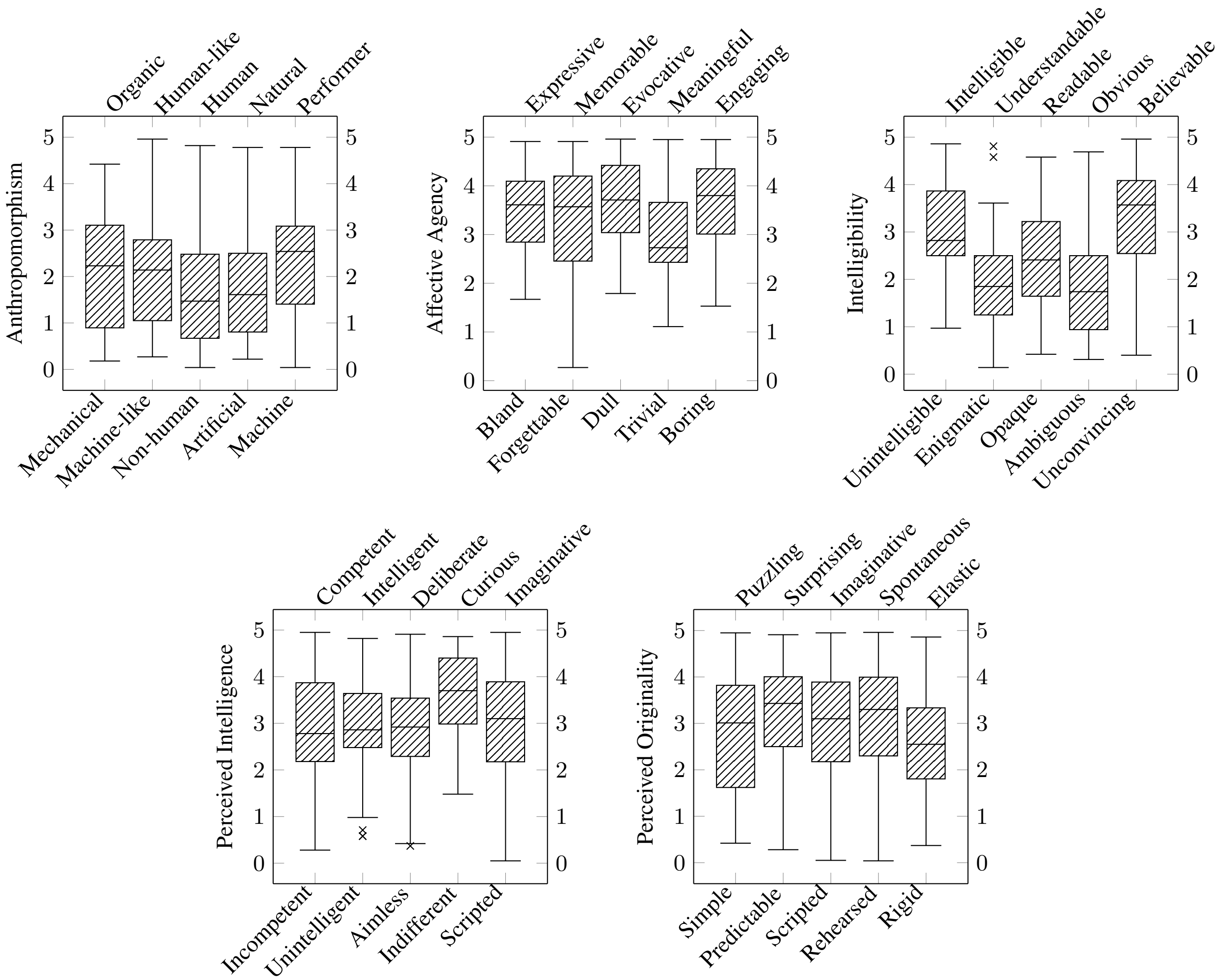

Figure 2: Analysis of Questionnaire Responses

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