Embodied conversations:
Performance and the design of a robotic dancing partner

Joslin McKinney, University of Leeds

Mick Wallis, University of Leeds

Sita Popat, University of Leeds

John Bryden, University of Leeds

David Hogg, University of Leeds

Abstract

This paper reports insights gained from an exploration of performance-based techniques to improve the design of relationships between people and responsive machines. It draws on the *Emergent Objects* project and specifically addresses notions of embodiment as employed in the field of performance as a means to prototype and develop a robotic agent, *SpiderCrab,* designed to promote expressive interaction of device and human dancer, in order to achieve 'performative merging'.

The significance of the work is to bring further knowledge of embodiment to bear on the development of human-technological interaction in general. In doing so, it draws on discursive and interpretive methods of research widely used in the field of performance but not yet obviously aligned with some orthodox paradigms and practices within design research. It also posits the design outcome as an 'objectile' in the sense that a continuous and potentially divergent iteration of prototypes is envisaged, rather than a singular final product. The focus on performative merging draws in notions of complexity and user experience.

Keywords

Embodiment, performance, tacit knowledge, practice-as-research, habitus.

There is increasing use of performance theory and practice beyond the field of performing arts, into other academic and professional domains from computer interaction and robotics to service industries.

Interest in machines which can respond to and thereby interact with humans is not new. Gordon Pask's 'Colloquy of Mobiles' at the Cybernetic Serendipity exhibition, Institute of Contemporary Arts, London 1968, for example, provides an early example of a computer-enabled reactive and educable system. However, the research represented here provides a distinctive slant from the field of performance. We report on the project *Emergent Objects (EO),* which used performance-based techniques to improve the design of relationships between people and responsive machines. We describe participatory prototyping techniques deployed by a trans-disciplinary research team. In particular, the development of a robotic object, *SpiderCrab,* reveals how embodied knowledge and tacit understanding can be mobilised in different ways and through iterative cycles of practice and reflection as a strategy for evolving design protocols.

Overview of the Emergent Objects project

The *EO* portfolio responded to one of the three aims of the Designing for the 21st Century Initiative, co-funded by the EPSRC and AHRC: 'To stimulate new ways of design thinking able to meet the challenges of designing for 21st century society'.

It comprised three sub-projects, each developing technological objects – *Hoverflies*, *SpiderCrab* and *Snake* - which afford affective interaction; and a meta-project, which guided reflection on and development of overarching concerns throughout the 12-month programme (January-December 2007). Performance frames – specifically concerned with *composition*, *embodiment* and *play* – were provided to the sub-projects to deploy as optic or practice, together with rubrics for their iteration between conscious application and tacit praxis. (Bayliss *et al*, 2007).

We adopted a collaborative design process whereby any participant was deemed an active design agent. While some participants were professional designers (from scenography to robotic engineering), the majority were not. With the addition of geographical distance between design partners, this was deliberately eccentric. The aim was not to propose an alternative model for direct emulation, but to defamiliarise the design process, to play with its nature and possibilities.

Central to our process of evaluation and dissemination were two Colloquia (June and December 2007) where invited design and performance experts from a range of disciplines scrutinised and critiqued the objects in development and workshops explored the value of integrating performance thinking and practices into design processes. Further information is on the website.

EO addressed two principal research questions:

(i) How can we design intimate interfaces between humans and technological objects by engaging with embodied experience rather than cognitive understanding?

(ii) How does performance knowledge help us to understand and facilitate emergence in the context of design processes?

This paper principally addresses the first question, engaging in that process with the second.

Performance in design research

Tools and techniques of theatrical performance have been widely employed within design. For example, performance-based techniques and scenarios in participatory design (Muller, 2002) and in interactive system design (Iacucci, Iacucci & Kuutti, 2002) have been examined. However, *EO* explored how performance theories as well as practical techniques might productively be deeply integrated into design practice and research. The *EO* project arises from strands of cross-disciplinary, collaborative research based in the School of Performance and Cultural Industries at the University of Leeds which have explored the application of performance knowledge in designing technological objects. Performance practices and concepts (in particular the phenomenology of performance and the adoption of theories of play) have been brought into productive dialogue with robotics (Popat *et al,* 2004) and with computing (Bayliss, Sheridan & Villar, 2005) and urban regeneration (Bayliss & McKinney, 2007).

Performance research embraces both aesthetic genres such as theatre and dance; and social genres such as play, festival and social dance (Schechner, 2003). And it extends its remit to apply performance understanding as an 'optic', or way of regarding phenomena not usually regarded as performances. So, for example, design which seeks to facilitate creative engagement between its objects and their users (for example Fischer & Scharff, 2000, Redstrom, 2006) potentially re-casts users as performers involved in a process of 'cultural and personal self-reflexion and experimentation' (Carlson, 2004 :216).

Embodied understanding

Embodiment, a foundational concept in the performance field, is attracting interest in design research.

The importance of embodied understanding in users' experience (van Rompay, Hekkert & Muller, 2005) has been investigated using image schemas proposed by Lakoff and Johnson to articulate and map perception of designed objects. From the other end of the design process, Rust (2004 and 2007) explores the value of embodied or tacit knowledge to design practice. Embodied understanding of objects and environments is seen to augment other modes of knowing and designers including Bowen (2007) explore the value to designers and users of an iterative dialogue, developing artefacts through a process of 'tacit transmission' (Rust, 2007:73).

In performance, the ways in which bodies 'know' is central to the practice and viewing of performance. Masked performers, for example, do not simply wear a mask. They inhabit it; and it drives them. The whole body takes on the shape and impulses of what the mask expresses. A process of contemplation of the mask progresses in stages to its embodiment by the performer, to produce a third entity, performer-as-mask. This embodiment, which exceeds mere copying, is a process of understanding and expression. Whilst performers have highly-developed capability for embodiment, the wide-spread capacity for embodied understanding is demonstrated when muscular empathy allows spectators to 'read' a stage character directly in their own bodies (Shepherd, 2006:73 -76).

Schiphorst (2006) has demonstrated how experience design can be augmented with 'first person' performance methodologies through the example of *Exhale,* an interactive art installation where wearable technology facilitates interaction through breath and touch. *EO* shares some points of reference but our concept of 'performative merging' articulates a more reciprocal model for the interface between technological object and human. It adapts the Turing Test in Artificial Intelligence, the criterion for which is that the human agent cannot distinguish its conversation with the computer from one with another human. Our criterion for 'performative merging' is that the dancer feels that they are improvising with a true partner, rather than simply being mirrored: there must be the sensation of a continuous 'offer' being made by the robot, as well as a responsiveness to the human dancer's own movement. A

dance improvisation is one instance of an *embodied conversation* and this latter term designates our general area of concern.

Practice-as-research

A further pertinent aspect of performance, in common with other creative disciplines, is a close iteration between theoretical modelling and practical research as a mode of knowledge production. UK Research Councils recognise the value of practice-led research where 'embodied knowledge of the practice is both prior to, and distinct from, the written (symbolic) account after the event' (Nelson, 2006: 107). The term practice-as-research, widely used in performance, articulates an approach to knowledge rather than a distinct set of methods. Knowledge might reside in what our bodies know as well as in what can be processed cognitively and expressed in writing. This presents particular demands on the dissemination of research. A characteristic model is iterative cycles of doing and reflecting where theoretical framing and research questions underpin the 'disorderly creative process' and give it structure and focus (Trimingham, 2002: 55- 56). This has some affinities with Action Research models (McNiff, Lomax & Whitehead, 1996) in that research questions and theoretical frameworks are gradually refined through cycles of action and reflection. Trimingham (2002) identifies this process as a 'hermeneutic spiral' which stands in contrast to overly schematic divisions of such as those described in Cox (2005) where creativity is 'the generation of new ideas' and design is 'shap[ing] ideas to become attractive propositions for users or customers'. New ideas of course arise in the creative dimension of the design process, and attention to the hermeneutic spiral enhances this.

We have taken a phenomenological approach to investigating embodied experience: that is, to value capturing the whole experience, and to attempt to deduce meanings and essences rather than measurements (Moustakas, 1994: 21). The notion of 'being there in the moment' (Moustakas, 1994: 85) is important in allowing the researcher to be receptive and 'seeing just what is there'. It also has resonances with techniques in devising performance which seek to dismantle habitual or obvious approaches in order to pursue new avenues of discovery.

SpiderCrab

SpiderCrab arises from previous collaborative research with the Shadow Robot Company investigating how robots might be more aesthetically and socially acceptable. It will be a 3.5-metre-high 6-legged multisensory robot, conceived as a cross between architectural

environment and dancing partner, for deployment both on stages and in participatory arts contexts. Thus far, one limb has been constructed, and the whole robot realised in computer simulation. *SpiderCrab*'s physical design depends crucially on Shadow's patent air muscles, which are simple, light, soft, flexible and easily controllable – rendering smooth, natural yet powerful movement together with self-dampening and cushioning. Each limb comprises four segments with relative proportions corresponding to the Fibonacci series, linked by joints combining radial and lateral movement.

Maquette to convey eventual scale of *SpiderCrab* (photo: pixelwitch)

SpiderCrab protype limb and dancer with armband (photo:Emergent Objects)

In the current iteration, human interaction with *SpiderCrab* is detected, via a green arm-band, by a vision system which forms the basis on which the robot's movements are generated using 'an *interlingua* for dance' (Wallis *et al*, 2007; Bryden & Hogg, 2008). This utilises Laban Movement Analysis (Hodgson & Preston Dunlop, 1990), a method of analysing and notating contemporary dance which focuses on the quality of movement

rather than on aesthetic poses of classical dance. *SpiderCrab* responds both to and through polarities of dynamics and effort; light/strong, direct/indirect, free/bound, sudden/sustained. The *interlingua* operates as a bias on the foundation of random generation of the robot's movement. The software further allows the introduction of programmed choice, designated as mode. The robot adopts modes which reflect those used when dancers improvise together – to Copy, Oppose (e.g. light in response to strong), or to Innovate. And in Follow mode, the limb follows the position of the dancer in the space. The modes can be programmed to vary in sequence, duration and combination. Our term for this is disposition.

Establishing a third space for interdisciplinary design

The *SpiderCrab* design team comprised experts in performance, choreography, computing and engineering. We incorporated physical games commonly used in preparation for improvisational performance into their preparation towards collaborative design and interdisciplinary knowledge exchange. Together, we addressed '*habitus*' - the way in which cultural frames are 'inscribed in the body schema' (Bourdieu,1998: 15) and how this bears on the design process. For example, the *habitus* of the software designer at the outset suggested an openness to experiment alongside a discomfort at the lack of a clear brief. Physical games helped him in his desire to experiment outside his 'safety zone'. They also established physical modes of expression and access to embodied understanding as key techniques in developing and evaluating the design. For some this initiation into physical play was at first terrifying: but as the *habitus* frame was recalibrated within the aims of the project it became liberating.

By such means performance practice helped construct a 'thirdspace' in a double sense: Soja's space between practice and theory, which is 'simultaneously material-and-metaphorical' (Soja 2000:24), provides a fluid space of disciplinary negotiation, where embodied metaphors (for instance the sculpted arrangements of bodies) are available to varied and speculative interpretation. In this space, performance theory provided its own language of exchange (*interlingua*). For instance, while computing specialist Bryden was solely responsible for the writing of algorithms, the software architecture as described above was negotiated through the language of play theory, projected on to our common broad understanding of object-related software design. That the latter was not eventually the platform did not matter: projections from bodies to words to mental or drawn visualisations were facilitated in this designedly playful space.

Visualisation and prototyping through embodied understanding

Student dancers - by training adept in locating and drawing on bodily, kinaesthetic and spatial perceptions - were employed to aid the process of design development. In an early workshop, dancers worked from a CAD drawing of the proposed robot and a provisional computer simulation of a single limb in randomised motion, to embody a 'distributed' robot - each dancer embodying a single limb. This was by means of the process of contemplation and embodiment described above: they treated the starting materials as a mask. Kinaesthetic empathy created a third entity; the dancer-as-robot.

Dancers embody the robot observed by software designer and engineer (photo:Emergent Objects)

Here, and in related work improvising beyond the limit of an actual robot, dancer-as-robot provided design insight for the engineers and an understanding of the potential for development that had both novelty and immediacy. Observation of and then detailed discussion with the dancers enabled the research team to develop design protocols. Dancer-as-robot here moved from dynamic mode of visualisation to flexible prototype. After a process of guided play - varying parameters such as responsiveness of the limbs to one another or the relationship between core and periphery of each body-as-limb - a new dancer then interacted as herself with the distributed robot without having witnessed the process of its creation. A key outcome was the realisation that bias would need to be introduced into the randomised motion, to lay the groundwork of behaviour which solicits a response or the 'offer' to interact.

Performative merging

Later in the project four of the same dancers evaluated an engineered prototype by approaching it as potential partner. They found initially that they needed to learn the robot's *habitus*: its movement vocabulary, its spatial range and dynamics, its weight. Three of the dancers reported feelings of initial intimidation due to SpiderCrab's size – until they found that the entire limb was padded, and they were strong enough to push against the air-muscles' power. In their first encounters, the students described the process as not unlike learning to dance with another person, particularly within contact improvisation modes, where one learns about one's partner's preferences and negotiates a way of working together in space. Interestingly for the observers, there were also subtle differences in the way the robot responded to each dancer. Even though they were trained to explore their full bodily range, the dancers found that the work expanded their movement vocabulary. Encountering a new embodiment put pressure on their repertoire of improvisation. At the same time, because the robot was responding to the movement qualities of its dancing partner, it effectively reflected back something of the human dancer's own *habitus*: for example, preferences for direct or indirect movement, fast or slow. This sensitivity was inherent in the sensing/programming relationship, but the dancers found that they became increasingly confident as the robot appeared to be learning their ways of moving. To the observers, it appeared to be a more iterative cycle: as the sensitivity of the robot made the dancers feel more confident, their own movement qualities became more spontaneous and this increased the range of movement of the robot. *SpiderCrab* is not in fact programmed to learn.

As an embodied conversation, dance improvisation has the quality of emergence; it is self-generating and unpredictable. Emergence is a quality of complex systems and the science of complex systems is itself emergent (Robertson, Lycouris and Johnson, 2007, p. 284). While it deliberately lacks the quality of far-from-equilibrium dynamics of some complex systems, the *SpiderCrab*-dancer couple is complex in that it is a closed system of multiple elements that performs self-generating, evolving and unpredictable behaviour. A multiplicity of elements was designed into the software in pursuit of such complexity. While Johnson (2002) classically identified emergence with the swarm intelligence characteristic of cities and, arguably, brains, the *SpiderCrab* software approaches complexity by means of its 'levels' – random generation / quality bias / mode / disposition. *SpiderCrab* may be termed 'quasi-complex', since it is not in itself complex but lays the foundation for complex interaction, in which it may appear to the human dancer to be complex, as she herself is. Thus it is the performance of the whole robot-human system that is emergent; but it is our

intention that both the robot and human agent themselves perform, in the sense of generating movement of aesthetic value. Ontologically speaking, each of these precedes the duet. The aim then is to engineer the robot so that it makes a persistent 'offer' to the human partner sufficient for them to feel that they are dancing with a 'partner' and so enter into a contract of mutuality and exchange - performative merging.

Evaluation methods

Evaluations of interactions with the robot were conducted as part of the ongoing iteration of design and prototype as described above. In addition, there were eight occasions for further reflection and evaluation: by delegates at our two Colloquia; delegates to the design for user-experience conference *dux07* in November 2007*;* with members of the public, two sets of dancers from participatory arts company Salamanda Tandem (ST) and student dancers in December 2007, and a retrospective evaluation by ST in March 2008. These purposive groups provided responses from specific perspectives. Identification of 'performative merging' necessarily rests on subjective response and subsequent reflection on the experience. In each case, evaluation data was gathered through direct observation and video recording of the physical interaction and through conversation, starting with an open question ('What was it like?') followed by a series of questions prompted by its answer. In several cases, this was a group conversation, with up to five respondents and three questioners, and respondents were given space to ask questions of each other. The aim was to arrive at a shared understanding of the range of embodied responses. The reported experience of one respondent might trigger self-reflection and analysis in another. Thus, introspection was encouraged. The open question was in every case asked after the respondent had interacted with *SpiderCrab* so that the experience was not hampered by forebrain activity introduced by the researchers. Introspection might then include a return to interaction and further reflection.

This approach, taken with a variety of classes of respondent, and our own commitment to introspection - drawing on these reports, our own witnessing of the interactions and our own interactions with *SpiderCrab* informed by both - aligns with the 'qualitative heuristic approach' reported by Kleining and Witt (2000). It is also aligns with Lanigan's method for phenomenological investigation, which identifies three phases: *capta* ('conscious experience of the phenomenon'); *reduction* ('observer determines which parts of the description are *essential*'); and *interpretation* ('an attempt to signify meaning'). (Ladly 2007, p.142) The open question immediately following interaction and the encouragement to introspection and conversational speculation are designed to reduce the gap between embodied encounter

and the primary objectification constituted by the *capta*. This can be regarded as a space of performance, or in performance theorist Schechner's terms 'restored behaviour'. Performance is 'twice behaved behaviour' in that the original behaviour is always absent. (Schechner 1991, p.206) Performance skills assist us in soliciting kinaesthetic re-embodiment by the respondent of the fugitive phenomenal experience, to enhance the quality of the *capta*. Thus the March 2008 retrospective evaluation was conducted as a re-embodiment. The ST associates recalled their experience kinaesthetically, by viewing video footage. ST and research team embodied the robot for their interaction, in a reprise of the 'distributed robot' process described above. Evaluation moved seamlessly into fresh embodied prototyping of the object as originally conceived and also in divergent iteration as an interactive room with robotic elements. Re-embodiment here offers an 'imaginative variation' (Moustakas, 1994: 98) through which participant experience can be processed towards identifying key themes and meanings of the experience whilst also generating fresh avenues for development. *SpiderCrab* is an 'objectile', a continuous variation of matter and development of form: the object becomes an event, always in the process of becoming through interaction (Deleuze 1993).

Re-embodiment exercise (photo: Emergent Objects)

Reduction and interpretation

Responses of two of the groups are reflected here as examples to show how themes and meanings emerged.

The *SpiderCrab* limb was demonstrated at the Colloquia to a total of 38 academics and practitioners from a range of performance and design fields in two phases of its development (see website for participants). In June, it consisted of the lower two segments in motion, with the third fixed horizontally. In December, the entire limb was demonstrated. In June, there

was considerable interest in the processes that had been used to design *SpiderCrab*, with much focus on the embodiment exercises that had taken place in the development of its movement. Several delegates worked with the prototype, and they noted its inherent rhythm, partly induced by the clicking of the valves operating the air-muscles. They were intrigued by the subtlety of the Copy mode based on the sensing of movement quality rather than spatial orientation or position. Consideration of user-experience affirmed the value of mapping movement rather than pose. A dance academic was particularly engaged by the way in which *SpiderCrab*'s reactions to her were clearly related to her movement but not predictable in the way that copying her aesthetic pose would be. This sustained her interest in the interaction even after she had 'worked out' what was happening. This prompted us to consider further the use of the Oppose mode to give a stronger sense of the robot sometimes taking the initiative in the movement composition. Later developments, for example the inclusion of the Follow mode, were prompted by discussions in June. In December, delegates noted the attention that the robot appeared to pay to the dancer/user when the Follow mode was introduced, enhancing the relationship between dancer and robot through acknowledgement of the dancer's position in space. This had an impact on both the dancer's experience and the observer's reading of that relationship. The alternation of Follow with other modes varied the response of the robot to the human agent, leading to a more sustained interaction by increasing the range of possible experiences.

At *dux 07* the *SpiderCrab* limb was installed for delegates to interact with. Seventeen volunteered as respondents. Fifteen found the robot approachable and indeed charming, and there was a strong tendency to ascribe it a personality; the soft terminal 'finger' segment, in particular, tended to 'goose' interactors. While this locally-produced sense of agency was strong, *SpiderCrab's* agency as embodied dance-partner was more elusive. In part this derives from the way many interactors approached the dialogue: they were inclined to try to lead the robot with the arm-band – worn or held out – to 'find out how it works' on a cognitive level, but reluctant to enter into a more organic full-bodied interaction. At the next public showing, we provided differently-coloured arm and leg-bands (three of them placebos). This helped somewhat, but without coaching, the urge to interrogate the system through movement rather than seek the experience of performative merging was a marked tendency in all groups of casual interactors.

Investigating performative merging, we identified a number of *reductions* (Lanigan) raised by both us and respondents:

- *offer* - the sustained sense of an 'offer' coming from *SpiderCrab* where its gesture or sequence calls forth a response, as part of the fluid 'conversation' that constitutes an improvisatory duet;
- *response* - the sense that the robot is responsive to one's own movements, while not being slavishly bound to them;
- *embodied agent* - the sense that the robot has an embodiment, in that it appears to have an historically-achieved *habitus*; and associated with this the sensation of both presence and agency.
- *friendliness* - compatibility with the human agent - the perceived 'friendliness' of the robot in terms of its general quality of movement, behaviour and physical being.

These subjective responses all depend on the feeling of the *interaction* as registered in each respondent's body. Finally, there is a more distanced and cognitively-processed response:

- *meta-engagement* - where the interactor reflects on the technical and conceptual aspects and of dancing (or not) with a robot.

This reduction schema laid a basis for reflection on the most substantial evaluative conversations, with four student dancers and the Salamanda Tandem team during December 2007. ST work with a wide spectrum of people to create artworks primarily derived from sensory experience, specialising in the performance of collective, multi-media events shaped around the distinctive abilities of the people who participate. Artistic Director, Isabel Jones, and associate artist, Julie Hood, made a first evaluation on 7 December 2007, which included assessment for the requirements of two ST associates, Adam Chillot (who has a learning disability) and Mickel Smithen (who has a visual impairment), who conducted their evaluation on 18 December 2007.

Isabel Jones and *SpiderCrab* (photo: pixelwitch)

Julie Hood (photo:pixelwitch)

A short selection of their verbal responses are quoted here in order to give an example of our movement from *capta* to reduction.

Adam first talks as he dances: 'It's like an arm thing isn't it? ... It's clever, it's good how it does it. ... Fantastic.' And later: 'It moved smoothly ... sometimes it couldn't see me. I don't know what it's going to do next, yes, I move then it moves'. Adam here combines a meta-engagement with an exploratory interaction using what Julie explained was Adam's familiar personal dance vocabulary.

Mickel moved rapidly from meta-engagement to a relatively immersive interaction mode, reporting an impression of embodied agent. Both Adam and Mickel found friendliness. Mickel reflected after dancing:

> At first it's like a robot, then you forget and you are having a duet, getting to know someone – shaking hands. You get to see the movements between, floats between, constant pulse, like it breathes. You can build a connection in play and be imaginative with it. It's like you're pushing it with your movement but it comes back at you. A friendly arm - like the Addams Family's walking hand, but not as scary. It becomes a human limb. I was aware of the clicking sound as the robot moved and I moved with this too.

Julie and Isabel had enjoyed equally positive first encounters but found that their engagement waned after a while. Lisa, ST company manager, commented:

> It's wonderful when dancing with another human being to engage with the element of unpredictability... If you dance with the robot for some time you can learn its responses and the element of unpredictability slowly leaves the space.

The robot's residual lack of embodied agency becomes foregrounded in a trio. Julie:

> When another dancer enters the space to join the first dancer moving with *SpiderCrab*, it's only a matter of time before the dancers gravitate towards each other... The robot is left out because we are not emotionally attached to it.

Mickel Smithen and Adam Chillot working in a trio with *SpiderCrab (*photo: Geoffrey Fielding)

From her point of view as a specialist practitioner in arts work with people, Isabel raised a perspective that supplemented our established reduction of 'embodied agency':

> …unlike in human interaction *SpiderCrab* didn't move on, it stayed with me, stayed still, didn't demand more, and this appeared as though it were listening attentively, as if it were giving me an unconditional acceptance, without ever getting bored.

Discussion

The sum of evaluations indicate that, for at least a first encounter, *SpiderCrab* successfully engages its human partners through the production of *offer*, *response*, *friendliness* and the sensation that it is an *embodied agent*. The *meta-engagement* which typically precedes this fades for a while but returns (routinely to less pleasurable effect) as the human partner tires of the robot's limited repertoire of invention. This suggests that, while the strategy of designing a quasi-complex robotic system - so that the robot-human couple achieves true complexity and thereby performative merging - was correct, further development should be through sophistication of the software architecture rather than adjusting the underlying algorithms. At the same time, one respondent indicates that this limit to the experience of *SpiderCrab*'s vitality may constitute a machine-specific embodiment worth pursuing for its own sake.

While, again, the focus on quality of movement rather than aesthetic pose (which we characterise as species of *gestalt* – a shaped whole), was correct, a route to a sustained sense of the robot's embodied nature and the production of emotional appeal may be through the reintroduction of shape to the system – not aesthetic poses, but compositional states (angularity; extension; symmetry) to which the observed dancer or driven robot tends.

We speculate that the undecidability between impulse and gestalt in human gesture is one means by which lived presence is generated. A robotic rendering of this undecidability is probably our best next goal. Robotic presence would then be constituted not by the seamless replication of lived presence – but rather by an undecidability between lived presence and mute machine. These speculations are informed by understanding of a fundamental of the Western stage: the presence of the stage figure comprises an endless circulation between presence and absence: as we witness the actor, the character recedes, and *vice versa*.

Conclusions

Polanyi describes tacit understanding thus: 'it is not by looking at things, but by dwelling in them' that we achieve full understanding of complex matters (Polanyi, 1967: 18). Bodily knowing provided a key means for designing *SpiderCrab*. It prepared the trans-disciplinary research team for the task of designing an object which itself works at the level of whole-body experience. Embodiment techniques informed the design development allowing us to imagine the future object by focusing on the emerging relationship between the object and the human body. Evaluating and disseminating these techniques has led to further iterations through the vehicle of performance-based workshops (to be discussed in a further paper) aimed at allowing wider groups of design and performance experts to experience and critique these methods.

Through the perspective of performance knowledge, tacit understanding has been mobilised to potentially enrich design functions. Clearly, where the focus of design is on interaction, this has clear benefits and the notion of whole-body engagement extends from the potential user to the whole design process. But the notions of embodiment as understood by performance might usefully be applied more widely to design. We suggest that the enfolding of tacit knowledge as part of the process of design research, from identification of issues through to dissemination of insights, might benefit from the iterative and performative approaches we have outlined.

References

Bayliss, A., Sheridan, J.G., & Villar, N. (2005). New Shapes on the Dancefloor: Influencing ambient sound and vision with computationally-augmented poi. *International Journal of Performance Arts and Digital Media* 1(1). Intellect: Bristol, pp. 67-82.

Bayliss, A., & McKinney, J. (2007). Emergent Objects: Design and Performance Research Cluster. In T.Inns (Ed), *Designing for the 21st Century: Interdisciplinary Questions and Insights* (pp.150 -165). Aldershot: Gower Publishing.

Bayliss, A., McKinney, J., Popat, S., & Wallis, M. (2007) Emergent Objects: Designing through performance. *International Journal of Performance Arts and Digital Media* 3 (2&3), pp. 269 – 279.

Bourdieu, P., (1998). *Outline of a Theory of Practice*. (R. Nice, Trans.). Cambridge: Cambridge University Press.

Bowen, S. J., (2007). Crazy Ideas or Creative Probes?: Presenting Critical Artefacts to Stakeholders to Develop Innovative Product Ideas. *Proceedings of EAD07: Dancing with Disorder: Design, Discourse & Disaster*, Izmir,Turkey. Retrieved March 17, 2008 from http://www.simon-bowen.com/downloads/research/crazyIdeas.pdf

Bryden, J., & Hogg, D., (2008). Building artificial personalities: expressive communication channels based on an interlingua for a human-robot dance. Submitted to *ALife XI*.

Carlson, M., (2004). *Performance: a critical introduction* (2nd ed.). New York and London: Routledge

Cox, G. (2005). Cox Review of Creativity in Business: Building on the UK's strengths. London: HMSO

Deleuze, G., (1993). *The Fold: Leibniz and the Baroque* (T. Conley, Trans.) Minneapolis: The University of Minnesota Press

Fischer, G. & Scharff, E. (2000). Meta-Design: Design for designers. *Proceedings of Conference on Designing Interactive Systems: Processes, practices, methods & techniques*, (pp. 396-405). New York: ACM Press.

Hodgson, J., & Preston-Dunlop, V., (1990). *Rudolf Laban: An Introduction to his work and influence* (Northcote House Publishers)

Iacucci, G., Iacucci, C. & Kuutti, K. (2002). Imagining and Experiencing in Design: The role of performances. In O.Bertelsen, S.Broedker and K.Kuutti, (Eds.), *Proceedings of 2nd Nordic Conference on Human-Computer Interaction*, (pp.167-176).New York: ACM.

Johnson,S. (2002). *Emergence : the Connected Lives of Ants, Brains, Cities and Software.* London: Allen Lane.

Kleining, G. and Witt, H. (2000). The Qualitative Heuristic Approach: A methodology for discovery in psychology and the social sciences. Rediscovering the method of introspection as an example. *Forum: Qualitative Social Research* 1(1), Art. 13. http://www.qualitative-research.net/fqs-texte/1-00/1-00kleiningwitt-e.htm [Date of Access: 13 January 2008].

Ladly, M. (2007). Being there: Heidegger and the phenomenon of presence in telematic performance. *International Journal of Performance Arts and Digital Media* 3(2&3) pp 139-150.

McNiff, J. Lomax, P. & Whitehead, J., (1996). *You and Your Action Research Project*, London and New York: Routledge

Moustakas, C., (1994). *Phenomenological Research Methods.* Thousand Oaks, London, New Delhi: Sage Publications.

Muller, M, J., (2002). Participatory Design: The Third Space in HCI. In J.A. Jacko & A.Sears (Eds.),*The Human-Computer Interaction Handbook: Fundamentals, evolving technologies and emerging applications,* (pp.1051-1068). NJ, USA: Lawrence Erlbaum.

Nelson, R. (2006). Practice-as-research and the Problem of Knowledge *Performance Research* 11(4), pp. 105 -116.

Polanyi, M., (1967). *The Tacit Dimension*. London: Routledge and Kegan Paul.

Popat,S. Ramsay,G., Trimingham, M. & Wallis,M. (2004). Robotics and Performance: A phenomenological dialogue. In: *Proceedings of Pixelraiders 2 Conferences, Sheffield, 6-8th April 2004* [CD-ROM].

Prestinenza Puglisi, L., (1999). *Hyper Architecture: Spaces in the Electronic Age* (Lucinda Byatt, Trans.). Basel, Boston and Berlin: Birkhäuser.

Redström, J., (2006). Towards User Design? On the shift from object to user as the subject of design. *Design Studies*, 27(2). pp.123-139.

Robertson, A. Lycouris, S., & Johnson, J. (2007). An approach to the design of interactive environments, with reference to choreography, architecture, the science of complex systems and 4D design. *International Journal of Performance Arts and Digital Media* 3 (2&3), pp. 281-294

van Rompay, T., Hekkert, P. & Muller, W. (2005). The Bodily Basis of Product Experience. *Design Studies,* 26(4). pp.359-377.

Rust, C., (2004). Design Enquiry: Tacit knowledge and invention in science. *Design Issues,* 20(4). pp.76-85.

Rust, C., (2007). Unstated Contributions- How artistic enquiry can inform interdisciplinary research. *International Journal of Design,* 1 (3). pp. 69-76

Schechner, R. (2003). *Performance Theory* (3rd ed.). New York & London: Routledge.

Schechner, R. (1991). Restoration of Behaviour in Eugenio Barba and Nicola Savarese (Eds). *The Secret Art of the Performer: A Dictionary of Theatre Anthropology*. New York : Routledge.

Schiphorst, T., (2006). Breath, skin and clothing: Using wearable technologies as an interface into ourselves. *International Journal of Performance Arts and Digital Media*, 2(2) pp. 171-186

Shepherd, S., (2006). *Theatre, Body and Pleasure.* London and New York: Routledge

Soja, E., (2000). Thirdspace: Expanding the scope of the geographical imagination. in Alan Read (Ed.), *Architecturually Speaking*, London and New York: Routledge, pp.13 -30

Trimingham, M., (2002). A Methodology for Practice as Research. *Studies in Theatre and Performance*, 22: 1, pp. 54-60.

Wallis,M., Popat, S., Bayliss, A., McKinney, J., Bryden, J., Hogg, D. et al. (2007). SpiderCrab and the Emergent Object: Designing for the Twenty-first Century. In *Proceedings dux07,* New York: ACM Digital Library

Emergent Objects
http://www.emergentobjects.co.uk/

Salamanda Tandem
http://www.salamanda-tandem.org/

Shadow Robot Company
http://www.shadowrobot.com/

Designing for the 21st Century Initiative
http://www.design21.dundee.ac.uk

Joslin McKinney

Joslin is Lecturer in Scenography in the School of Performance and Cultural Industries at the University of Leeds, UK. She was a Co-Investigator for *Emergent Objects.* Her own practice-led research investigates the nature of the communication that occurs when audiences encounter design for the stage. She is interested in the interrelated operation of space, light, objects, costumes and human bodies and the how the phenomenological experience of these elements takes on significance for spectators. Publications include 'Projection and Transaction: The spatial operation of scenography' *Performance Research* 10(4) 2005. Recent research has included *Forest Floor* (2007), a scenographic installation which blurs the boundaries between performer, designer and audience and invites creative participation, interaction and re-interpretation through the medium of scenographic materials. She is the co-author of the forthcoming *Cambridge Introduction to Scenography* (Cambridge University Press) and co-author of 'Research Methods in Scenography' a chapter for the forthcoming *Research Methods in Theatre Studies* for Edinburgh University Press.

Mick Wallis

Mick is Professor of Performance and Culture at the School of Performance and Cultural Industries, University of Leeds. He was Principal Investigator for *Emergent Objects* and for the AHRC-funded 'Village Theatre Survey', investigating the use of amateur theatre in inter-war England. Recent work includes *Drama/Theatre/Performance* with Simon Shepherd (Routledge, 2004) and *Performance Research* 10:4, 'On *techne'* (2005) edited with Richard Gough. His keynote essay therein proposes a reassessment of Heidegger's writing on technology, so as rigorously to resist the philosopher's unhistorical romanticism; it also proposes the theatrical apparatus as a collective subject of *techne.* Forthcoming work includes a chapter on performance and the science of complex systems. Mick co-founded the Arts Work with People Project (AWP) with Isabel Jones, Artistic Director of Salamanda Tandem. AWP is committed to the design of processes to deliver and evaluate participatory arts practices for people with severe access needs. For more information see: http://www.leeds.ac.uk/paci/artworkpeople/artworkpeople.htm

Sita Popat

Sita is Senior Lecturer in Dance in the School of Performance & Cultural Industries, University of Leeds. Her research interests centre on relationships between dance choreography and new technologies. She is currently working on the e-Dance project (AHRC/EPSRC/JISC-funded), exploring Access Grid and other e-Science technologies as platforms for dance performance and documentation. Recently completed projects include Projecting Performance (AHRC-funded) in collaboration with Scott Palmer and KMA Creative Technology Ltd, investigating the relationship between performer, operator and digital 'sprite' (2006-8). She was a member of the Emergent Objects meta-project team, and she was also part of the *SpiderCrab* sub-project, applying dance knowledge to the design of robotic limb movement (2007). Her book on online choreography is published by Routledge, titled 'Invisible Connections: Dance, Choreography and Internet Communities' (2006). She is Associate Editor of the 'International Journal of Performance Arts and Digital Media' (Intellect).

John Bryden

John was Research Fellow on the *SpiderCrab* sub-project in *Emergent Objects* and works in the School of Computing at the University of Leeds. This involved designing and then

developing the software to control the Spidercrab robot and then implementing it at the various demonstrations. John has a range of experience from computing and biological backgrounds. While working in the computer games industry, he developed software tools for the game Aliens versus Predator. As a software consultant, he also worked on the European Multimedia Archive of the Holocaust. He has recently finished his PhD at the University of Leeds. This work, 'The Evolution of Social Organisms: Modelling Reproduction Strategy', studied the Major Evolutionary Transitions considering why an organism might stop reproducing on its own to reproduce as part of a larger collective. He is about to take up a position as a Research Associate at Royal Holloway, University of London, studying complex networks in biological systems.

David Hogg

David was a Co-Investigator on *Emergent Objects*. He has a BSc in applied mathematics from the University of Warwick, an MSc in computer science from the University of Western Ontario, and a PhD degree from the University of Sussex. He was on the faculty of the School of Cognitive and Computing Sciences at the University of Sussex from 1984 until 1990, when he was appointed as full Professor of Artificial Intelligence at the University of Leeds, where he now heads the Computer Vision group. He was head of the School of Computing from 1996 to 1999, and a Pro-Vice-Chancellor of the University from 2000 to 2004. During 1999-2000 he was a visiting professor at the MIT Media Lab in Cambridge. He is a member of the EPSRC College, a Fellow of ECCAI, and an Associate Editor of IEEE-PAMI, has been on the programme committee for most of the leading international conferences in the field for over ten years and advises many research funding agencies worldwide on a regular basis. His current research is on the development and application of spatio-temporal models within computer vision, dealing especially with learning, stochastic processes, and the integration of qualitative and quantitative representations.