Light Arrays: a system for extended engagement

D Wilde[1], A Cassinelli[2], A Zerroug[3], R J N Helmer[4], M Ishikawa[5]

[1,2,3,5]Ishikawa Komuro Laboratory, University Of Tokyo,
Hongo 7-3-1, Bunkyo-ku, Tokyo, JAPAN

[1]Department of Fine Art, Monash University,
900 Dandenong Rd, Caulfield East, Melbourne, VIC, AUSTRALIA

[1,4]Division of Materials Sciences and Engineering, CSIRO,
Henry Street and Colac Road, Belmont, Geelong, VIC, AUSTRALIA

[1]*d@daniellewilde.com,* [2]*alvaro@k2.t.u-tokyo.ac.jp,* [3]*alexis@k2.t.u-tokyo.ac.jp,*
[4]*Richard.Helmer@csiro.au,* [5]*Masatoshi_Ishikawa@ipc.i.u-tokyo.ac.jp*

[1]*www.daniellewilde.com,* [1,2,3,5]*www.k2.t.u-tokyo.ac.jp/members/index-e.html*
[4]*www.csiro.au/science/ps3xg.html*

ABSTRACT

We present the development vision of a range of interactive body-worn lighting systems for performance, play, rehabilitation and dis- or altered- ability support. The systems combine experimental and off-the-shelf technologies to arrive at outcomes that require and inspire extended physical and expressive engagement, and afford a range of different learning opportunities. We discuss the context and background, our aims and approach – mixing art, design and engineering methodologies. We then outline a number of scenarios of use and their relevance to ArtAbilitation. Our aim is to open up a dialogue with the ArtAbilitation community in the early stages, to generate collaborative interest and inform development.

1. INTRODUCTION

The *Light Arrays* extend the dynamic moving body with light to make visible the nuances and complexity of movement (fig.1). They were initially prototyped for *Swing That Thing: moving to move*, an investigation of how technological extension might poeticise experience through novel forms of physical engagement (Wilde 2010, 2007-2011). By incorporating lasers and LEDs into garments and modular fabric supports, the *Light Arrays* prompt wearers to interact and engage, through the lights, with body position and movement, as well with their dynamic position in space. Wearers of the initial prototypes report being inspired to move in new ways and to discover and explore their body through movement, in ways that differed from their usual methods, approaches and habits (Wilde, 2007). The experiments brought to light synergies across the authors' research, and provided the impetus for the current collaboration to extend this work into an interactive space. We present here the background research and context, as well as a number of development scenarios. Each scenario prompts a different kind of physical engagement, so different opportunities for learning movement and learning about and extending the bodies' expressive capabilities. From this perspective we discuss the relevance to ArtAbilitation.

2. CONTEXT & BACKGROUND RESEARCH

2.1 Context

The overarching research project, *Swing That Thing: moving to move*, is a doctoral investigation being undertaken at Monash University and at the CSIRO. The *Extended Light Arrays* brings this research to the University of Tokyo. The three contexts differ considerably – a Department of Fine Art in a University Faculty of Art and Design and a Government Scientific and Industrial Research Organization, both in Australia, and a Department of Creative Computing in a University Faculty of Engineering in Japan. The research in each of these contexts is driven by different concerns, constraints, challenges, opportunities and requirements regarding outcomes and reporting. The research is also being undertaken in different social and cultural contexts and languages – in Japan, for example, the work is being undertaken in a combination of

©2010 ICDVRAT; ISBN 978 07049 15022

French and English, in the broader context of Japanese. In Australia, the work takes place in English. The authors thus bring cross-cultural, as well as multi- and cross-disciplinary experience. Collectively they have extensive experience in fine art, materials science, engineering, garment design and construction, performance development, and the design, implementation and evaluation of interactive systems for a range of applications. The collaborators' complementary, as well as common skills, lead them to approach similar questions with different perspectives. This leads to rich outcomes informed by a broad knowledge base, and is an integral aspect of the *Extended Light Arrays* project. Short descriptions of background research perspectives follow, to enable a clear understanding of our approach.

Figure 1. *Light Arrays [Wilde, 2008].*

2.2 Background

2.2.1 Swing That Thing : moving to move is practice-based research guided by Art and Design ideation techniques and intuitive processes. The investigation sits within the broader field of Interaction Design, and is being undertaken in a mixed context of Art, Design, Science & Technology Research. Outcomes evolve from a common design intent: 'to move the body through real and virtual extension'. Extending the body mechanically, gesturally and sensorially can encourage people to move in extra-normal ways, so view and experience their bodies from perhaps hitherto unknown perspectives. This opens up a free-form expressive space that can provide a rich playground for self-expression, as well as surprising opportunities to observe how people learn in, through and about their bodies. It affords insight into how our bodies can move and what this feels like; individual body-centric learning preferences; and the idiosyncratic nature of personal, corporeal expressiveness. This research seeks to engage both body and imagination, and blur the boundaries that separate art from everyday life. As discussed in (Wilde et al, 2010) many applications in the area of rehabilitation and disability have been identified for the different praxis outcomes. Throughout the research, the experiential potential of the body and the imaginative capacity of people are foregrounded, guided by the belief, and experience, that doing so can provide radically different opportunities for engagement than coming from more pragmatic, technologically- or functionally- driven perspectives. A direct result of this approach has been extended engagement, and repeated requests for more opportunities to use the devices. This desire for continued and extended engagement may be beneficial in abilitation contexts where maintaining engagement has proven challenging.

2.2.2 CSIRO, Advancing Human Performance. At the CSIRO, researchers are developing wearable interactive textile systems and garments for a range of applications in sport, entertainment and health. The main driver is to move from traditional hard electronics to a combination of hard and soft electronics in garments and on the body, with the knowledge that new devices can enable new information, experiences and engagement in new environments. The group develops textile based wearable technologies for sensing limb movement, pressure, impact, moisture, and the electrical activity of the body using advances in new materials that when combined with digital infrastructure enable new mobile measurement and information for feedback in diverse environments. The focus is on empirical validation of the utility and value of the devices that are developed. The work is not only "good fun" but is socially beneficial and can demonstrate devices that have a tangible, real life benefit.

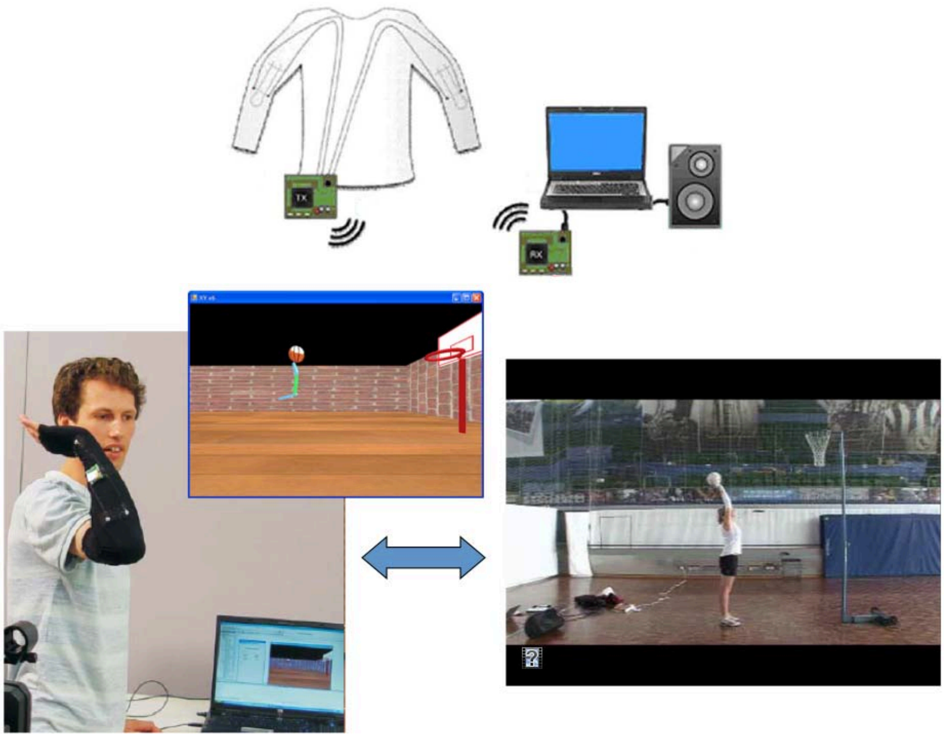

Figure 2. *WISh Wearable Instrument Shirt. A mobile system that uses music to support body-centric learning in real world environment.[Helmer, et al., 2010]*

One of the sensors being used in the *Extended Light Arrays* project was developed by CSIRO to measure elbow and wrist flexion, to link elite skill to novice development through a wearable device, by combining music with biomechanics for skill development, focus and engagement. The device (fig.2) uses rhythm to promote temporal and spatial awareness of a throwing skill. Participant groups include elite athletes and novices and, more recently a participant with Cerebral Palsy. The work with the able-bodied participants has allowed for improvement in skill through prescribed use of the device, without direct input or presence of a coach or skilled mentor. It has also included benchmarking to other measurement systems. (Helmer et al., 2008, 2010) We are interested to observe how these outcomes map onto the disabled participant, who has very different needs. For *Swing That Thing…* the same sensor has been adapted to measure flexion at the waist (Wilde 2009), for use by able-bodied and disabled participants.

The CSIRO system is mobile. It operates independent of architecturally based infrastructure, allowing field work to be undertaken both indoors and outdoors, in real-world settings, far from the lab. This represents a major advantage over camera vision techniques, and we believe is highly relevant to people with different physical and communicative disabilities, who may feel more comfortable, and thereby more able to undertake certain tasks and express themselves freely, in familiar environments.

2.2.3 Meta Perception at the University of Tokyo. The Meta Perception Group foreground culture and the body as they investigate how to extend perception through technological mediation. Most research outcomes are developed for cultural contexts, and result in technologically innovative solutions, and sometimes significant advances in engineering. Increasingly the group has become interested in wearable works. The *Haptic Radar*, for example, is a spatial augmentation device for the visually impaired. (Cassinelli et al., 2006a,b) (fig.3). It is a modular device that allows the wearer to perceive and respond to spatial information using haptic cues in an intuitive and unobtrusive way. The system is composed of an array of invisible lasers that simulate “optical-hair modules”. Each laser senses range information, which it transduces as a vibro-tactile cue on the skin below. It thereby operates as a kind of cellular cilia (insect antennae), or in the same way as the specialized sensory hairs of mammalian whiskers. The first prototype of the *Haptic Radar*, a headband that provides the wearer with 360 degrees of spatial awareness, has had positive reviews in proof-of-principle experiments. Further testing, with a sample of 50 blind users, has since been undertaken and results are currently being analysed[1]. This system complements the *Light Arrays* systems outlined here as,

[1] In collaboration with Eliana Sampaio, Laboratoire Brigitte Frybourg, Conservatoire National des Arts et Métiers, France: *http://handicap.fr*

rather than reflecting the wearer's movement onto space, the *Haptic Radar* reflects the proximity of space, dynamically, onto the wearer.

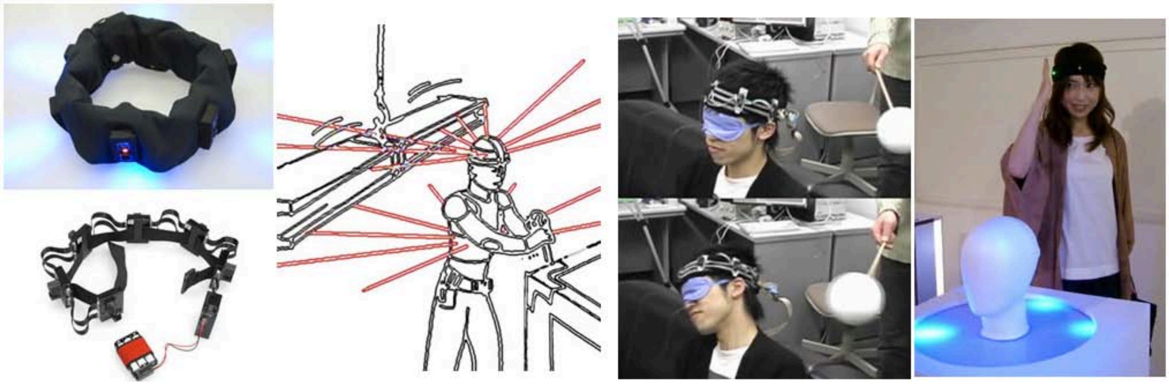

Figure 3. *Haptic Radar / The Extended Skin Project [Cassinelli et al., 2006]*

3. RELATED WORK

Light has long been used as an exploratory tool to gain insight into body dynamic. Historic examples include Marey and Muybridge's photographic locomotion studies (Marey 1994; Muybridge 1979). Motion Capture provides a contemporary equivalent. (for an overview see Furniss, 2000). Merce Cunningham said that motion capture technology allows him to "see movement in a way that was always there – but wasn't visible to the naked eye" (Schibsted, 1996). The *Light Arrays* do the same, but in real time, independent of architecturally based infrastructure, so potential applications and scenarios of use are broader. Though intangible, the *Light Arrays* echo Rebecca Horn's early body extensions (Zweite et al. 2007), and Hussein Chalayan's fashion collection, *Readings* (Chalayan and Waldemeyer 2008). *Readings* does not provide information on body motion, it does, however, provide a startling example of the aesthetic power of pairing lasers with the body. Hewitt-Parsons speaks of the advantages of tactile media aids to maintain and strengthen motor skills and eye/hand co-ordination, to simulate the sensory system and improve visual-spatial awareness (Hewitt-Parsons 2006). The *Light Arrays* are intangible, but visible. We are curious to see if they will lead to similar or complementary outcomes.

The co-authors of this paper collectively have a large body of artistic and scientific research into worn technologies, extension and the use of lasers for physical engagement. See (Wilde 1997-2011) for a range of approaches to extension, as well as *Sticky light* and *scorelight*, dynamic laser systems that turn any object, including the body, into a light- or optical- 'pickup' (Cassinelli at al., 2008a,b). Also of relevance is Manabe's *Face Visualiser*, which uses Masaki Teruoka's myoelectric sensing system to turn the face into an optical pickup head (Manabe 2008). We may collaborate with Manabe, to use this system to translate muscle movement into light. (see 5.1.3)

4. AIMS & METHODOLOGIES

A number of different light-based, body-worn systems for physically engaged, expressive interaction are being implemented. These are outlined in Section 5. The development process in each case is an iterative, reflective process guided by Art and Design ideation techniques and intuitive processes. We begin with very basic prototypes, which we develop in constant negotiation with a broad a range of participants. We work with highly skilled performing artists and people with different physical challenges and abilities. By covering extreme case scenarios (Moggridge 2006) we hope to better understand the limitations and affordances of the different approaches, as well to make devices that work for different bodies. Our intention is to arrive at systems that are physically and imaginatively engaging, for a range of contexts and abilities.

5. PROPOSED SYSTEMS & SCENARIOS OF USE

5.1 Overview

We present here three different approaches. In each case the desire is to bring attention to the body by extending it with light, to support playful physically engaged exploration. Cultural artefacts including performances, objects and garments for a range of contexts are being developed for the general public, as well as specific user groups. These form part of the research process and are also considered research outcomes. Importantly, within this process, we will work with disability groups to understand and incorporate their needs and tailor the devices as appropriate. Considerations include fit (being able to put the garment or support on may be a major challenge for some people), feel (how comfortable the device is to wear plays a crucial role in its use), and also the broader aesthetics of the interaction. It is important that the outcomes are engaging. It is also important that they bring the wearer, in new ways, to knowledge about their bodies. The reasoning behind this is discussed below.

5.1.1 Light Arrays. This work builds upon the original *Light Arrays* prototypes. By extending the body perpendicularly with rays of light we can visually magnify the minutae and complexity of movement. This has a number of applications. It may be particularly useful for participants with vestibulaire disorders, for example, if the lasers extend from the waist. By observing the array of dots on the walls surrounding them, the participant would be able to identify if they are standing upright (in which case the dots would be aligned horizontally) or if and how they may be off balance (in which case the light array would be tilted).

In a very different application, the system may be used to inspire people to engage their bodies through imaginative tasks. For example, a treatment for leg ulcers involves compression bandages and regular movement of the ankle to maintain circulation. If circulation is not maintained treatment fails, yet it is challenging to get people to regularly and randomly move their ankles over extended periods, so success rates remain low. By attaching a laser to the base of the foot, the patient could be asked at regular intervals to draw objects, write lists or otherwise or map out things that they are interested in or passionate about. Tasks could include: writing the names of their grandchildren; mapping out their favourite walk through town; the relationships between their friends; the plants in the garden; the tools in the shed; etc., etc., or they could simply be asked to follow the contours of the room with the laser; or trace out different objects in the surrounding environment; to solve complex mathematical equations; to draw pictures or to write out musical scores. The role of the health practitioner would be to assist the patient in finding tasks that resonate for them emotionally. Our hypothesis is that if the task resonates emotionally for a patient, they will be more likely to engage over an extended period. In the case of patients with leg ulcers, this enhanced engagement would lead to beneficial results in their healing process.

We are currently developing a robust and elegant system to be tested with groups of people with physical and communicative challenges. We aim to fully explore the potential of this very simple application of technology to the body, to examine if and how the current positive outcomes might map onto people with different disabilities, and whether or not our hypotheses stand. Outcomes with able-bodied participants include discovering new things about their bodies, learning how to make different kinds of movement, and being inspired to explore and investigate their potential for movement in ways that are unexpected, novel and stimulate extended and unfamiliar abilities.

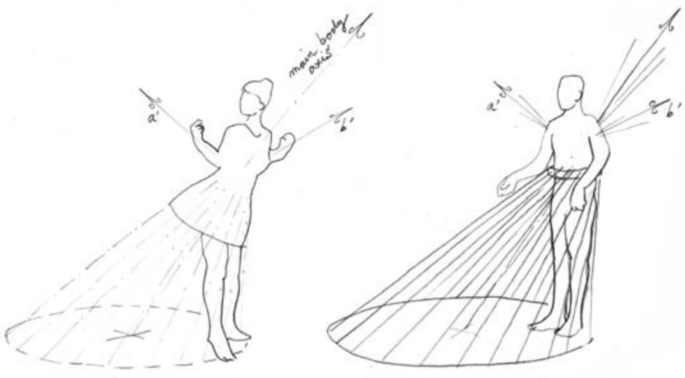

Figure 4. *In-visible garments for two – mapping movement and posture of one participant onto another participant's "skirt".*

5.1.2 An in-visible garment. A skirt made with lines of light. This garment has a number of iterations that each behave in different ways, and thereby support different kinds of physical interaction. In each case, the relationship between waist, hip and torso is measured and used to control laser position, rendering the interface ideal for hip-focused rehabilitation, or any kind of therapeutic care where increasing lower back flexibility is desirable. Technically, the interface consists of an undergarment that measures flexion at the waist (using textile sensors discussed in 2.2.2), as well as a wide hip-belt that supports servo motors, laser modules and an integrated circuit that uses the input from the undergarment to infer body position and thereby inform laser position. In their neutral state, the lasers point downwards, angling out from the hip to suggest the presence of a striped A-line skirt (the lines of light from the lasers forming the stripes, (see fig 4). The garment is being programmed with a number of playful behaviours such that the movement of the lasers echoes, extends and exaggerates the "natural" or expected movement of the light based "fabric" as the wearer of the "in-visible" skirt moves. The skirts provide a context in which to playful explore movement.

A two-person version is being developed to allow pairs of people to play and interact with each other through their skirts. By mapping one person's movement in playful and exaggerated ways onto the other person's "skirt" (fig 4), we hope to encourage playful and extended physical exploration in a more social setting. In such a scenario, learning about body movement would be a shared activity. This may further support the greater ease in communication that has been seen to result from physical engagement. (Gallagher, 2005)

5.1.3 Trace Memory Garment. In a very different use of light, we propose a system that measures muscular tension and physical pressure, and translates this data into light intensity and duration, on the body, at the point of tension or contact. The proposed system will use myoelectric sensing to measure muscular stresses, and will also leverage the natural optical phenomenon known as frustrated total internal reflectance (FTIR) (Gettys et al., 1989) to mechanically translate contact or pressure into light. Visually representing physical sensations where they occur may be of particular relevance to people with damaged, low- or mis-functioning somatosensory systems. It provides an alternative modality through which to access tactile and proprioceptive information. It may also provide learning opportunities for people who have problems with physical proximity and expression. This system provides radically different experiences from, for example, haptic systems, that bring the attention through the body to a screen, or through a screen and haptic feedback device to the body. In a way we are proposing a collapse of the traditional body-screen paradigm to render the body itself as screen.

5.2 Summary

Our expertise is not in disability research, so our suppositions in this area risk being naïve. Nonetheless we see many applications for this work in disability and rehabilitation. The scenarios of use we are proposing include artistic applications for performance and play; engaging rehabilitation patients, physically, through their imaginations – having patients draw or write things through their bodies (Lieberman et al., 2009; Wilde, 2009). We also see broad application with people who have underdeveloped or damaged proprioceptive abilities and/or communicative issues. Extended physical exploration seems to lead to greater self-knowledge, which in turn may lead to extended abilities, enhanced empathic relationships with the self, and thereby greater ease in communication (Gallagher 2005, especially pp. 144-146). We believe this to be of value in many abilitation contexts.

6. DISCUSSION

The proposed devices provide free-form expressive spaces that encourage different qualities of attention: on the task at hand, the actions and gestures of the body, or on the results of those actions as presented through the laser extensions. By focusing on the results of their actions, rather than on the actions themselves, participants may be able to enhance their ability to learn physical skills (Helmer et al., 2008). Bringing focus back to the body can enhance self-awareness. The resulting increase in physical dexterity and range, may also impact positively on the individual's ability and ease communicating (Gallagher, 2005). In related research, participants have been prompted by the affordances of wearable interactive systems to explore and test the possibilities for action in their body, (Wilde, 2010) and thereby engage in a process of creating and reflecting on new modes and patterns of bodily experience, facilitated by the interaction between body movement and the effects of the technology.

The openness of *The Extended Light Arrays* allows for the generation of activities, pitched at an appropriate level, to target specific outcomes. Practitioners will be able to work with each participant to design individual programs, and guide them as they invent their own games. Benchmarks are set on an individual, case-by-case basis. The devices may thus be used by people with different challenges and unconventional abilities to achieve a range of results at a speed or pace appropriate to the individual. Tasks can also be designed for personal idiosyncrasies. Outcomes provide access to the inherent aesthetics of different movements, as well as novel ways of seeing and experiencing the body. Those with low- or unconventionally-functioning bodies may be encouraged to use the neglected parts of their body willingly, inspired by the expressive potential of the light extensions as their attention shifts away from their bodies to the aesthetically refined results of their actions. Doing so may allay further muscular degeneration through extended engagement and lead to greater physical control. Highly positive results have been seen, for example, when dance is practiced by people with Cerebral Palsy (see Tamar Rogoff's work with Gregg Mozgala[2]). The Extended Light Arrays System provides an alternative to dance, whereby participants can engage expressively through their bodies in a multitude of ways.

Gibson (1977) writes of perception leading to an awareness of affordances. If we consider that perception is a skilled activity (Varela et al. 1991), turning attention to and through the body by augmenting perception may lead to opportunities to learn new somatic techniques and increase specific skills and/or range of movement. Nöe (2005) insists that "perceiving is something we do", and that perceptual awareness depends on the perceiver's having "sensorimotor knowledge" – an implicit understanding of the way sensory stimulation varies with movement. By providing novel opportunities to experience in and through the body, and gain insight into the body's capacities and affordances when contexts for engagement are shifted, we hope that people will be able to develop their sensorimotor knowledge and skills. We believe this is relevant to people with many different physical abilities and challenges and look forward to better understanding how to explore this premise.

There are a number of challenges inherent in this research project. To begin with, we have a limited amount of time and the ideas emerging from the collaboration are incredibly rich. We hope to find research partners who are interested in assisting us with user testing and analysis. In particular we would like to work with groups of people who have a range of disabilities to explore and test the relevance of our outcomes, and also impact development. Finally, we are also looking for disabled groups and organizations interested in exploring the creation of cultural artefacts.

7. CONCLUSION

This research crosses many discipline boundaries and requires expertise in a broad range of areas. We believe it will result in innovations that are relevant to a number of research communities, as well as to a diverse public, most important to those with physical and communicative challenges. We invite collaborative interest.

Acknowledgements: Our thanks to the participants. Wilde's presence in Tokyo is made possible through an Australian Prime Minister's Australia Asia Endeavour Award. For supervision of her doctoral research, she would like to thank Dr Richard Helmer and her principal supervisor at Monash University, Dr Melissa Miles.

8. REFERENCES

A Cassinelli, D Manabe, Y Kuribara and A Zerroug (2008a), *scoreLight* Available from http://www.k2.t.u-tokyo.ac.jp/perception/scoreLight/index.html.

A Cassinelli, K Yusaku, S Perrin and M Ishikawa (2008b), *Sticky Light*. Available from http://www.k2.t.u-tokyo.ac.jp/perception/StickyLight/

A Cassinelli, C Reynolds and M Ishikawa (2006a) Augmenting spatial awareness with Haptic Radar. *IEEE Proc. Intl Sympos. Wearable Computers (ISWC)*. Montreux, pp. 61-64.

———. *Haptic Radar / Extended Skin* (2006b). Available from http://www.k2.t.u-tokyo.ac.jp/perception/HapticRadar/index-e.html.

H Chalayan and M Waldemeyer (2008), *Readings*. Available from http://www.waldemeyer.com/laser.html

M Furniss (2000), Motion Capture: An Overview. *Animation Journal* 8, 2, pp. 68-82.

S Gallagher, (2005) *How the Body Shapes the Mind.* Oxford University Press, USA.

E W Gettys, F J Keller, and M J Skove (1989), *Classical and Modern Physics.* McGraw-Hill, New York.

J J Gibson (1977), The Theory of Affordances. In *Perceiving, Acting, and Knowing,* Eds. Robert Shaw and John Bransford, University of Minnesota Center for Research in Human Learning. Hillsdale, Erlbaum, New York, London

[2] ***http://www.nytimes.com/2009/11/25/arts/dance/25palsy.html***

R J N Helmer, M A Mestrovic, D Farrow, S Lucas and W Spratford (2008), Smart Textiles: Position and Motion Sensing for Sport, Entertainment and Rehabilitation. *Advances in Science & Technology* 60 (Smart Textiles), pp. 144-153.

R.J.N. Helmer, D. Farrow, S.R. Lucas, G.J. Higgerson, I. Blanchonette (2010), Can interactive textiles influence a novice's throwing technique? *Procedia Engineering* (The Engineering of Sport 8 - Engineering Emotion) 2, 2, pp. 2985-2990

S Hewitt-Parsons (2006), Unintentional Therapy, Unexpected Results: My artistic life to this point. *Proc. ArtAbilitation*, edited by A. L. Brooks. Esbjerg, Denmark, pp. 91-96.

Z Lieberman, J Powderly, E Roth, C Sugrue, T Quan and T Watson (2009), *The EyeWriter*. Available from http://www.eyewriter.org/.

D Manabe (2008), *Face Visualiser*. Available from http://www.daito.ws/works/smiles.html

E-J Marey (1994), *Etienne-Jules Marey*, (Photo Poche). Centre de la Photographie, Paris.

B Moggridge (2006), *Designing Interactions*. MIT Press, Cambridge.

E Muybridge (1979), *Complete Human and Animal Locomotion : All 781 Plates from the 1887 Animal Locomotion : New Volumes 1-3 (Reprints of original volumes 1-4, 5-8 and 9-11)*. Dover, Mineola.

A Noë (2005), *Action in Perception*, MIT Press, Cambridge, MA

E Schibsted (1996), LifeForm. *Wired*, October 1996, pp. 172-173.

F Varela, E Thompson, E Rosch (1991), *The Embodied Mind*, MIT Press, Cambridge, MA

D Wilde (1997-2011), http://daniellewilde.com

——— (2007-2011), *Swing That Thing: moving to move.* Available from http://daniellewilde.com/dw/SwingThatThing.html

——— (2010), Swing That Thing: moving to move : extending our poetic and expressive potential. *Second Nature International Journal of Creative Media.* 2,1, pp.164-197

——— (2009) *hipDrawing*. Available from http://www.daniellewilde.com/dw/hipDrawing.html

——— （2008a) Extruding the Body with Light to Make Visible the Spatial Relationships inherent in Gesture and Posture. *Workshop on Pervasive Visual, Auditory and Alternative Modality Information Display. Proc. Intl Conf. on Pervasive Computing*. Sydney.

——— (2007) *Light Arrays*. Available at http://www.daniellewilde.com/dw/lightarrays.html

D Wilde, R J N Helmer and M Miles (2010), Extending Body & Imagination : moving to move. *Proc. ICDVRAT with ArtAbilitation* Viña del Mar/Valparaíso, Chile

A Zweite, K Schmidt, D von Drathen, and R Horn (2007), Rebecca Horn, Drawings, Sculptures, Installations, Films 1964-2006, *Exhibition Catalogue*. Hatje Cantz, Berlin.