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# COMMUNICATING MOVEMENT

*Full-body movement as a design material for digital interaction*

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## ABSTRACT

Today, our movements are increasingly informed and influenced, shifted and shaped by a digitised environment. The aim of this thesis has been to explore and present a creative potential in conceptualising full-body movement and movement data for digital interaction. I was motivated by the expressive and performed movements that we observe and act upon in interpersonal communication to identify a potential in digital interaction. I use concepts and intermediary digital tools as a way to both explore and communicate full-body movement as a design material, that is, as a communicative resource for meaning-making in digital interactions. I take a communicative approach and adopt a Social Semiotics framework. I discuss how corporeal qualities are in part expressed through our movement dynamics in that movement requires a body and this body is aged, gendered, cultured and conditioned as well as sensate, expressive and performed. I explore how to address such notions through their visual form, by way of abstracted data, represented in dynamic visualisations. My argument is that there are creative and pivotal decisions in how we materialise movement and movement data for design.

I draw on choreographic research and digital tools to position movement in design and I propose the concepts of *Accessibility*, *Immediacy* and *Generation* as central for how movement needs to be visualised for interaction design. I suggest a textual conceptualisation of movement dynamics in a *Movement Schema*, where I identify *Velocity*, *Position*, *Repetition* and *Frequency* as modalities that address how we use movement dynamics to communicate. I further explore dynamics in movement data by way of design investigations in collaborative workshops with interaction designers Hellicar&Lewis. We created a digital application, *Sync*, which allows for dynamic visualisations of movement data. I also devised the concepts of *Malleability*, *Visuality* and *Ambiguity* highlighting creative considerations in handling movement data.

My motivation for naming and conceptualising movement is to understand how movement can be made to matter for design. By making a case for movement and movement data as a creative material for a designer, I place a focus on *movement scripts*, that run and increasingly perforate our surroundings, informing and altering our movements. Corporeal qualities may be made creatively available through *materialising acts* such as through digital tools for the dynamic visualisations of movement data. By unfolding the concerns of the various stages of materialising movement, designers can consider the role of movement at a conceptual level and in turn enable interactions to be built that are informed by a critical view on movement and, by extension, the role of our bodies.

# 1

## INTRODUCTION: MATERIALISING MOVEMENT

Our environments are becoming increasingly digitised, influencing not only where and why we move, but *how* we move. The relational materiality of digital information has been described in the following metaphor by the philosopher Noë:

I can't swim if there is no water. The water and its availability is part of that which enables me to be a swimmer and likewise the world around me and other people are part of what enables me to perform or enact my experience (2009: online).

Today, our everyday movements are increasingly informed and influenced, shifted and shaped by a digital 'water' or a digitised environment that includes pervasive Wi-Fi access, marker-less sensors (e.g. *Kinect*) and pocked-sized devices (e.g. *iPhone*). By exploring the relational dynamics of movement and digital systems, we can see the reverse argument that we can in turn shape the role of technology in design by exploring how we use our movement as communication and expression. In such explorations it is central that we have a critical view on full-body movement and movement data as they form a constituent role in our interactions with, through and for technology.

### Materialising movement opens up a design space

Movement data is distinctive in that it encompasses corporeal and computational qualities. Noë's water metaphor reveals that the qualities of water enable swimming. Likewise I argue that the digital water in which we swim or move through today enables particular movements, activities and communications. When we design with movement data, we also inform and shape the kinds of movements that digital information influences. As Hallnäs writes, 'Interaction design is a matter of designing the acts that define the intended use of things and systems' (2011: 75).

The more we know about the material qualities and the nature of movement data, the more informed are the decisions we can make as designers influencing the application and development of technology. In terms of design, material is defined as all the elements that are shaped in order to build an interaction: 'Form is the way material builds things; to build a thing, we form materials' (Hallnäs et al. 2002: 157).

In order to address movement for design, designers need to conceptualise or abstract movement. This is because, unlike choreographers, designers rarely work on shaping movements with actual movement although we design with and for both. Therefore, we need to materialise movement through language or visualisations because the movement is addressed abstracted from actual movement. We also need concepts, named qualities and relations that come into play when we work with and apply movement as material in digital interactions.

### Materialising acts

In developing an understanding of movement as a material, designers need to explore, twist, pull and get a 'feel' for the material properties of movement. For more traditional material such as wood or fabric this is an instant exercise, but for movement data such explorations remain more elusive. This is in part because 'digital information is inaccessible to direct experience by humans' (Wood 2007: 4). Also, computation is a composite, and 'computations need to be combined with other materials to come to expression as material' (Vallgård & Redström 2007: 513). Further, digital media often work in terms of processes, with ideas, structures and relations 'that are invisible on the surface' (Wardrip-Fruin 2011: 320). In addition, movement data is particular in that it comprises of corporeal and computational qualities making it in part gendered, enacted, relational and cultural, yet abstracted from the body. In this sense designers need an informed or skilled vision of movement in order to unfold the possibilities of movement as communication. Therefore,

designers need tools for exploring movement data, similar to being familiar with a camera to take advantage of its photographic possibilities. People are highly skilled in deciphering movement with their eyes, yet to do so computationally is still in its infancy (Bevilacqua 2007).

I argue that a material exploration of movement data has the potential to inform a development of novel designs and communications. By drawing on a critical view of movement as part of digital interactions, design may extend the way we communicate and in turn the way we move:

Through digital abstraction, we can get a better understanding what people are doing in spaces, and this will make a massive differences for how we can make new kinds of interactions and new kinds of artwork and new improvements to life through design (Levin 2012: online).

This thesis materialises movement through conceptual developments (introducing, naming and positioning concepts) and design developments. It describes the making and experimental uses of a tool called *Sync*. Overall, I make an argument for full-body movement and movement data to be considered as a material and as part of a designer's repertoire. I argue for a research trajectory of movement as communication (in concert with movement as experience in computing) and reflect on the possibilities of such a new design space.

### Background

The motivation for the study was the coming together of reflections gathered through my training in graphic design at Central Saint Martins College of Art & Design and the Royal College of Art, London, as well as in dance at Den Norske Operas Ballettskole and Kirsti Skulleruds Ballettskole. Having explored movement through many years of dance training, I was intrigued by the sophistication with which we all use our bodies to communicate with each other and, equally, by the lack of complexity in the way technology 'senses', reads, uses or applies such communication.

### Research questions

The overall query of this thesis is as follows: How may designers explore movement qualities and potentials as a design material in interaction design? This played out in three more specific questions as the study progressed and was published in peer-reviewed journal articles: (1) What qualities and communicative aspects of full-body movement visualisations are important when designing for digital movement-based interactions? Reflecting upon the research for this initial part of the project allowed me to identify movement

data as a creative material for design. This led to the next question: (2) How may we conceptualise and materialise movement in order to inform a design process of movement-based digital interactions? This was explored through the two strands of theory and practice. The former resulted in a *Movement Schema*, while the latter in the digital application, *Sync*. These two concurrent strands of enquiry led me to the next research question: (3) How may digital tools enable designers to creatively engage with movement data and by extension movement, in order to explore the inherent dynamics in movement data? In this part of the project, I developed concepts that addressed the making of digital tools as part of a process of materialising data for interaction design.

### Framings

I make a case for a design-sensitive approach to movement by way of movement data. Movement as communication has been studied in several domains related to design. In linguistics, movement is studied foremost as gesture and posture in relation to language (e.g. Birdwhistell 1971). In developmental psychology it is seen as pre-verbal as opposed to non-verbal (e.g. Stern 1998). Art history has been concerned with movement as posture and by how it is captured in paintings, sculptures and photography (e.g. Penny 2004). Further, film and performance studies is concerned with movement as style in styles of acting and style as expression (e.g. Mamet 1992, Foster 1995). In dance theory, movement is seen as a form of non-verbal communication expressing what words cannot (e.g. Williams 2004).

I adopted a Social Semiotics approach to movement in order to focus on the semiosis of movement for design. This was in part because of the complexity of the meaning-making of movement and in part due to the fact that movement data is a material continuously made as data is presented and is thus a pivotal step in developing movement-based digital interactions.

I draw on how movement has been understood in related and overlapping fields addressing movement data. I do this by exploring the ways in which the moving body has come to signify meaning, that is, as a creative resource for interaction design. I further explore the practical and technical concerns of movement data, according to which movement data handling is a creative resource for design. In so doing, I draw on the three components of digital media, design and body. Movement has been addressed regarding all three but with different frameworks and different knowledge-building practices (see Figure 1).

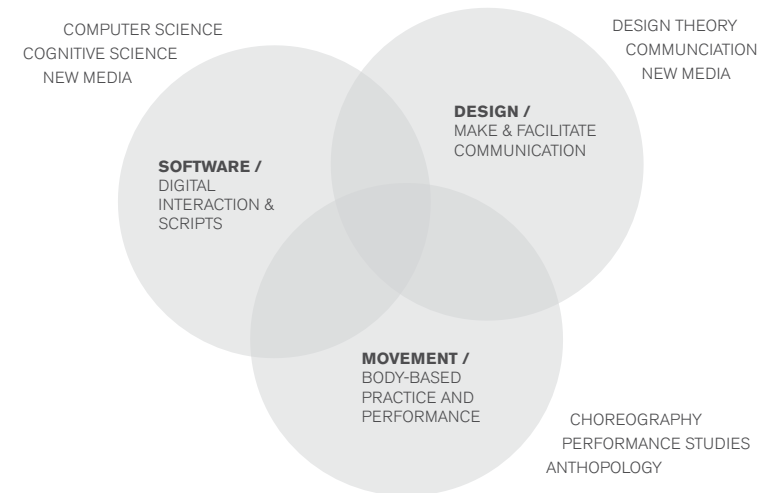


Figure 1 Overlapping fields and practices: the diagram identifies the elements that constitutes movement-based interaction drawing on a different practices and theoretical fields.

I chose Social Semiotics to address movement data as a design material and make an argument for a creative potential for design. However, I do also acknowledge the limitations of categorisation, abstraction and representation that come with such an approach. This extends to the tendency of Social Semiotics to be centered on grammatical, structural and systemic linguistics, as Prior argues (2005). Norris goes some way in addressing situated sociocultural practices by attending to the structure and materiality of mediating action (2005). However, this thesis attends to how a material can *come to be* part of such mediating action. Thus, I argue that by attending to *how* we categorise in addition to *what* we categorise we may address issues of embodiment and agency through movement and movement data.

### Methods

Methodologically, I drew on both theoretical reflection and practice-based design investigations in my explorations of how designers may creatively engage with movement and movement data in order to understand and shape it as a design material. These approaches were positioned from a communication perspective as this framework enabled me to textually analyse current research on digital tools in choreographic practice and to identify concepts addressing visualisations of movement for interaction design (Article 1). I then drew more closely on Social Semiotics in developing



a *Movement Schema* that identifies and names central modalities in full-body movement and how they relate to each other in terms of design. I also drew upon my own and others' design expertise in collaborating with interaction designers Hellicar&Lewis in developing *Sync*, a digital tool for exploring movement data through dynamic visualisations (Article 2). These design investigations, together with textual analysis informed by Social Semiotics, further allowed me to identify and propose concepts central to digital tool-making for interaction design (Article 3).

Throughout the research, I also attended workshops, art labs and symposiums where I had the opportunity to present my work and be exposed to other's related enquiries, fields of work and expertise. I could also observe, discuss and ponder my own and others' design developments and artistic and technological explorations. I found that this was an invaluable resource, as I was able to connect with people in larger international projects and become aware of current developments in the field. This was also compounded by the online open source community ethos with which this study aligns itself, enabling collaboration across projects and countries.

### Positioning movement for design

The chapters that follow, discuss how it is complex to frame movement as communication, since it is embodied, experienced, expressive, cultural, relational and performed. Perhaps this is why movement is only narrowly addressed or lacks a critical reading in design, as Farnell found in *Anthropology* (2011), Williams in *Dance* (2004), Sheets-Johnstone in *Philosophy* (1999a, 2011), Stern in *Psychology* (2010) and, indirectly, by McCarthy and Wright in *Human-Computer Interaction* (2004) through an experiential account of use.

I found that movement data drawn from an embodied, expressive, cultural, relational and performed body is unique in that it encompasses both corporeal and computational qualities and that these are in themselves particular (e.g. Munster 2006, M. B. N. Hansen 2006, Portanova 2013).

### Exploring movement for design

I make a case for dynamic visualisations giving designers insights the distinct qualities of movement data and, by extension, movement as communication. The tool *Sync* addresses some of the concerns raised in the framing of movement as material for design e.g. movement as embodied communication. I discuss *Sync* in light of full-body movement as a resource for digital communication.

Overall, I reflect on how designers may approach movement as a material. I address how movement has been conceptualised in dance, anthropology and linguistics in order to study expression, experience and communication. I also make a case for how design may conceptually address bodily agency by way of movement. The motive is to highlight the role of movement as a constitutive part of interaction designs as well as to inform a design process of movement-based digital interactions. I also briefly describe some limitations of my project.

### Contributions

(1) The first article introduces the concepts of *Immediacy*, *Accessibility* and *Generation* in movement visualisation for interaction design. (2) The second article centres on a *Movement Schema* as well as *Sync*, a visualising tool for the dynamic representation of movement data. (3) The third article develops the concepts of *Flexibility*, *Visualisation* and *Malleability* in tool making for digital movement-based interaction design, as well as a model positioning these concepts in a tool design process. (4) The open source tool is available (<http://kinetically.wordpress.com/sync-download/>) and is thus both a research contribution and a contribution to practice. (5) This exegesis argues for how computational materials are generated through theory and practice in *materialising acts*. The exegesis positions movement data as a design material through the tool *Sync* and movement data visualisations. It further positions the relational mix of movement and movement data as a topic ripe for further research.

### Outline of the thesis

In summary, the thesis consists of three published peer-reviewed articles, a published open-source digital tool and an exegesis. The exegesis is structured as follows:

Chapter 1 introduces and outlines the overall aim of the thesis, the research questions, touching briefly on the framings and methods, and presents the structure of this publication.

Chapter 2 outlines the background and motivation for the research questions and presents Social Semiotics as the theoretical framework for the research. I describe a lack of approaches and tools for design to work with and explore movement. I position full-body movement as a resource for design, drawing on the dynamics and conventions in movement-based interpersonal communication. I further relate movement to design by way of movement data and identify the handling of movement data as a materialising and creative act, which in turn informs the design of movement-based digital interaction.

Chapter 3 presents methods for developing the research and the research designs. It discusses textual analysis and concept construction, design investigations and collaborative design as methods for generating and communicating knowledge in and for interaction design. The chapter further presents a summary of the published articles.

Chapter 4 takes up the overall question of the ways in which designers may materialise movement. I use concepts from my articles to discuss concept-building as a materialising act. Motivated by the need to unfold various possibilities in movement visualisation for design and digital tool-making for design, I found that proposing concepts was a way to discuss and communicate such possibilities. In turn, these concepts present an extension of Social Semiotics, as they address the semiosis of movement for design.

I then discuss the *Movement Schema* and *Sync* by considering the ways in which they materialise movement and movement data by providing insight into dynamics and real-time visualisations. I focus in particular on corporeal and temporal qualities and the ways in which movement data represents these. I argue that the practice of digital re-corporealising offers a creative resource for interaction design. In turn, such a materialising act or materialising production is a semiotic resource in itself and also presents an extension of a social semiotic understanding of movement.

I proceed by reflecting on the implications that addressing movement in this way has for the design process. I argue that a dynamic material such as movement data positions interaction design as composition and innovation (rather than a digital imitation or technological optimisation). I point to some of the implications of materialising movement for design as well as suggesting further research.

Chapter 5 is a summary and a conclusion of the research. It suggests that a material exploration places the moving body as part of the action in the design of interactions, rather than as a post-design occurrence. It further suggests that a material exploration of movement provides performative data in that they may inform novel communication. The conclusion also presents a short list of my main contributions to a critical understanding of full-body movement as a design material for digital interaction.

# 2

## MOVEMENT AS A MATERIAL FOR DESIGN

In this chapter, I present the philosophical visions and positions of this thesis as a context for identifying movement as a material for design. I explain the motivation for the project, which has proved pivotal in research development both in terms of my background and training (design and dance) and in terms of the subject matter of digital movement-based interaction design.

I explain why I included design processes as a part of the research and why the project focused on movement and movement data as the design materials. I also argue for why methods need to be revisited and developed especially as they relate to the body. I discuss the need for interaction design research to acknowledge the relevance of body-based knowledge production. I also outline some ethical considerations.

I describe Social Semiotics as the theoretical framework adopted for the thesis. I discuss how the body and the moving body in particular, can be a resource for digital communication. I briefly outline the steps whereby movement is abstracted with attention to what each transaction addresses in a materialisation of movement for design.

## 2.1 STARTING POINTS

I trained as a graphic designer at Central Saint Martins College of Art and Design and at the Royal College of Art, London. Previously, I had trained to become a dancer at the Norwegian Opera's Ballet School until the age of 17. I mention this training as it informs a skilled vision, the 'socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group' (Goodwin 1994: 606). This mix of training sparked my initial questions: Where is movement in interaction design processes? How may interaction designers address and work with movement as communication?

This prior knowledge and training coupled with a desire to design as well as understand movement-based interactions informed how I read, analysed and positioned the theory close to practice. Design research has been defined in a variety of ways (e.g. Sevaldson 2010). However, design research can be distinguished as a motive to generate 'knowledge about design and for design' (Horvath 2001: 1). This is an apt definition of design research for my doctoral research as I approached the project through two means: theory and practice. For design research, these have been distinguished by Frayling as being *into* design i.e. studying the practice of other artists or designers and *through* design i.e. the practice serving the purpose of meeting the research aims (1993: 5).

### The role of design: why make?

The project comprises several overlapping but distinct disciplines, from choreography to interaction design and Human Computer Interaction (HCI). This imposes a challenge with regard to methods or processes of enquiry, as each research field is based on different practices and analytical frames. With an aim to inform interaction design research, I chose to include a design process as one strand of enquiry informed by theoretical writings in each field as well as collaborative workshops and arts labs where the making was close to the theory building.

My approach to making with reflection as a mode of enquiry is motivated by the possibility of exploring materials to inform design processes and use of movement beyond how movement is currently applied and affected in digital interactions. With the aim then to explore the potential of movement and movement data in interaction design, I look beyond current practice by adopting a material approach to movement. Goodwin's research on how a 'professional vision' informs practice places this potential (2003: 20). Goodwin refers to archaeologists whereby the discovery and excavation of an object or feature is understood through the embodied work of making the

object or feature visible or apparent. It is also understood in the context of conversations with colleagues, the forms with which the discovery must be registered and so on. In this sense, one can argue that we are simultaneously making what we find as we discover new features or objects. In this sense, my stance is that it is important to voice concerns and considerations that come from within a field to complement research and insights coming from a more situated stance where the research comes from observing design rather than designing. As such, the project aligns itself with Archer's view on design research:

there are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, or to enact something, calculated to explore, embody or test it (1995: 11).

I propose that exploring movement in interaction design is a circumstance wherein the role of design may inform the query in ways that would be hard to identify without engaging with the material. With novel access to computation through affordable sensors and building-block algorithms in movement-capture coupled with an active and accessible open-source community, designers may now explore computation as a creative material in ways not previously possible. This has in part been a challenge of access to technology and in part a challenge of software itself being 'outside of the phenomenal field of subjectivity' (Hansen 2000: 17) and data needing another material in order to come to expression (Vallgård & Redström 2007). This materialising step is seldom addressed and despite software's 'underlying logic exists in an explicit encoding that can be examined, this takes place very rarely' (Wardrip-Fruin 2011: 320).

In other words, there are conceptual and creative decisions already taken in the making of computational material that inform how one may then design using such material. I found that this was an underdeveloped area in relation to the pervasiveness of digital interaction today. Slavin points to the same concern in his critique of virtual reality by saying that we could be 'inventing new ways to see rather than new things to look at' in that reality is plenty: there are plenty of things to learn to see in the worlds around us (2011: 173).

### A design approach: why focus on material?

I position design material as the elements that are formed through a design process: 'Form is the way material builds things; to build a thing, we form materials' (Hallnäs et al. 2002: 157). In other words, this refers to the elements where there are choices to make such as regarding their shape, scope or the

role of the elements that contribute to or become part of the interactions. A designer works with various levels of knowledge as to how materials may appear in their finished state. A shaping process can in part be informed by studying the appearance of a finished design, which for interaction designers can be the experience of a digital interaction. However, in order to inform the *making of designs* rather than an *experience of*, designers also need to know and explore a material's properties or characteristics, as Hallnäs writes:

The logic of design expression is the basic aesthetic guiding force in the design process. What is given in the process of designing is a task to express something, to introduce, to define that which displays a thing. Experience of use is in this respect always secondary (2011: 75).

Thus it is important to know how materials may be shaped and shifted, mixed and meshed or activated into a final design. Additionally, designers need to know the tools with which to do so.

Therefore, in order to explore 'that-which-is-not-yet-in-existence' (Nelson & Stolterman 2012: 154) I decided to explore the possibilities of the constituting materials in digital movement-based interactions. I found that movement data, despite being a fundamental element in any movement-based digital interaction, was rarely addressed as a creative material. I also found that there were few tools for working with movement data and that these were in the main developed for interaction with and for sound. The software used by choreographers for instance, have mainly been 'written by and for musicians (BigEye, Image/ine, Max/MSP, VNS). Such code may not be ideal for physically rich and complex action' (Birringer 2008: 146).

In addition, the available software for movement concentrated on analysing, creating and facilitating movement for the stage and performance e.g. *Isadora* (<http://troikatronix.com/>), *PieceMaker* (<http://motionbank.org/en/event/pm2go-easy-use-video-annotation-tool>), *Field* (<http://www.openendedgroup.com/field/>) and *Whatever Dance Toolbox* (<http://badco.hr/works/whatever-toolbox/>). This may differ from the kinds of processes and movements that design usually engages and draws upon.

In shaping a material such as movement, by way of movement data, I also lacked access to the possibilities of designing the various processes with which to handle and 'play out' such data. In particular I needed to understand the visualisation processes if I was to design with movement data:

Digital media are not simply representations but machines for generating representations [...] the operational and ideological

commitments of digital media works and platforms are visible more in the structures that determine their movements than in the tracing of any particular series of states or outputs (Wardrip-Fruin 2011: 303).

In other words, the visible in a digital media design will not necessarily reveal the potentials of its computational material. A finished design will present a particular instantiation or a particular process or generation of a computational material. Similarly, an understanding of choreographic processes can only be partially informed by viewing finished pieces performed on stage. One would also need to understand the potential expressiveness of movement and the physiology of bodies as well as techniques for movement generation and movement rehearsals.

In this sense, for an interaction designer to gain an understanding of the design processes of digital interaction, the designer needs to couple an appreciation of existing work with an informed view of the processes with which they are made. Interaction design is a young research field and there is much to explore through design:

When we are moving beyond the well known and on to the new and not yet known, these 'areas' become useful and creative exactly because of their vagueness. Their blurriness makes them open, that is, open to diversity, creation, and combination. Thus, the blurred edges of concepts are places (topics) where invention and innovation take place (Liestøl 2003: 405).

In this sense, we can start to explore how materials come about today and how a material's capacities may be communicated (e.g. Bell & Dourish 2007). I position a material's agency to reference its capacity for action e.g. the possible ways in which a material may be formed or put to work. I further position this work in relation to a designer's process as elements made material in particular ways in order to be designed or to be part of a design. In this sense, I see a material's agency as continuously negotiated and made in a design process as well as in a finished design: 'Agency is not an attribute but the ongoing reconfigurings of the world' (Barad 2003: 818).

### **New methods for new computational materials**

My literature and software reviews suggested that computational modelling of movement, though precise, lacked an identification of creative potential in the data or the creative potential in handling the data. This entailed that in part I had to find out how to find out. On the subject of computational material shaping design Manzini termed this ‘extending the knowable’:

Faced with new matter, which takes the form of a set of encoded information, the designer’s capacity to communicate increasingly becomes the central feature of design practice (Manzini 1989: 63).

In this sense, it is important to explore and articulate design materials because computational practice also builds conventions, as Haigh writes:

Software tools encapsulate craft knowledge, working practices, and cultural assumptions. [...] these encapsulated qualities are reproduced with each new software revision, often enduring for decades’ (2009: 7).

This concern is also described by Blaauw and Brooks regarding the difficulty of arriving at the design choices and possibilities in the analysis of a finished design in computer architecture (1997). In this sense, by researching and engaging with a material, its processes and possible expressions, we gain an understanding of the possible ideas that can be achieved through a materialisation process. This informs design processes and, in turn, research processes. I explore materialising acts on movement and movement data. However, my concern is to develop an understanding for design knowledge. This entails different methods and different outcomes as discussed further in Chapter 3.

The research presented in this thesis was shaped by the journey I took as a design researcher, initially planning to design movement-based interactions by way of installations and explore the nature of interactive full-body movement. However, the further I progressed with theoretical and practical enquiries on the role of movement in interaction design, the more foundational questions I found unanswered. In other words, before I could design movement-based interactive systems and settings, it required a positioning of movement as a design material for digital interaction, then to see how movement data could be visualised and its communicative potential presented and, finally, to find how one may design tools for such materialising acts (e.g. Hansen 2010, Hansen & Morrison In Press, Hansen 2013).

### **Acknowledging body-based knowledge generation**

My focus on movement data in movement-based interaction design lies at the intersection of design, digital media and the body. The investigations therefore in part draw upon knowledge acquired through body-based practices. It is important to include and acknowledge such knowledge-building practices. In the context of performance studies, Dolan asks how dance and theatre studies may avoid being ‘dispersed into metaphor’ as they develop academically (1993: 417). Foster further critiques the ease with which other disciplines adopt concepts and concerns built up through body-based practices such as performativity (1998). I mention these concerns because they could also be addressed in the context of interaction design. Although I am addressing movement for the design of interactive systems, it is important to note that ‘virtually all interaction with technology makes use of human movement’ (Matthews 2006: 403). It can also be said that design not only makes use of movement but shapes it as well:

Rather, technology becomes a structural force. For this reason, technology (design) is not the result of socially formulated needs or utilized functions. On the contrary, it permeates our environment and becomes a precondition for our individuality and our self-conception, since it produces use.’ (Buurman, 2005: 53)

There is also a growing acknowledgement that designers need to physically move themselves to fully grasp the implications of the concepts that they develop (e.g. Hummels et al. 2007). In order to address these concerns, my explorations of full-body movement as a material for design were informed by these discussions, and I chose to organise workshops where we as designers could investigate movement by way of making and moving ourselves. Ingold argues for this kind of knowledge from material making, working with its properties ‘and what it feels like to work with them’ (2011: 3). Bunn further writes the following:

the maker’s relationship with materials is an important and fundamental part of making for craftspeople, artists and handworkers throughout the world, without which culture would not be as we know it. Moreover, there is more to the way we use our bodies in working with materials and in making than merely skill or technique (2011: 21).

These discussions emphasise the role of the designer in relation to materials for interaction design, both with regard to the process of making and material as well as the outcome i.e. the designs. I discuss this further in Chapter 4.

### Addressing agency

These issues point further to a matter of agency in conceptualising and designing for and from movement. Burkitt places our socially informed movements as follows:

We never simply ‘have’ a body, for it is always the object and subject of signification and of attitudes and judgements, which are socially formed (1999: 99).

In other words, when a body is a part of an interaction, it is a body particular to a certain time and space. The choreographer Paxton describes the challenge of deriving laws of movement from objective analysis: ‘Being essentially objective Newton ignored what it feels like to be the apple’ (1987: online). For interaction design, this is a central issue. The design of interactions also needs to find ways to address the role of agency in our bodies along with the potential communicative role of our movements. These are central to movement-based interaction in the sense that a body’s capacity for action is acted upon by a particular person at a particular time and place.

In this sense, movement cannot be seen as a constant in interaction. The way we move and use our bodies is closely shaped by culture. Mauss described the way we move as ‘techniques of the body’ informed by society so that as society changes, so do our movements (1992). Wegenstein points to how the body has been seen as a constant yet neglected part of cultural production throughout history (2010). However, the roles our bodies play do not stay constant. In this respect, Foster argues for the importance of revisiting the body as culture develops:

as long as every body works to renew and recalibrate these codes, power remains in many hands. Otherwise the conventions will take us ‘unawares’ and gain the upper hand (1995: 19).

I mention these arguments in order to acknowledge the agency of bodies in interaction, which is a core issue to consider when building and designing interactions for future designs such that they can leverage the sophistication with which we communicate through movement. In Chapter 4, I discuss the potential for digital interaction in addressing the communicative potential of movement and movement dynamics in particular. As a design researcher coming from practice, one of the aims of this research project was to remain relevant to practice. As such, I needed to find a way to address the agency of a body or our movement in a way that would be relevant to designers. This motivated my choice of Social Semiotics as a theoretical framework. As will be explained in subsequent sections, this framework aligns itself with the

design process of sense-making through material exploration, by identifying meaning-making processes rather than settling on a fixed meaning and as such reflecting a designer’s process of creating, communicating and facilitating meaning through material explorations and designs.

### Ethical considerations

It is important to note that this study of movement for digital interaction and materialising movement data was not undertaken to automate or functionalise interactive movement communication or by extension to gain control of movements. The thesis has an experimental, explorative material approach, which implies that its aim is to open up, unfold and inform design researchers about movement data and how it may be used to communicate. The research aims to support designers, artists and others in creatively and critically drawing upon movement and applying such data for people and with people, as opposed to people having to adjust their movements to the design.

I assume that with increased knowledge of the nature, scope and possibilities of movement as communication through and with digital media, designers may make more informed choices concerning technical and moral issues:

it is political and ethically crucial to recognise the vital role of infrastructure in the ‘built moral environment’. Seemingly purely technical issues like how to name things and how to store data in fact constitute much of human interaction and much of what we come to know as natural (Bowker & Star 1999: 326).

However, by focusing on creating systems that enable expression rather than having a focus on function, we may also be adding to the ways in which we express ourselves and use our bodies rather than automate, imitate and limit. I am in particular motivated by the computational possibilities of addressing a variety of movements and a variety of bodies. Thus, instead of automating and streamlining designs for an average body, we may use computational possibilities to tailor and tack for a greater variety of expression in movement with and through digital media. I am however aware of the argument that by presenting a tool modelled *on* movement dynamics, I thereby implicitly present a model *for* dynamics (Suchman 2007).

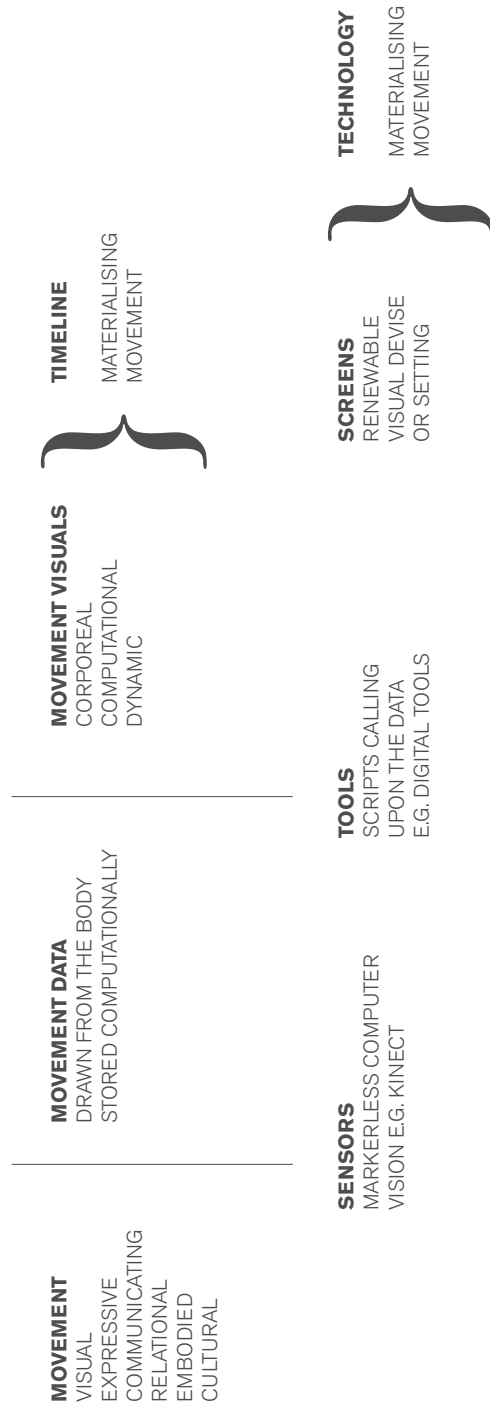


Figure 2.2a The diagram describes a timeline of the kinds of technological assemblages I address in my thesis. Sensors, tools and screens enable the transitions in a materialisation of full-body movement to computational data and finally to re-configured visuals. These transitions are positioned in a timeline in order to identify the various steps that influence and may be shaped in movement-based digital interaction design. The timeline highlights the sequence of steps in preparing movement data for a design process.

## 2.2 CREATIVE POTENTIAL IN MOVEMENT DATA

The next section describes the resources made available for design in approaching movement as a design material. I position an approach to the body in relation to digital media and present a diagram of the process of materialising movement by way of abstracting movement data for digital interaction. The diagram describes a timeline of the transition from physical movement to data to visuals. It also positions the technology that enables these transitions. I discuss an approach to movement data as a design material, first as a material with particular agency: the immaterial yet decisive nature of software that extends and encourages our moving selves. Second, I address this as a way for designers to address actual movement.

### Digital water

Noë's description of the relationship between water and swimming from Chapter 1 points to a relational dynamics between the properties of water and the act of swimming, where one element influences the other and together they create particular possibilities. Today one could approach our urban surroundings as digital water, with digital technology tracing and tracking our movements: a digital water in which we move and live our lives. Examples from our surroundings today range from sensors that register our arrival, open doors and turn on lights to the smartphones in our pockets that make site-specific information available and allow us to communicate beyond our physical reach. Figure 2.2a outlines the kinds of technological assemblages that I address in this thesis as well as the step each technology will allow.

As we move through this digital water, we are conditioned by how we are seen, how we want to be seen and what we want to communicate. In doing so, we perform a swimming act akin to Noë's as we move through our days affected by and affecting our surroundings. This agency or potential for communication with our body has been described by Goffman as a performance: 'All the activity of a given participant on a given occasion which serves to influence in any way any of the other participants' (1959: 15). Goffman describes such interactions as characterised by a fragile yet indispensable 'procedural order' or 'working consensus' (1959: 173). Goffman is concerned with interpersonal interaction, yet the notion that we choose how to present ourselves is pertinent for digital interaction design as these choices are corporeal (e.g. Noland 2009) and expressive (e.g. Moore & Yamamoto 2011) also in a digital interaction.

However, there are some defining differences in that designers can set premises for a communication or expression and can shape physical



surroundings or inform an understanding of how we may be sensed and read in various ways. In order to understand the design principles for such a world Kirsh, argue that,

we become familiar with the ongoing developments in embodied, distributed, and situated cognition' in other words develop an understanding of the agency of or bodies, of our movements for design (2013: 26).

In this sense we may say that all movement is interesting for design in that 'we cannot not communicate' (Watzlawick et al. 1967: 49). In this sense, all movement, whether intended or not or whether perceived as intended or not, *is* communication in that it is visually available to others. We can see this as we go through our day, reading and responding to the movements of others in queues, negotiating people on pavements, perceiving a waiting scenario as we walk into a meeting and so on (Wei 2002). The role this kind of communication may have in digital interaction we cannot yet know; we need to build a critical understanding of this kind of communication. The choices we make regarding how we move are expressed through the media in which they are made i.e. the body: 'Movement is unique among media of expression. In other media, the mode of production is different from the mode of reception' (Sklar 2000: 72). However, movements communicate to others only as far as they can be seen. As Kendon writes, 'if signs are to be transmitted, they must be seen' (1995: 116). In this sense, we can position movements as a visual occurrence, and such visuals can be understood as communication, in part available to computational systems as well as other people.

However, I am concerned with digital *interaction*, which includes but does not limit itself to remote movement analysis. Therefore, I will also need to explore how to account for movement as an experienced and influenced form of communication. These dual points of view i.e. an external observer of movement and the experience of performing a movement, come together in digital interaction. However, as my research aims to inform design processes, I attend first to movement as observed. This is required to understand the design of digital interaction. As Galloway argues, 'these new digital devices are all logic machines to begin with' (2011b: online).

This is not to exclude the agency of the mover; however, we need to attend to this agency in such a way that may be harnessed by an externally observing system, in other words, as a material. 'Logic is the science of appearing, just as ontology is the science of being' (Galloway 2011b: online). To first attend to the material contribution in movement is aimed at seeing how movement

may be shaped and drawn upon through design, as opposed to experiential accounts of existing technology. These two points of view are often mixed in discussions on digital interaction, and it is thus important to separate *what* to address *when* (also see Figures 2.2a and 2.2b).

### Designed mediation

When our physical bodies are sensed, registered or traced through digital media, we may understand our bodies as extended. In other words, our movements may be registered, processed and re-presented, and this in turn may influence how we move. It can be akin to a glimpse in a mirror or window that we pass by, which allows us to check what we look like to others, and, more often than not, to correct our posture. However, with digital media, what we see reflected back may be technically mediated.

M. B. N. Hansen describes this disparity between our body schema (how we experience our 'inner' motile body) and our body image (how we see our visual self outwardly) as 'body-in-code' (2006: 20). Hansen describes how with digital media, this relation may be technically mediated. Herein lies a creative potential – designers can shape the material and communicativeness of digital technology and thereby may shape some of the dynamics of how we may choose to present ourselves to the world. However, as Suchman writes, we may focus on the relational boundaries for and in communication:

The accountability involved is not, however, a matter of identifying authorship in any simple sense but rather a problem of understanding the effects of particular assemblages and assessing the distributions, for better and worse, that they perform (Suchman 2007: 285).

Suchman makes a case for how we may understand the capacities for action or agencies at play in a human-computer interaction not from first principles or computationally, as they cannot be answered in principle. Rather, these capacities or agencies have to be articulated in practice, that is, we need to approach them performatively.

Hansen describes how experiences of bodies-in-code have been explored in fine art installations and artworks such as in Utterback's *Text Rain* (2004) and Penny's *Traces* (1997). These artworks give a screened, visual representation of the body, yet it is important to note that a technological system does not necessarily need a screen (nor visual representative feedback) in order to influence our actions. Slavin illustrates this by describing an automatic voice recorder: we change our voice according to how we think we might be understood by the script running the automatic voice and we usually adopt

a tone of voice that we would rarely use to address a person (Walker 2011). In other words, if we know how we are being read or know how our movements are being registered, we adapt accordingly.

The adaptability in our movements in interpersonal communication is sophisticated and complex. It can be argued that it may be easier to study meaning-making through movement when such communication does *not* work, such as in Bergson's analysis of a stumble (2009) or in Goffman's writings on embarrassment (1956). Loenhoff (2012) also argues for such an approach in digital communication and that to gain insights into processes of technology-mediated communication, we need to study communication that does not run smoothly. This is because it permits us to understand the constitutive conditions of processes of communication as they are currently applied.

I mention these examples in order to couple concerns of material with communication and also to highlight the near invisible ways with which we use our bodies to communicate. They point to how easily we adapt and adjust according to how we are seen or are registered in various ways. I also refer to the examples to argue for a critical view on how our movements become conditioned by digital media i.e. the application of digital technology. This approach acknowledges a constitutive model for communication where 'worlds are made by us through our dynamic coupling with our surroundings' (Noë 2007: 127).

### Designed relations

In order to examine how designers may work with the creative potential in shaping the relational dynamics of a body-in-code, we need to understand not only the experience of a body as it is digitally extended but also understand how the relational dynamics comes to be and how to make it so i.e. how a body-in-code comes to be materialised. One way of doing this is by studying its constituent parts. Importantly, these parts or elements need to be studied in combination. This is important for interactions as it is in the meeting with one another that the specific and novel aspects are brought into play in the elements. Researcher and choreographer Schiller describes this relational dynamics as follows:

If we accept this entanglement between human-created techniques and movement as a dynamic structural and relational event, then we replace discussions of the body and space or body and machine with the fluid surprises of relational dynamics (2006a: 109).

Schiller labels such embodied transactions a *Kinesfield*. She describes the 'body-medium as a temporal-spatial dynamic based on interactive processes of feedback which take place between the body and its environment' (2006b: 225) by expanding on Laban's notion of a *Kinesphere* where he delineated the physical space a body could occupy (Guest 2005).

However, a designer does not have the scope of a choreographer in instructing dancers in creatively shaping movements. Movements are less accessible for an interaction designer as interactions are usually not meant to be staged but played out, often in settings independent of the designer. Thereby, the role of technology is brought into focus for designers, yet it is important to see technology as *arrangements* that can enable particular meaningful associations of persons and digital objects or systems (Suchman 2007).

A particular reading of agency and events is thus central to understanding movement in interaction design. In gaming, Wood describes such interactive events as 'digital encounters' and explores the notion of choice as part of the experience of the wide variety of interfaces as a way to reveal our changing digital landscape (2007). My argument is that as designers shape and influence these digital encounters, they need a critical understanding of what they are working with, which aspects and elements they may alter, shift and shape and which they may not, in order to understand the effects of these changes.

Movement data is one of the many elements making up the relational dynamics sketched out here, and by emphasising the potential in movement to be influenced and informed by technology, designers may start to see movement data as a particular material in itself, with distinct qualities and concerns.

In this sense, a material approach has the potential to show designers that movement data is a way to articulate and discuss movements as well as shape movements. As I discuss below, by describing movement data as material, we can build a vocabulary that addresses the properties of the material and in turn communicate what they enable in design. Little research has addressed this kind of direction, and I take this up below.

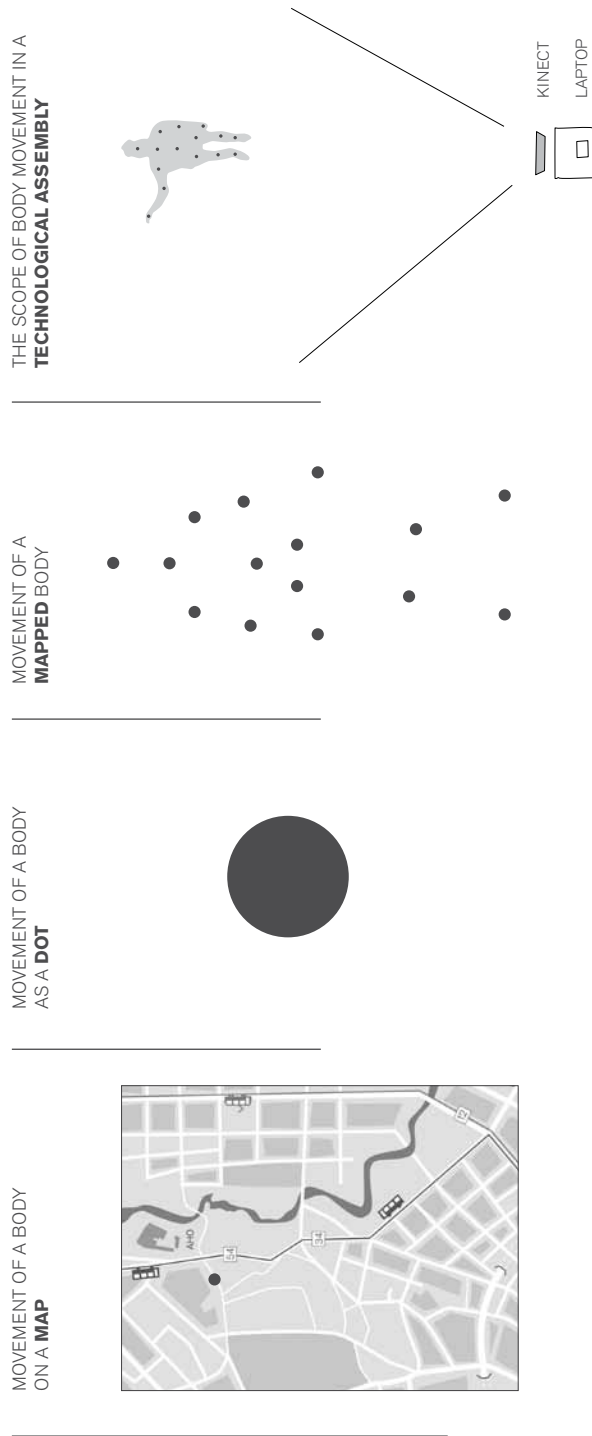


Figure 2.2b The diagram outlines different kinds of movement data by their different points of view. From a bird's eye view where the movement data relate to coordinates on a map to a more detailed view of the body as a dot, where the movement data refers to how the body moves as a single unit of analysis. By allowing movement data from different parts of the body to be analysed, the movement data can allow for the body to be represented as a complex, multimodal system in itself, such as with a *Kinect* skeleton of 15 points illustrated here. The last section shows a *Kinect* set-up to illustrate its limited scope as well as the simplicity of the set-up.

### Movement data

In this project, I approach movement data as a design material. The creative potential in handling movement data by way of material properties is rarely addressed. It is however arguably an element that an interaction designer can consider, use and shape. Designers usually work conceptually on screens and in sketchbooks as well as by making models and mock-ups. Rarely do they design with live bodies to 'sketch' out interactions like a choreographer would sketch out a new movement in a choreography workshop. Thus, in design, movement is usually worked with as an abstraction. In Figure 2.2b, I describe the various levels or kinds of movement data that can be drawn from full-body movement.

Design tools are required in order for designers to explore the movement data on its own terms i.e. not in order to test the limits or scope of the technology nor to test an imitation of actual movement but to explore how movement data may be presented to see what we could then make and design. In particular for digital material, Victor argues that you need to connect visually: 'You can't discover if you can't see what you're doing' (2012: online).

Movement data may be presented at various levels of computation from 1s and 0s to scripts and visuals (see Figure 2.2b). This needs to be communicated via interfaces and data sets that designers can access, shape and use as material. There is little research on interaction designers' relationships with their tools, in particular on 'how interaction designers choose and use tools for generating ideas' (Stolterman & Pierce 2012: 25). The area is further made complex by movement data having corporeal and temporal qualities and relations, which become apparent sometimes only in the ways in which the data is called upon and presented.

However, the answer to how we may understand corporeal and temporal qualities and relations in movement data may differ from the way we understand such qualities and relations in actual moving bodies. My explorations have been based on the working assumption that movement data is different than actual movement and that the steps in abstracting movement are decisive for the resulting material with which we design (see Figure 2.2a). Yet I argue that the body retains a role in the sense that the visualised data allows us to read bodily qualities from the masses of numbers pertaining to a movement. Munster argues for such a role for the body that she sees as an embodiment existing in a particular time and space:

It is not that bodies time and space have disappeared from digital culture, but the experience of them has shifted to the arenas of

technological speeds, lived intensities and information flows (2006: 185).

Further, Wood describes how with digital technology, rather than causing disembodiment,

we are placed within different spatio-temporal orientations and organizations. One of the consequences of being placed within these organisations is the revelation of both the possibilities and limits of agency in our encounters with technological interfaces (2007: 163).

Exploring just this kind of embodiment and agency in the making of the dance performance *Future of Memory*, Coniglio describes how he worked with 1:1 representations of full-body movement in order to:

create unions, counterpoint and other constructs in the same way one would approach creating a duet for two dancers – even if the accompanying image was not representational’ (2010: personal correspondence).

Coniglio here points to the importance of scale and this is perhaps in part because we draw upon insights from our own moving body when we interpret the movement of others, be they human or machines (Wachsmuth et al. 2008). Csordas has also taken this line of reasoning to senses beyond the visual and introduced the term ‘somatic attention’ as ‘culturally elaborated ways of attending to and with one’s body in surroundings that include the embodied presence of others’ (2002: 8). In design research, perception is usually discussed by way of affordance, as what an environment may offer an animal (including humans) (Gibson 1986). I am however, highlighting affordance as a skill, and therefore draw further on discussions on material in anthropology and performance studies (e.g. Ingold 2000, Farnell 2011, Csordas 2002 and Noland 2009).

The discussions above on embodiment influence how we may understand movement data and propose new kinds of engagements through digital media. These points of view determine to a certain extent what is seen as possible to be expressed with movement data, which again informs the designs of the future. This is because for interaction design, ‘function resides in the expression of things’ (Hallnäs & Redström 2006: 166). In movement-based interaction, these expressions are in part informed by the possible movement repertoire of our bodies (e.g. Loenhoff 2012, Noë 2004). In addition, the potential expression of movement for interaction design is conditioned by the way movement is sensed or captured, calculated, stored

and finally called upon and presented. In other words, the design of the role of movement in interaction design depends on the way movement is materialised in the conceptual design process as well as in the final design.

Definitions of the design process have varied over time and with the various strands of design. Jones has observed that the different design definitions seemingly describe very different process. However, ‘one thing that is common to all [...] is that they refer not to the outcome of designing, but to its ingredients’ (Jones 1992: 4). In other words, the process of designing (and thereby how we may define it) is closely linked to its material. Thus, with new materials come new processes.

When designers work to enable new expressions, then a design process is concerned with facilitating and communicating the material properties within a design or within an interaction. In taking up movement as a material, I set about investigating how movement might be framed, analysed and visualised as data that could allow the realisation of what I call movement scripts. This is the focus of the next section.

### **Movement scripts: from collecting data to running scripts**

The project focuses on full-body movement in the sense of the body as a complex, multimodal communicating system. This focus enables a study of movement as action and its meaning-making. As Williams points out, movement is often studied as behaviour that enables a study of culture and society, rules and regulations, but fails to address movement (2004). A central aim of my research is to be able to apply the research outcomes both to practice and further design research; thus, I focus on movement rather than the result of the movement i.e. I focus on the ways in which designers may see movement as meaningful for designing interactions rather than discussing the specific meanings of specific movements.

As can be seen in Figure 2.2b, my research looks at the technological assemblages that draw upon a moving body in a marker-less way, in other words, by computer vision. I am concerned with the way data is collected in the sense that there are creative decisions to take as to what digital information should be registered and what the digital media should be calibrated to ‘see’. This entails that the data is collected from an expressive, moving body and the digital information is data that in various ways refers to the ways in which body parts move. I refer to data as information stored as numbers, collected by way of a mathematical model, which allows movement to be identified and registered numerically as data. Code is the way in which

this data is called upon and,  
 software consists of lines of code – instructions and algorithms that,  
 when combined and supplied with appropriate input, produce routines  
 and programs capable of complex digital functions (Kitchin 2011: 3).

Berry (2011) has argued that in order to understand computation, we do not need to understand the writing of code but to analyse the different layers that make the code become software. He divides code into the *delegated* (source code) and *prescriptive* (software or running code). This distinction is relevant because we attend to data by way of software. As I have shown in the previous section, the body as a communicative source provides in itself rich communication potential. However, the world in which we live is increasingly perforated by both sensors and screens, recording and feeding back information. Software runs the dynamics between these two: sensors and screens. This dynamic led Thrift to argue that today ‘software quite literally conditions existence’ (2005: 241).

This leads to the question of how to gain an understanding of code and software for design in order to inform the shaping of the conditions for our existence. Hornecker points out that ‘the irony is that as a research area, TEI (Tangible and Embodied Interactions) is still young and smallish, yet augmented objects permeate our lives’ (2011: 19). Further, Miller argues that the way objects become peripheral to our focus challenges how we may understand materiality:

precisely because we do not ‘see’ them [objects]. The less we are aware of them, the more powerfully they can determine our expectations by setting the scene and ensuring normative behavior, without being open to challenge. They determine what takes place to the extent that we are unconscious of their capacity to do so (2005: 5).

Berry writes that we need interdisciplinary approaches to software and the ontology of code in order to see ‘how our lives are made possible through the application of computational techniques’ (2008). The ‘grammar’ of code that Berry outlines also foregrounds that code is *made* as the products of programmers’ labour and skill. Yet, Berry’s characterisation of code as grammar also leads to a reflection on how code compares to language, whether spoken or written. Halliday has observed:

We cannot transform language; it is people’s acts of meaning that do that. But we can observe these acts of meaning as they happen around us, and try to chart the currents and patterns of change (1978: 199).

Software like language can also be articulated by us through our bodies as Thrift points out: ‘Software is more like a kind of traffic between beings, wherein one sees, so to speak, the effects of the relationship’ (2005: 241). Yet, software programmers have a role that does not exist with spoken language, whereby programmers can change the rules for how we communicate, they can alter and implement a software’s relationships and effects. New code can be written in ways that affect the actions and behaviours of many:

A facet of digital technology, and of technology more generally, is not that they separate us from the world, but rather that they create within it distinct kinds of engagements. Given the conning pressure towards technological innovation, moving image interfaces not only take us to representations of other worlds, but are also in themselves articulations of the impact of ever-changing networks of interactions between humans and technologies (Wood 2007: 164).

How lines of code run may seem intangible or ‘withdrawn’ as Berry terms it (2011). However, as we now live increasingly influenced by running code, it is important to understand the nature of movement data and the ways in which we materialise data into code and how code is run as software. As Kitchin observes, softwares actively shape ‘people’s daily interactions and transactions, and mediate all manner of practices in entertainment, communication, and mobilities’ (2011: 8). These issues are also of particular importance now, as the role of software is not settled:

We are still laying down the infrastructure, structures and conventions, the uses, functions and ways of expression and communication. Yet these dilemmas, these compromises, these struggles will increasingly matter, as the software infrastructure comes to mediate a breathtaking proportion of social relations’ (Blanchette 2011: 15).

Thus, to question the possible role of code and software as a material, as something to be created and shaped and applied, is a complex matter, yet with the potential to affect many. This points to the need for a critical view of such design and such code. However, Bevilacqua points out that we can observe movement qualities ‘with the human eye, but methods to extract such information from the digital data stream are still in their infancy’ (2007: 27). It is also worth noting that this is not only the case in computation:

In spite of the pioneering work of Bateson, Birdwhistle, Hall and others in the 1950s, the multimodal study of human social meaning-making remains in its infancy (Baldry & Thibault 2006: 249).

In the following section, I will outline the theoretical framework with which I approached movement and movement data, informed by the concerns discussed above. In this section, I have pointed to notions of the body in digital interactions. I have discussed data and code and their role in shaping software as pervasive and normative, with the aim of identifying potential for design in digital movement-based interactions. The section also explains my motivation for choosing a communication approach. I will now outline Social Semiotics as a theoretical framework, whilst further outlining the challenges and considerations of using Social Semiotics as a theoretical framework in the study of full-body movement for design.

### 2.3 A SOCIAL SEMIOTICS FRAMEWORK

In the next section, I outline my Social Semiotics approach, the theoretical framework for the thesis. I discuss semiotic concepts central for my research: sign, resource, medium, material, mode. I consider semiosis with regard to the making of materials, system networks and finally a designer's critical role in meaning-making.

#### Semiotics & Social Semiotics

In this thesis I have taken a socio-cultural view on movement and designing, which acknowledges that meaning making is situated in a social, cultural and historical context (Lemke 1995). In order to explore a potential role of movement and movement data in designing, I draw on Social Semiotics, a theory of communication that seeks to understand how people communicate by a variety of means in particular social settings.

Social Semiotics came out of semiotics, which in its broadest sense is a study of 'everything that can be taken as a sign' (Eco 1976: 7). Semiotics studies signs as the means by which people interpret and express meaning. The Swiss linguist Ferdinand de Saussure and American philosopher Charles Sanders Peirce are regarded as the founding fathers of semiotics (Hodge & Kress 1988). They worked separately in the same time period, both producing a theory of semiotics, however each settling on a distinct approach to the study of signs (Hodge & Kress 1988). Saussure saw signs as constituted by the signifier and signified i.e. the physical sign and the symbolic sign, and he saw the system of these signs as closely related to language (Chandler 2002).

Peirce, meanwhile, saw the interpretative aspect of a sign as a core aspect of its meaning. He suggested that the meaning of a sign is made up of the form of the sign, the symbolism of the sign and the interpretation of the sign i.e. a triadic model of the representamen, the object and the interpretant (van Leeuwen 2005). Peirce's model places meaning-making as central to signs and thereby positions the process of meaning-making as continuous in the life of signs.

However, Hodge and Kress suggested that traditional semiotics still emphasised structures and codes over the interrelations and social uses of meaning-making in social practice (1988). They developed Social Semiotics with a focus on how meaning is communicated and constructed through social practice. This development of social semiotics was also based on the linguist Halliday's systemic functional approach to language, which focused on the function of language – what language does and how it does it in a

given context. With this approach, Halliday focused on how meaning comes about through a choice of use in language. This to a certain extent liberated language from structure as it made choice a central organising dimension of his theory (1978). In this sense, we can analyse language through the choices made in its use. In social semiotics, what can be chosen for meaning-making are positioned as *resources*:

the actions and artefacts we use to communicate, whether they are produced physiologically – with our vocal apparatus; with the muscles we use to create facial expressions and gestures, etc. – or by means of technologies – with pen, ink and paper; with computer hardware and software; with fabrics, scissors and sewing machines, etc. (van Leeuwen 2005: 3).

With a focus on the processes of meaning-making or *semiosis*, this approach sees resources as made rather than used:

in a social-semiotic account of meaning, individuals, with their social histories socially shaped, located in social environments, using socially made, culturally available resources, are agentive and generative in sign-making and communication (Kress 2010: 54).

In this framework, a *medium* is the *material form* that constitutes a sign. Kress and van Leeuwen have argued that the material medium, such as paper or paint, contributes to the meaning-making but has yet been disregarded in traditional semiotics. Similarly, the material production (what they have previously referred to as technologies of inscription) is a vital part of meaning-making. They argued that each form of semiosis has a ‘range’ of signifying resources and how a resource is made significantly contributes to the possible meanings available for semiosis (2006: 215).

There is an on-going debate about whether a resource can be defined as a mode or a medium, as this varies with the context and also in use. For example, a graphic designer may see a variety of options available in typography, yet this knowledge and thereby the awareness of the possibilities may be less available to someone untrained in typography. It is precisely in this terrain that this thesis situates itself.

### **Materialising process as a semiotic resource**

In this approach, a material can become a resource for semiotisation, by way of making explicit or uncovering the range of possible meanings of a material form and also the production of the material. Social Semiotics then sees a mode as a set of culturally and socially made resources for meaning-making.

Specifically, a material will have a certain range of semiotic potential. For instance, sound enables different possibilities for meaning-making compared to printed matter or hand gestures that present a different set of possibilities compared with colours. However, as I have discussed above, each medium does not come with a given or set scope of possible meanings. This will depend on the knowledge of the medium available to the person shaping the resource. This step is particularly important with regard to computational material, as it depends on another material to come to expression as a material.

This approach positions Social Semiotics as a form of enquiry, coming into its own when applied to specific instances and specific practices (van Leeuwen 2005a). van Leeuwen outlines three areas of work for the field of Social Semiotics: (1) the study of semiotic resources and their histories by combining semiotic analysis and cultural history (2) the study of the uses of semiotic resources in specific contexts by combining semiotic analysis and ethnography and finally (3) the development of new semiotic resources, requiring collaboration with designers and artists (van Leeuwen 2005b). It is this last area with which this thesis is concerned.

Social Semiotics has extended beyond the written text to include print media and screen-based media and, to a limited extent, moving images. Social Semiotics has previously been applied in product design (e.g. Krippendorf 2006) to map action (e.g. Martinec 2000), movement in interfaces (e.g. Eikenes 2010) and situated action (e.g. Norris & Jones 2005). However, there are a few arrays into digital movement-based interaction.

Visualising movement data is a materialisation process in the sense that the visuals may show how movement can come to be meaningful for a designer, in turn informing a design process. Such an exploration e.g. discovering, presenting and communicating semiotic possibilities, turns movement data from a medium to a mode. It does this by allowing designers (and others) to see the available possibilities in movement data and, in turn, full-body movement as a resource for design:

We regard material production as particularly significant because often it is in its processes that unsemioticized materiality is drawn into semiosis. At times production is therefore somewhat less subject to the various forms of semiotic policing than are other regions of the semiotic landscape, and thus leaves more room for individual possibilities of expression than those regions which have better-known cultural histories, are more foregrounded and have better-understood

conventions. To explore material production is therefore also to explore the boundaries between the semiotic and the non-semiotic, and between individual expression and -social semiosis. (Kress & van Leeuwen 2006: 217).

### The designer as meaning-maker

In relation to Social Semiotics, designers can be seen as professional meaning-makers of semiotic resources. Semiotic production, the process of semiosis through the meaning-making of materials and with materials is always motivated by whomever is performing the meaning-making (Kress & van Leeuwen 2006). This kind of activity is akin to a design activity, and taking account of the motives of these makers or designers gives a critical view of Social Semiotics. However, the meaning of a resource also comprises how a resource is then seen:

Sign producers use the semiotic resources available to them according to their interest at the moment of sign production. Exactly the same thing can be said of sign interpreters: they use the interpretative resources available to them according to their interest at the moment of sign interpretation (van Leeuwen 1999: 193-194)

This points to the importance of communicating the material possibilities, the properties and potentials that may be achieved with and through a material to not only to the designers and resource-makers but also to the interpreters.

In turn, by uncovering the processes of how a material gains significance, we may also understand the underlying motives and presumptions of material-makers. This approach can form a critical view on 'the mediating role of signs and of the roles played by ourselves and others in constructing social realities' (Chandler 2002: 10).

However, for my research, I found that little attention has been paid to material production. Prior points out the following, in particular with regard to Kress' work: 'The focus on semiotic artifacts is matched by an almost total neglect of semiotic practices' (2005: 28). Prior further writes:

I do not believe that we can account for multimodality and affordances without a focus on the whole of practice – on artifacts, activity, and people alike' (2005: 29)

Norris goes some way in addressing this by attending to the structure and materiality of the various communicative modes in an interaction (2004). However, Norris is looking at a meaning-making scenario where there are

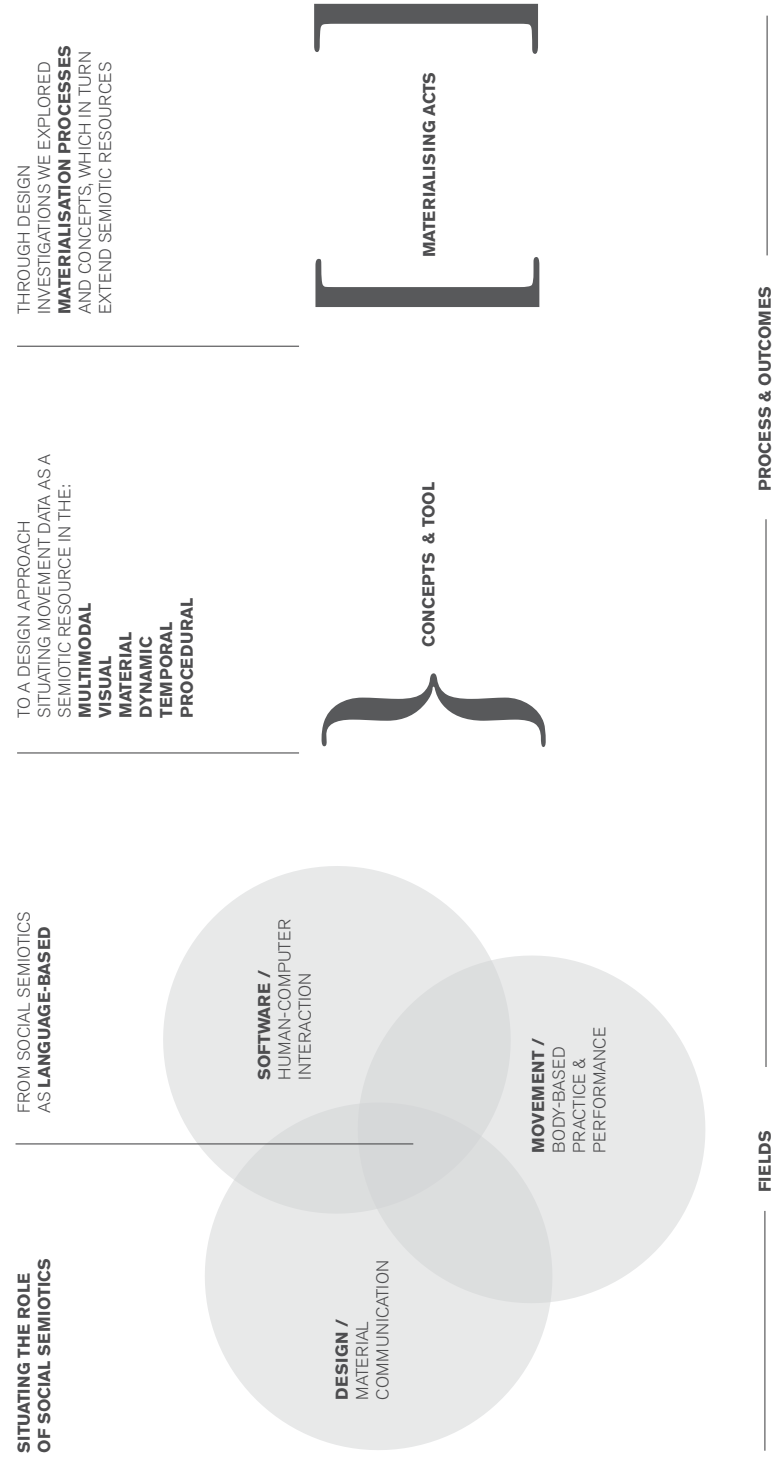
available resources. I address how such available resources or materials *come to be* through a creative, meaning-making process. This has received little attention in Social Semiotics, and yet for digital interaction (as I will discuss in the next section), movement is represented by way of several steps or stages of semiosis (e.g. selecting and collecting data, calculating and storing data, organising and calling upon data and visualising data) before we can get the effect of how such a material representation of movement may play out in an actual interaction. Social Semiotics' limited attention to practice has been described by Prior and Hengst:

However, much of this attention to multimodality in new media has so far addressed a narrow range of oppositions: print texts vs. electronic screens, language vs. the visual, critique vs. design. Multimodality has primarily been taken up as an issue of the composition of artifacts rather than engagement in processes, of representational forms rather than situated sociocultural practices (2010: 3).

These writers go on to say that Social Semiotics has 'focused on multimodal objects rather than multimodality as situated activity' (Prior & Hengst 2010: 6). Morrison further argues that multimodal texts 'demands that we examine how various perspectives for construction and analysis may be negotiated and combined, nor simply converged' (2010: 28).

Bolter and Grusin (1999) suggest a complex view on media by way of immediacy and hypermediacy to address the role of remediation historically across media. In part, this makes a case for an understanding of technology and material as rooted in history, though Huhtamo and Parikka point out, studies of new media often share a disregard for the past (2011: 1). It also makes a case for understanding media as part of practice whereby there are complex mutual effects in designing and using digital media. Bolter has previously addressed writing and the compositional writing practice that the computer enables (1991). Together these discussions suggest that the development of technology is not a linear nor inevitable progression. The application of technology is in part conditioned by our creative acts and what we see as possible (e.g. Manzini 1989). An initial step then, is to see how we may understand the materials we are now able to apply and implement in digital interaction design, in order to understand and imagine what we in turn can make with them. I now turn to address how movement can be such a resource for design.





**2.4 FULL-BODY MOVEMENT AS A SEMIOTIC RESOURCE FOR DESIGN**

In this section, I place the body and the moving body in particular within a Social Semiotics framework. I describe how movement can be a resource for communication performed by a body in specific contexts. I further describe how movement can be seen as relational and that meaning comes from repetition, as with each new repetition there is also potential for revealing a new combination of all the elements mentioned above. In turn, this suggests how qualities of a moving body may be made an available resource to an information system.

**The moving body as a resource**

Uniquely as a sign, movement needs a body (Franko 1995). In this sense movements are different from other signs in that they are performed by a body. As a sign, the material is a sensate, motor body thereby:

The possibility of a body that is written upon but that also writes moves critical studies of the body in new directions. It asks scholars to approach the body’s involvement in any activity with an assumption of potential agency to participate in or resist whatever forms of cultural production are underway (Foster 1995: 15).

This entails that designers need to understand and acknowledge that by designing from and for full-body movement, there are issues of bodily qualities such as age, gender, ability and health as well as intent and culture potentially communicated in the way we move and, by consequence, in movement as a material. For movement-based interaction design then, when designers draw upon a moving body in the design of interactive systems, designers may acknowledge these qualities and in turn be able to address an agency in movement. As Noland argues, ‘Kinesthesia allows us to correct recursively, refine, and experiment with the practices we have learned’ (2009: 4). In other words, the experience of performing a movement in itself will inform new movements alongside information from the effect or perceived role of the performed movement. This aspect of movement makes it a complex resource for design. This motivated me to adapt a design approach e.g. a material, multimodal and visual approach in exploring the process of semiosis by

Figure 2.4 The diagram positions a Social Semiotics framework in the project. Firstly as a communication-based approach to the fields of design, technology and choreography. I then use the Social Semiotics framework to explore how a temporal, dynamic, procedural, multimodal material may come into signification, by proposing concepts and creating a tool for visualising movement data. Lastly, I frame the findings, the concepts and tool within current discussions on Social Semiotics thereby proposing how Social Semiotics may be extended.

attending to movement as dynamic, temporal and procedural (see Figure 2.4). A foundational aspect of Social Semiotics is the emphasis on how 'signs are always newly made in social interaction' (Kress 2010: 54). This aligns Social Semiotics with an exploration of movement as meaning in interaction design. Yet, there is a challenge in accounting for the variation by production and situation and this is a challenge for Social Semiotics. As Noland points out:

It is rare for a semiotician to consider the ways in which the experience of producing a sign (orally, scripturally, or corporeally) contributes to a sign's contour, dynamics, duration, or communicative force (2010: xiii).

#### *Performed movement*

Our movements are cultural and were described nearly a century ago by Mauss as techniques of the body: 'the ways in which from society to society men know how to use their bodies' (1992: 455). He describes the ways we move such as walking and swimming as socially learnt techniques. Mauss further writes that the body is man's first and most natural instrument. Though seeing movement in this way is suitable for (certain aspects of) design as it allows designers to align the techniques of the body with functions in design, this technical approach does fall short of precisely the scope of movement and the issues of movement's agency in interaction design that I wish to address.

The sociologist Goffman describes the choices we make every day as to how we present ourselves to the world through posture and positions, glances and gestures as a 'performance' (1959: 22). Thus, by seeing our movements as chosen as well as acted out, we may understand movement as communication beyond technique. Crossley further points out that Goffman's understanding of the body is not only concerned with how society is imposed on the body but also how 'we can manipulate our corporeal expressivity to foster and create impressions of self and subjectivity' (1995: 147). Thomas further argues for a reading of Goffman as a 'scribe to the corporeal' rather than a 'handmaiden of the Cartesian tradition' (2003: 62). In this sense, we can see that our movements are performed and create a kind of communication that we can visually access. This account of agency in how we communicate we 'all too often ignore or take for granted in our (clinical/cleansed) concern with the meanings and practices which constitute our world' (Crossley 1995: 148).

The choices in movement then may give us insight into a person's intent. An expression of intent is described by Bergson as influenced by present and past:

my body, taken at a single moment, is but a conductor interposed between the objects which influence it and those on which it acts, it is, on the other hand, when replaced in the flux of time, always agitated at

the very point where my past expires in a deed (2007: 88).

We may say then that present in the form of a moving body, albeit limited, we may also find a reason behind a move or attempt to rationalise the result of a move:

By the very nature of its spatio-temporal-energetic dynamic bodily movement is a formal happening. Even a sneeze has a certain formal dynamic in which certain suddenesses and suspensions of movement are felt aspects of the experience. Form is the result of the qualities of movement and of the way in which they modulate and play out dynamically (Sheets-Johnstone 1999a: 268).

Sheets-Johnstone's example of a sneeze shows that a movement may be meaningful for digital interaction whether the movement is performed with intent or not. Subliminal habits and happenings can shift and turn how we are seen as much as what we usually think of as expressive and performed movements. Thus, all movement communicates through its various forms e.g. how it plays out dynamically, and as such can be considered by designers for a possible role in digital interaction. Dourish points to this when he writes 'action both produces and draws upon meaning; meaning both gives rise to and arises from action' (2001: 206).

#### *Situated movement*

By seeing the way we move as a performance also draws attention to where the performance takes place. This is in the sense that every movement is situated and 'space is not an inert backdrop for movement, but is integral to it [movement], often providing fundamental orientation and meaning' (Reed 1998: 523). This is particularly relevant for my research as I propose a materialisation of movement where movement is abstracted by digitising tools such as computer vision or video. This abstracts information from a moving body and (more often than not) removes the context and timings of the movements.

Berger has used the expression 'ways of seeing' to refer to the fact that 'we never look just at one thing; we are always looking at the relation between things and ourselves' (1972: 9). In other words, how we show something or how we present a resource invites different kinds of seeing. This is important because just as we relate to, are influenced by and draw upon the movement of others in informing our own movements, we also interpret movement by its surroundings. In other words, our movements are relational and allow us to take on different meanings according to their context (Norris 2004).

*Repeated and revealing movement*

This complex picture of meaning in movement expressed and interpreted in inter-personal communication is further complicated by the tension between repetition and revelation in the sense that movement gains signification by both (Gilpin 2011). In other words, we understand movement through its context and in relation to what we already know and have already seen. Yet, each newly performed movement, even if repeated, is unique as it appears and is seen anew.

For interaction design, this poses a challenge in harnessing the variation and plurality of a unique movement to what is known and can be set to register and categorise. This is, the tension between the unique event and the system in which the event is designed to occur.

It is important though to remember that the complexities in performing and perceiving movement is something we all do every day as we negotiate and navigate each other. Through our everyday movements we communicate and perform ourselves whilst simultaneously reading others' body language; we act upon and give feedback through a visual reading of each other. Matthews makes the point that whilst we can in principle *say* anything we like, we cannot *mean* anything we like and that this is a core movement issue in digital interaction, as movement has no set grammar (2006: 406).

It is precisely this tension between the event and the system that I seek to address by way of movement as a material with particular properties and possibilities for design. To this Thrift writes the following:

to acknowledge that the biological cannot be set to one side as though it somehow inhabited another background realm rather than being a key moment of the invention of performance and the performance of invention (2008: 252).

Thus, whilst interaction design removes data from a body, I was motivated to find ways to attend to the body and the qualities that can communicate both bodily notions (e.g. ability, gender, age, culture etc.) as well as the bodily enactments (e.g. the intensity, repetition, rhythms and intonations). To this end, the developmental psychologist Stern points to how we communicate a wealth of information, just from the way we move:

we naturally experience people in terms of their vitality. We intuitively evaluate their emotions, states of mind, what they are thinking and what they really mean, their authenticity, what they are likely to do

next, as well as their health and illness on the basis of the vitality expressed in their almost constant movements (Stern 2010: 3).

Stern proposes that *vitality* is a key to the communication of movement. Positioning movement in this way (as opposed to relating it to function or to language) gives a focus on the sophisticated ways we have of reading each other in order to communicate and to relate to each other, intended or not, articulated or not, successful or not. I mention this to make the point that even if we focus only on a visually available movement, we are still able to gain an understanding of a person's ability, age, gender and class as well as authenticity, health and so on, as Stern argues. Movement seen in this light presents a rich resource for interaction design, expressed in our almost constant movements.

It is important however that the focus remains on action i.e. the ways in which we move and not on our behaviour. Williams contends that the science of behaviour,

fails to encapsulate or acknowledge the particular and the cultural, ignoring that actions cannot be seen apart from human intension, passion and contexts (2004: 220).

As Williams argues, the ways in which we address movement matters. I will now turn to how we may find ways to attend to such vitality, movement dynamics or communicative movement. I outline challenges with regard to a conceptualisation of movement that addresses qualities such as those mentioned above, with the particular motivation to make a communicative potential in movement as an available resource for designers.

**Abstracted movement as a resource**

Based on the above approaches, movement can be seen as culturally situated and informed, performed and communicated. In Social Semiotics, the ways in which and processes of how a material becomes a resource (e.g. material production) is only briefly addressed as a resource in itself (e.g. Kress & van Leeuwen 2006). However, this is a central issue for the meaning-making of movement data: 'However immaterial it [the digital] might appear, information cannot exist outside of given instantiations in material forms' (Blanchette 2011: 1042). Below I discuss some concerns regarding the material production of movement data in order to explore the ways in which movement dynamics may become a resource for digital interaction, in that there is a gap in experiential accounts and the decisions relating to the design of experiences.

Loke and Robertson have approached movement-based interaction through attention to experience, and suggest that the account of a ‘mover’ ensures that ‘designers are accountable to the felt, lived experience of the mover and to the potential users of technology’ (2013: 10). This work is important for research on movement-based interaction as the design outcome is a lived and experienced event. Whilst this approach is central to understand design outcomes, it only goes some way in addressing processes of designing. My argument is that by the time an interaction can be played out, there are a number of important decisions and considerations that have been taken, embedded and scripted in the computational material. My concern is whether these initial decisions on for instance collection and calibration, are revisited when the designs are developed to a stage where they can be tried out.

Therefore, it is important to acknowledge that interaction designers usually work with representations of movement rather than actual movement. As I have mentioned, whilst a choreographer may work in a studio directly with dancers in creating new movements, a designer will shape movement in a less direct manner through objects and screens and increasingly through interactive systems and settings. This poses the question of how to address a body in ways that also encompass its agency by way of movement. Below, I outline some challenges imposed by the abstraction of movement identified in particular from body-based practices. In brief, these are challenges of the identification of relevant movement qualities through language, an object focus in design and a detail focus in mathematical modelling.

#### *Challenges of an object-tethered language*

With the aim of informing a design process of movement-based interactions, I acknowledge that Social Semiotics has limitations in addressing the agency of full-body movement. However, I recognise the possibility of extending its reach and vocabulary: ‘Learning to describe “what could be” is the single most important job now facing semiotics’ (van Leeuwen 1999: 11).

Semiotics has been criticised for its linguistic roots, in particular when it comes to the body, as it fixes too rigid a system of signification ‘imposed by culture upon the body’ (Noland 2010: xi). However, the critique [of a purely semiotic perspective] should not be construed as negating the study of signs with respect to the body, but as making a place for a complementary appreciation of embodiment and being-in-the-world alongside textuality and representation (Csordas 2002: 243).

The tension that arises from these two approaches, of tending to the semiotics or to the somatic, is particularly pertinent for interaction design. Though a designer’s focus is on shaping interactions through objects, code and context, the interaction (and this is particularly true for movement-based interactions) and the outcome is played out in an event, and the interaction exists as an experience. Design addresses this tension in its practice: ‘Design stands midway between content and expression. It is the conceptual side of expression and expression side of conception’ (Kress & van Leeuwen 2001: 5). Yet, such expressions need to be understood beyond linguistic-centred views in Social Semiotics, because to describe movement through language is in itself problematic as Sheets-Johnstone points out:

linguaging the dynamic of movement is a challenging task [...] The challenge derives in part from an object-tethered English language that easily misses or falls short of the temporal, spatial, and energetic qualitative dynamics of movement (1999a: 268).

This challenge has long been acknowledged in performance studies e.g. Phelan (1995), Foster (1995) and Sigman (2000) and is in part what motivated a research path in a practice-based enquiry of movement data visualisations (as I describe further in Chapter 3).

#### *Challenges of a thing-focus in studies*

Addressing movement is also challenged by a difficulty in visually representing full-body movement. Despite being substantiated in our limbs and our near constant repositionings, it is a resource that immediately fades, existing only as it appears:

there is nothing rock solid in movement [...] The observation is significant in itself and significant academically; simply put, it is easier to study objects. That empirical fact in the end motivates many to believe that matter matters more, and in turn to concentrate attention on the study of objects (Sheets-Johnstone 2011: 124).

This calls for a shift in a design process focused on delivering content for screens and artefacts to a focus on movement as material and as part of a conceptual process. This is in part from the particular nature of digital media: Media technologies per se differ from traditional and modern techniques of communication in that they inscribe the information they process: they not only mediate but memorialize – capture and store – their content. (Clarke 2010: 237).

Therefore, the step from actual movement to a mediated abstraction is one of pivotal importance (see Figure 2.1). This has implications for communication in particular with regard to distance, embodiment and time. In other words, this is a shift from facilitating functions to exploring a temporal, relational dynamics through compositional design. In terms of interaction design, this is a core issue as the designed 'object' is a situated activity.

#### *Challenge of detail as precision*

A central feature in my approach to movement for design is that the depth of information or the granularity of data matters. A body typically has 240 moveable joints, each with six degrees of freedom, yielding 1380 in total. Therefore, we may quickly generate a wealth of data. Yet, higher precision and more detail may not give the kind of information that communicates nor provide the tools with which to work with movement. Technology is developed towards an increased resolution, precision and capacity, yet there is a need to critically discuss how today's available technology is applied and the possibilities that come from how these technologies already are or could be applied. This shift in focus is also argued by Bell and Dourish with regard to ubiquitous computing (2007).

The failure of increased understanding through increased detail can also be seen in a critique by Williams with regard to the notational system in Birdwhistell's *Kinesics*. Williams takes Birdwhistell's description of hitch-hiking to task:

When we are told by Birdwhistell that a 'macro-kinesic' explanation of this state of affairs is something like this: 'two members of the species homo sapiens, standing with an intra-femoral index of approximately 45 degrees, right humeral appendages raised to an 80 degree angle to their torsos, in an antero-posterior sweep, using a double pivot at the scapular clavicular joint, accomplish a communicative signal' we are justified in saying 'no.' That is not what we see. We see persons thumbing a ride" (2004: 184).

Consequently, in order to address the meaning of an interaction where the body is concerned, precision in detail and categorisation may well diffuse meaning-making rather than aid it. This is similar to when we magnify a map to increasing degrees and may lose track of structures and relations that could be governing dimensions. When we are looking at movement, temporal qualities are problematic to represent through language (Sheets-Johnstone 1999a). It is also a challenge to represent temporal qualities through visual abstractions. Sklar argues that notation of movement has a lack of focus on

movement dynamics and calls for 'qualities of vitality' in action descriptions (2008: 103).

The discussions above informed my choice to focus on the ways in which we move to be able to position movement as expression as part of communication in digital interaction. In this sense I address the visually available dynamics of movement as a resource. This approach sits between dance notation software such as *Labanwriter* (<http://dance.osu.edu/labwriter>) and *MovEngine* (<http://www.movement-notation.org/VisualizingArchives/>) on the one hand and on the other hand, there are projects placing individual approaches in specific movement repertoires such as in Transmedia Knowledge Base's work with the choreographer Rui Horta (<http://tkb.fcsh.unl.pt/>) and the Motionbank project's work with the choreographers William Forsythe, Deborah Hay, Bebe Miller, Thomas Hauert, Jonathan Burrows and Matteo Fargion (<http://motionbank.org/>).

In this section, I have argued that meaning in movement is not a given nor set. Meaning through movement is something we continually create, perform and regulate socially and visually. I have further argued that by attending to movement dynamics or the vitality with which we move, designers may address a wider scope of meaning-making through movement as well as by challenging the normative notion of bodies in interactions.

## 2.5 A SEMIOSIS OF MOVEMENT DATA FOR DESIGN

Motivated by the richness and complexity in human-human interaction, I now turn to human-computer interaction in the sense of focusing on the moving body as a resource for the design of digital interaction. In this section, I briefly outline the steps whereby movement is materialised in interaction design with attention to what each step addresses in a materialisation of movement for design.

These provide framings for discussing choices in which movement qualities or modes are selected or mapped, and this is a motivated choice which physiology and technology can only partly inform.

The complex and nuanced meaning-making in human-human interaction described in the previous section provides resources for how we may design interactive systems that draw upon, facilitate and create movement-based communication. In order to make a case for creative potential in a material approach to movement and movement data, I position each act in the semiosis of movement data as a meaning-making activity. These are abstraction, presentation and perception, as described below.

### The process of abstraction as a resource

#### *Access to a variety of spaces and places*

Today, we have increasingly easy access to increasingly sophisticated sensors, from the *Kinect* to high-definition miniature sports cameras such as *GoPro*. These allow for marker-less registration and capture. This means that they are less intrusive in that they do not require markers to be placed prior to capture. Thereby they can give insights into how people move in a variety of ways, in various spaces and places. The availability of digital media also leads to numerous choices regarding how technology is set up and applied in that there is more choice and availability today than only a decade ago. Adaptable and portable hardware allows for new spaces to be drawn upon in a variety of ways. Designers can also increasingly determine what the technology captures and also as I argue, engage with finding materialisations of movement themselves.

Levin points out that depth cameras have been around for a while before the *Kinect*; however, 'when they become cheap and distributed throughout the culture then suddenly people have a new way of expressing themselves' (2012: online). In this sense, there is potential in exploring the variety of ways in which we can now capture movement as well as the variety of places and thereby the variation in movement.

#### *Access to a variety of digital contexts*

Designers today have access to unprecedented computational speed and thereby increased capacities for mapping and processing. Designers can also switch between various capturing modes in the variety of technologies available. In this sense, designers may compare one set of data to another, of the same event or the same movements. In other words, there is the potential to change the context and comparison of movement data in ways that were not previously accessible in near 'live' conditions.

The ability to change both the location and the computational frame within which the data is collected gives designers the ability to swap between models of movement. They can choose what is recorded and how. However,

the danger of trying to codify, generalize, and formally model the aesthetic experience for technology design is that it may miss precisely the phenomenon that was originally of interest. In abstracting from specific embodied contexts, many of the ineffable aspects of the aesthetic experience – those escaping formal articulation – may be either overlooked or designed away (Boehner et al. 2008: 3)

It is important to note that with new technology we do not only gain a new way of capturing what is out there, we also gain a new way of moving, following my previous argument that we move in relational ways i.e. Noë's enactive perception (2004, 2012). When we are 'captured' or sensed in a new way, we also alter our actions accordingly. Coyne refers to this as tuning: the ways in which we create our own spaces through digital media, as in digital devices and the infrastructures that support them (2010). If designers want to leverage the way people tune or adjust to technology and to being 'seen', it is essential that designers understand the potential of such movement.

### The presentation of abstraction as a resource (from data to scripts)

#### *Computational power gives live-ness*

Computational power in handling movement data today, the collecting, storing and again calling upon of movement data to be visualised, enables little latency or near 'live' conditions. This gives designers a different creative approach to working with movement data, in that they are able to materialise the abstracted data in real time. This informs new ways of working. Materially, this matters, first because designers can compare the data to actual movement and second because it brings the designer closer to the source of the movement data.

*Code is handmade*

Due to the complexity and commercialisation of software, it is easy to forget that code is handmade, as in, made by people, by hand (see Figure 3.2g):

We're beginning to think that an individual can have no voice in this. I think it is essential for artists to have a seat at the table in determining the future trajectories of technologies. (Levin 2012: online)

The focus on the handmade also draws attention towards the choices made by the person shaping the lines of code and how we may address issues of motivation, such as the optimisation of a script over the ease of use of the final software. The notion of handmade also points to the choices that are made at this level of materialisation of data. Like all design materials, software is shaped and informed by both process and outcome; thus, the writing of code is a creative, decisive act whereby data may be presented.

*Code as open source*

One way to open up the practice of writing code is through collaboration and communication. This we can see in the open source community, where code is increasingly shared and made available through programmes such as Processing, openFrameworks, Puredata, vvvv and others. However, open source resources are still made; they are 'a specific communicative artifice like any other' (Galloway 2011c: 383) and as such require a critical approach to how they are applied in a design process.

**The perception of abstraction as a resource***Data presented through scripts*

As previously discussed, raw data, the numbers stored on a hard drive, are beyond our senses, and we cannot work directly with the resulting 1s and 0s that refer to full-body movement. Thus, to be able to 'see' and make sense of the data, we run scripts that call upon the data and present it. These scripts are rarely studied, despite being available as lines of code (Wardrip-Fruin 2009).

The numbers relating to how we move must be first stored computationally and subsequently identified and presented in such a way that movement is represented. How the data is presented is not a given, as A. Galloway argues that data has no necessary form (2011a) and in this sense it means that there are choices and motivations behind the various ways in which data is presented, in that technology alone can not determine how data presented.

*Movement represented*

In discussing the animation of visuals of body movement, Kaiser critiques animation in that 'lost in such special effects is not only the subtlety of movement but also the crucial identification and alignment of viewer and dancer' (2003: 86). Hayles further points to how we as a society have dissociated information from the body (1999). In this sense, we can see a need for 'alignment' of the data visualisations to our perception as central in order to tap into the sophistication with which we perceive movement. This is further explored in the cognitive scientists Cross and Ticini's work on dancers viewing their own movement sequences (2012). They compare perceptions of dancers' own performed movement sequences to those of others, to explore our cognitive ability to appreciate movement. Closer to design, Mentis and Johansson also suggest that 'seeing movement qualities can be very different depending on experience and background of a viewer' (2013: 3382).

Noland proposed that we can challenge the linguistic model conventionally used to explain corporeal signs by 'attending to the somatic, experiential, aesthetic, cultural, and contextual dimensions of gesturing' (Noland 2010: xv). Following the discussion above, from a communications perspective, I argue that our conventions of corporeal signs in design today can be challenged by enabling a visual reading of movement data and extending our conceptual understanding of movement in design. In this way, by extending how we make sense of movement, in part by focusing on the dynamics with which we communicate, we may begin to attend to the somatic, experiential, aesthetic, cultural and contextual dimensions in designing movement-based digital interactions.

# 3

## **METHODS FOR MATERIALISING MOVEMENT FOR DESIGN AND A SUMMARY OF ARTICLES**

In this chapter, I discuss the research methods for my enquiries and the design techniques for the practice as part of the research. The methods include textual analysis, system network analysis, concept generation and design investigations. The design techniques involved analysing designs, sketching and modelling, adapting and altering technology and creating by way of coding, collecting, moving and making. These have been described below in a discussion on the design process and collaboration. The research set-up was a dialogical process of concept-building from theory coupled with concept-building from practice. Both my research and design methods are contextualised with debates on research in new media, human computer interaction and performance studies. I also briefly reflect on an evaluation of progress through seminars, arts labs and design and development-based workshops.



### 3.1 POSITIONING RESEARCH METHODS

In this section, I discuss the implication of a focus on the material for my choice of methods. As the previous chapter has shown, designers may shape body movement by designing information systems and may thereby alter the dynamics of how a human-computer relation may play out. The aim of my research was to inform design processes about movement and movement data. The motivation was to enable designers to identify, understand and be able to draw upon the unique mix of corporeal and computational properties of movement data as well as the capacities of action and expression that reside in this material. In order to explore the nature of a material, designers need to be able to familiarise themselves with it, just as we understand more traditional materials such as plastic or clay by twisting, stretching and moulding them. By finding ways to move from one material appearance to an alternative material appearance, designers can become familiar with a material's potential for design and are able to understand its particular possibilities as well as limits.

Movement data is rarely considered in this manner. It is usually described in terms of technology, such as when it is studied for computational prediction and identification of objects (e.g. Dodge et al. 2009). The evaluation of such research is related to the suggested mathematical models' ability to identify and predict movement with less focus given to how these mathematical models may be applied or, more importantly, for interaction design, altered.

In order to inform how designers can work with movement data and, by extension, movement itself, it is essential for designers to be able to twist, stretch and mould the ways in which movement data is made material. This first required an account of how movement data can be created (e.g. the potential for communication that appear visually in full-body movement). Second, it led to an exploration of the processes and procedures that turn movement data into a material (e.g. the potential in the scripts that draws upon movement data and again presents the data). This was a matter of exploring how to move from one computational representation to another, in order to be able to twist, stretch and mould the data as a design material.

For interaction design research, it is particularly important to include computational processes in order to build knowledge informed by interaction design practice. Wardrip-Fruin argues that authors and artists need to know the causal and instrumental computational processes that express meaning and that these may not be available to an observer or audience in the form of finished designs (2009). Sundström and colleagues also found that 'in HCI

and interactive systems design the properties of a technology are often glossed over' (2011: 1).

In the field of interaction design, it is essential that designers understand the material properties of how digital media come to expression, as well as how the moving body communicates, as I argued in the previous chapter. My focus on informing interaction design practice then requires a critical approach to the computational processes that make digital media function. Klemmer and colleagues make a case for considering all constitutive elements in interaction design and that,

for a combination of virtual representations and physical artifacts to be successful and truly go beyond what each individual medium can offer, we need a thorough understanding what each can offer to us first (2006: 147).

Each medium or material, however, needs to be understood in light of practice. In part, this is because movement data only exists (for us) as it is continuously made material, materialised by way of another material such as on a screen in number tables, visuals or charts and partly because movement is influenced, shaped and understood in context, that is, in relation to technology. Both these aspects then ask for the processes of practice—the making and materialising—to be considered as part of an analysis or study of movement and movement data as a material. Movement data then depends on a materialisation process for us to study what may be particular to it. Also, an understanding of the materialisation processes is necessary for designers to understand how to design with movement and movement data.

These processes are often overlooked as Ingold has pointed out in studies on material culture. He critiqued anthropologists for their focus on made artefacts and a lack of material considerations: 'Not for the most part being makers themselves, they have a blind spot when it comes to materials, their properties, and what it feels like to work with them' (Ingold 2011: 3). Bunn, an artist-anthropologist, further writes,

this ignores the action of making, which is a *working with* rather than a *doing to*. It has often led to the assumption that the worker has a blueprint of what he or she is making in mind, and simply executes this (2011: 21 original italics).

I mention these considerations and critiques as they are relevant to my choice of methods as well as the outcomes. Considering the nature of making in my study of materials gives my project a propositional perspective as the designs

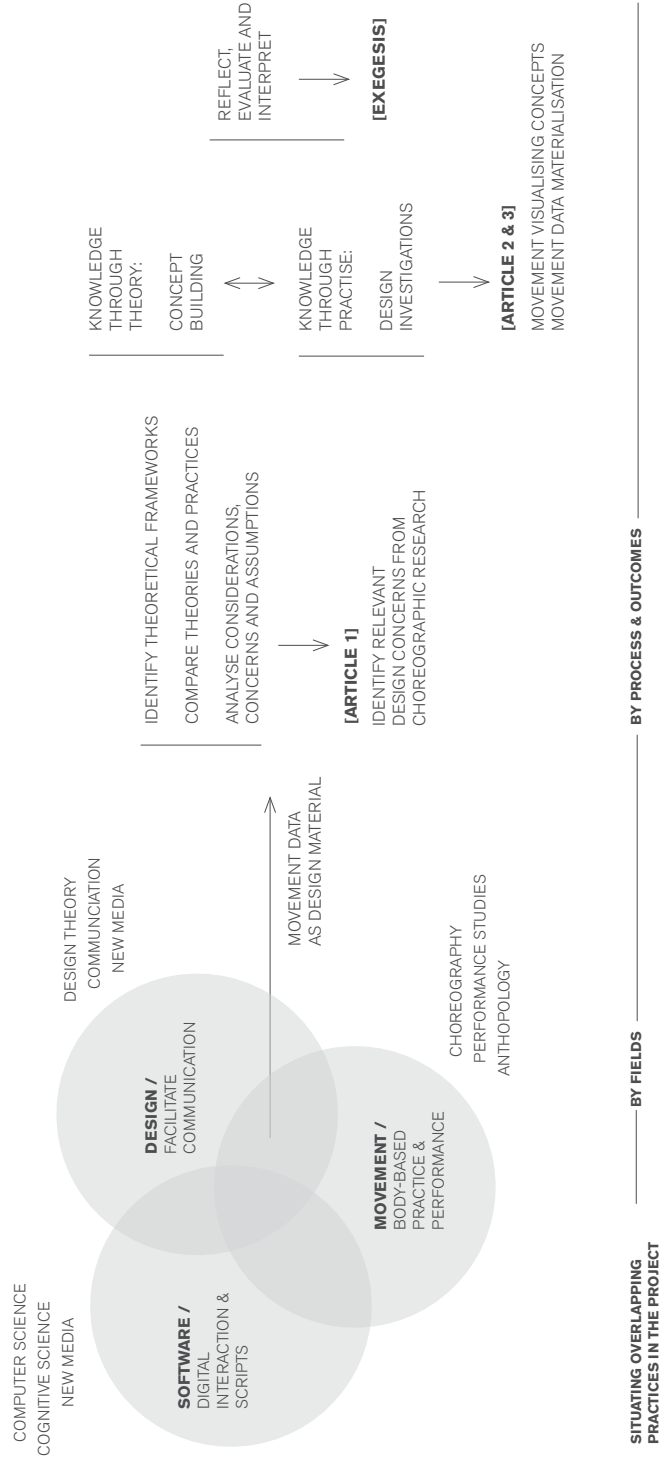


Figure 3.2a This diagram outlines my research process by an initial placing of relevant practices and fields that constitute the design of movement-based digital interaction. The diagram then shows the different research activities and their resulting publications.

created as part of my explorations are conditioned by the maker(s). In turn, this entails that ‘research through design is likely to produce theories that are provisional, contingent, and aspirational’ (Gaver 2012: 937).

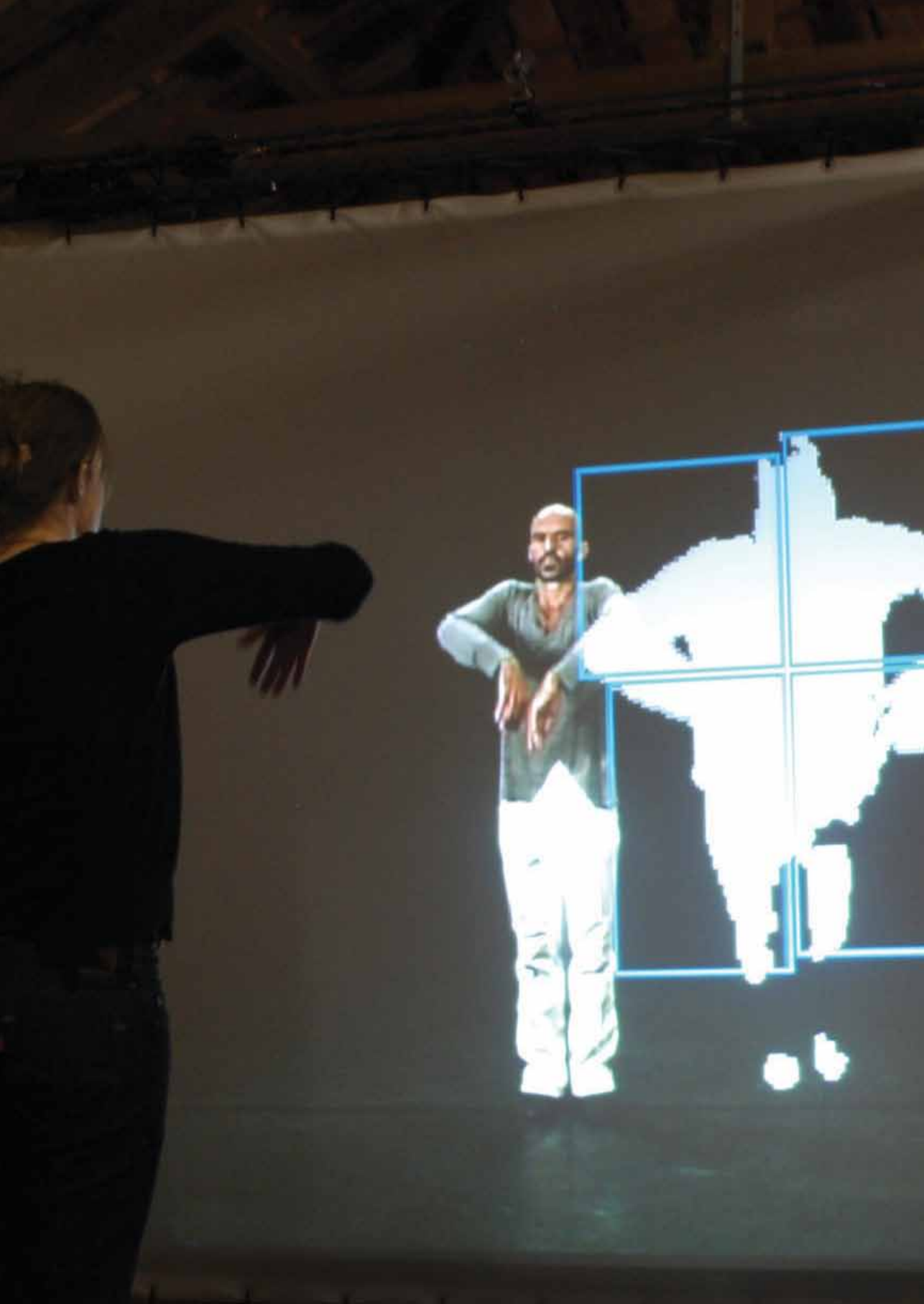
In order to identify a creative potential in movement and movement data for interaction design research, I used design investigations to seek insights different from that of post-design use-analysis. For interaction design research, Redström argues that there is value in such identifying and envisioning of ‘possibilities’ as well as more traditional testable ‘actualities’ (Redström 2007: 171). I mention these considerations of design research in order to position the status of what we expected to find through designing and to place the methods employed in the context of interaction design research.

### 3.2 RESEARCH METHODS

I approached my research questions through two key approaches. Initially through theory: a study of the material in the overlapping and related fields by way of textual analysis, system network analysis and concept building. In addition, I created a practice-based approach by way of design investigations through collaborative workshops. How these activities are positioned in relation to each other in the project is visualised in Figure 3.2a. Below I describe these approaches and how they relate to each other.

#### Textual analysis

Liestøl suggests that analytical concepts can be either drawn from neighbouring disciplines, from other fields or general approaches as well as through searching for conceptual sources in developers’ discourses (Liestøl 2003). Although the latter refers to developers of games, I take Liestøl’s point that ‘discourse embodied in and coexisting with this production [of games] often includes a vocabulary that describes key qualities of the object itself’ (Ibid: 392). This can be equally well applied to designers’ discourses, in particular in the context of interaction design where projects are mainly collaborative. I have drawn upon all these methods – movement studies in dance and choreography, anthropology and linguistics, in design and computation as well as new media and communication studies (Hansen 2010). I have also used approaches and core concepts from social semiotics to inform and shape my queries (Hansen & Morrison 2014). Lastly, by way of collaborative design investigations, I could draw on my own collaborative designers’ discourses by way of design investigations through workshops, to develop an application and key concepts for analysis (Hansen 2013).



### *Drawing on related disciplines*

My starting point was textual reviews of fields concerned with the same materials and processes, movement and its potential for communication. Within a social semiotic framework, a ‘text’ does not only refer to printed text but any media or artefact that can be understood to produce meaning, ranging from gestures to posters, from books to screens and from spoken language to computational scripts (van Leeuwen 2005).

Drawing on knowledge in related fields and approaches in combination with propositional material helps understand the potential of that which is yet to be realised:

Connective judgements along with compositional judgements are therefore seminal to the creation of that-which-is-not-yet-in-existence (Nelson & Stolterman 2012: 154).

Despite social semiotics’ critique of the linguistic roots of semiotics, Kress argues that we can use language, or naming, as a way to build semiotic theory:

We cannot afford to let older ‘language-based’ thinking to constrain how we see mode, in a semiotic theory. The consequence of a multi-modal approach, of taking meaning seriously, is that rethinking, new thinking and, with that, new naming becomes essential (2010: 92).

A social semiotic framework also asks for an account of the reader or meaning-maker of such work. Barthes’ seminal essay ‘The death of the author’ made way for the notion of texts’ meaning depending on the reader (1977). To this end, I presented my background and training to further situate my reading and interpretations of movement studies in related fields and how they may pertain to interaction design.

### *Drawing on alternative approaches*

The range of texts relevant to my query extended beyond traditional printed publications and included software and digital tools. I was able to work with and gain insight into these by participating in applied research workshops and arts labs such as an *Isadora* workshop with its developer Coniglio (See Figure 3.2c-d).

Figure 3.2b An image of the author participating in the *Double Skin | Double Mind* installed in *Espaço de Tempo* as part of Transmedia Knowledge Base’s Arts lab in Portugal in May 2010. The digital, interactive installation was conceived as a virtual workshop for Greco’s dancers, in order to understand his way of working with movement. The installation was a part of the research project *Capturing intention* by deLahunta, Bermudez, Ziegler and Bevilaqua (2007) and is now used as an educational tool at the Amsterdam School of the Arts.

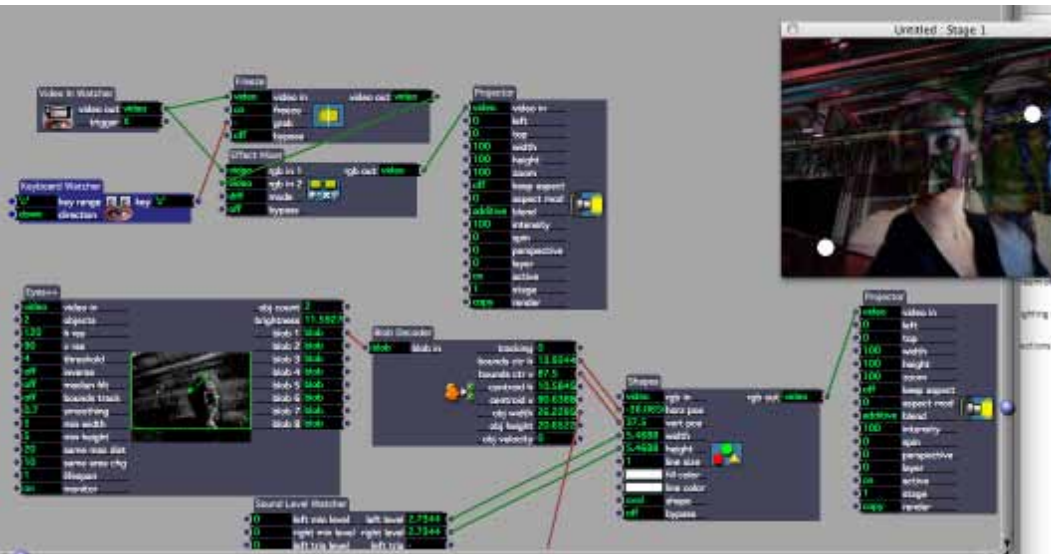


Figure 3.2c A screenshot from an Isadora workshop run by Coniglio at the Art-on-Wires conference in Oslo in 2010.



Figure 3.2d A screenshot of working in TKB's Arts lab with an openFrameworks (oF) example adapted in an oF workshop with Castro at the Art-on-Wires conference in Oslo in 2010. The application uses pixel comparison to calculate direction of boundaries (smaller circle) and of overall movement in the frame (larger circle).

I also engaged with research projects that were in the process of developing digital tools specifically for choreographic practice as part of their research, such as Transmedia Knowledge Base and its *Creation-Tool* (Fernandes & Jürgens 2013), Capturing Intent and its *Double Mind | Double Skin* installation (see Figure 3.2b) and Motionbank workshops (see Figure 3.2e). Workshops arranged or attended are listed in Appendix A & B.

The motivation for participating in such research scenarios was to gain insight into a variety of working practices and a variety of ways of collaborating. As van Leeuwen states in his semiotic research on sound, 'I have no interest in telling you what this or that sound means, I want to offer you some tools for making meanings (1999: 195). For instance, attending a Motionbank workshop on scores with the artist Baer, allowed me to read, create and perform scores or scripts in an explorative setting. These gave me insights into processes and practices on creating scenarios, in particular through discussing the scores and individual performances (see Figure 3.2e). By attending to a variety of ways in which movement is researched then, I could make informed choices on how to explore and present potential meaning in movement studies for interaction design and to position these within a cultural communication frame.

#### *Drawing on designers' discourses*

From such material production environments (as those mentioned above), Liestøl suggests that we can develop concepts that can be used to serve analytical purposes:

When one is producing objects, particularly in a group, discourse embodied in and coexisting with this production often includes a vocabulary that describes key qualities of the object itself. In fact these might be necessary conditions for the design of the object and thus also be relevant to the description and understanding of the nature of the object, including academic analysis. Consequently, according to this argument, the developer's discourse is a relevant place to (re) search (for) conceptual sources (2003: 396).

Liestøl also extends this argument to say that if this is so, then concepts from interpretation may also enrich and inform construction. Addressing this overlap of knowledge production in interpretation and construction, Bolter writes that 'what we need is a hybrid, a fusion of the critical stance of cultural theory with the constructive attitude of the visual designer' (2003: 30). By adapting a dual approach to my research questions, I worked with concepts coming to and from practice and theory, aiming to create such a fusion.

Attending collaborative workshops and arts labs showed me that a trans-disciplinary vocabulary on movement and movement qualities is still to be created. Research on this topic is currently underway, for instance in Schiphorst's *Moving Stories* project ([www.movingstories.ca](http://www.movingstories.ca)). On a similar note in terms of design, Wiberg and Robels propose that we see interaction design as composition in order to reconcile the digital and physical and that such a

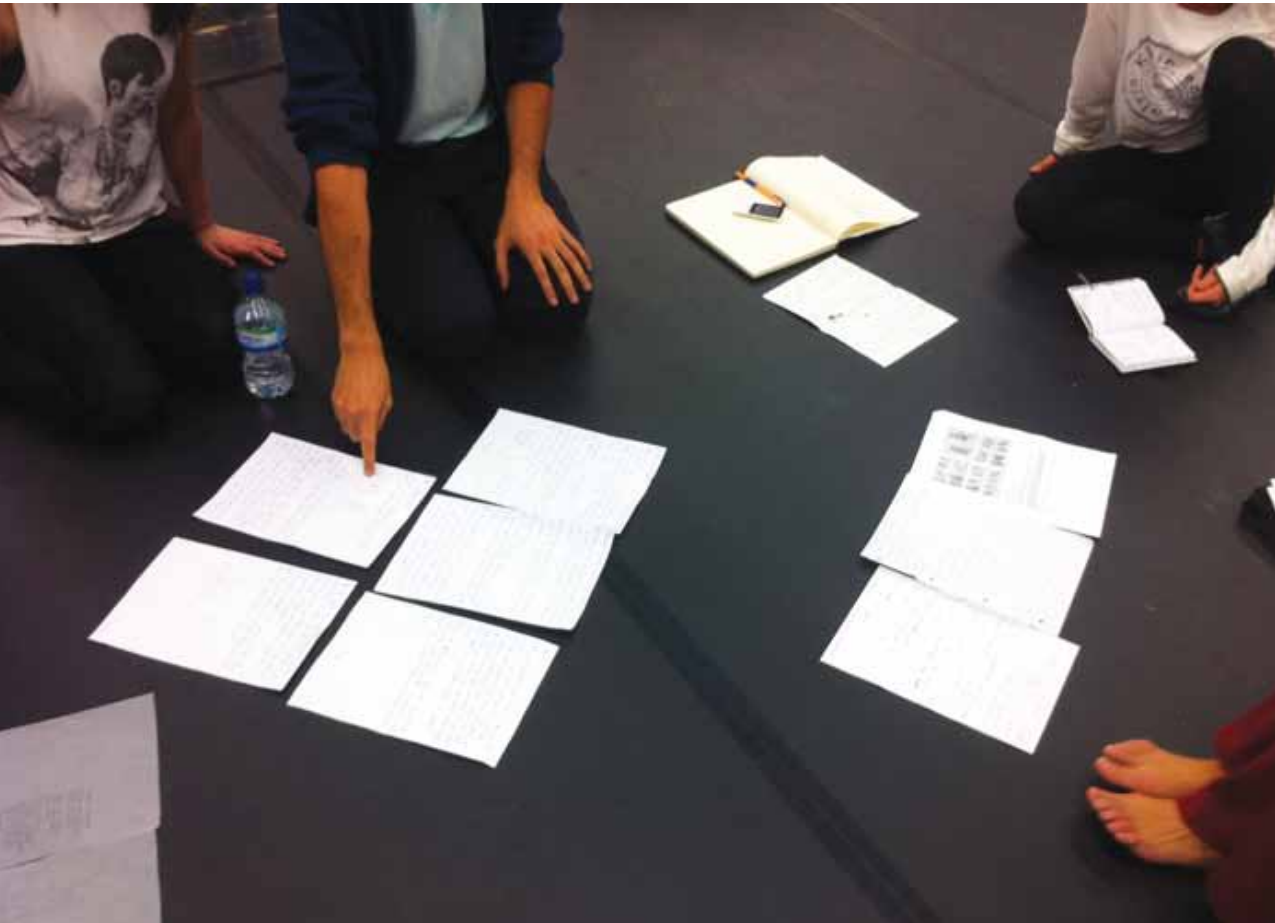


Figure 3.2e Image from Motionbank workshop with artist in residence Baer, in Frankfurt September 2012. The workshop centered on performance scores. In this instance, we are discussing a set of scores we had written. We have just seen the scores performed and are discussing the performances in relation to the written (or drawn) scores.

view on design will 'require articulating an aesthetic vocabulary that formally relates diverse materials whether digital or physical' (2010: 65).

Höök and Löwgren further suggest that for interaction design, such a vocabulary can come from *strong concepts*, each with the following properties:

[It is] generative and carries a core design idea, cutting across particular use situations and even application domains; concerned with interactive behavior, not static appearance; is a design element and a part of an artifact and, at the same time, speaks of a use practice and behavior over time; and finally, resides on an abstraction level above particular instances (2012: 1).

As outlined above, drawing on existing concepts and naming concepts provides a textual analytical method for interaction design research. It is important to note that the challenges of finding ways to analyse movement as communication also apply and are yet to be solved for other temporal, digital communications such as multimodal texts. Therefore, Baldry and Thibault ask for a development of 'better multimodal transcription practices and the development of computer-assisted tools for storage, retrieval, processing and analysis of multimodal texts' (2006: 248).

### System network analysis

After attending to studies of movement and technology, I turned my attention to the material itself: to movement. Informed by research from related fields and from alternative approaches within interactions design research, I wanted to find a way to analyse movement as visual communication, specifically for interaction design.

In order to understand the ways in which movement comes to be meaningful in digital interaction, I then positioned movement as a semiotic resource. I approached movement through system network analysis, a diagramming technique whereby meaning potentials of a mode can be mapped (e.g. van Leeuwen 1999). This can be used for analysis as it can provide a taxonomy of a mode, which may then give insights into the ways in which a medium comes to give meaning and comes to be a mode.

The technique is to identify and name available semiotic *choices* within a resource and list these in an inventory. Each choice is then further classified into an increasing level of detail, and this generates a *system network*. Such a mapping can then enable us to explain how a semiotic resource is understood, used and how it may be expanded (see Figure 3.2f). The aim was to find

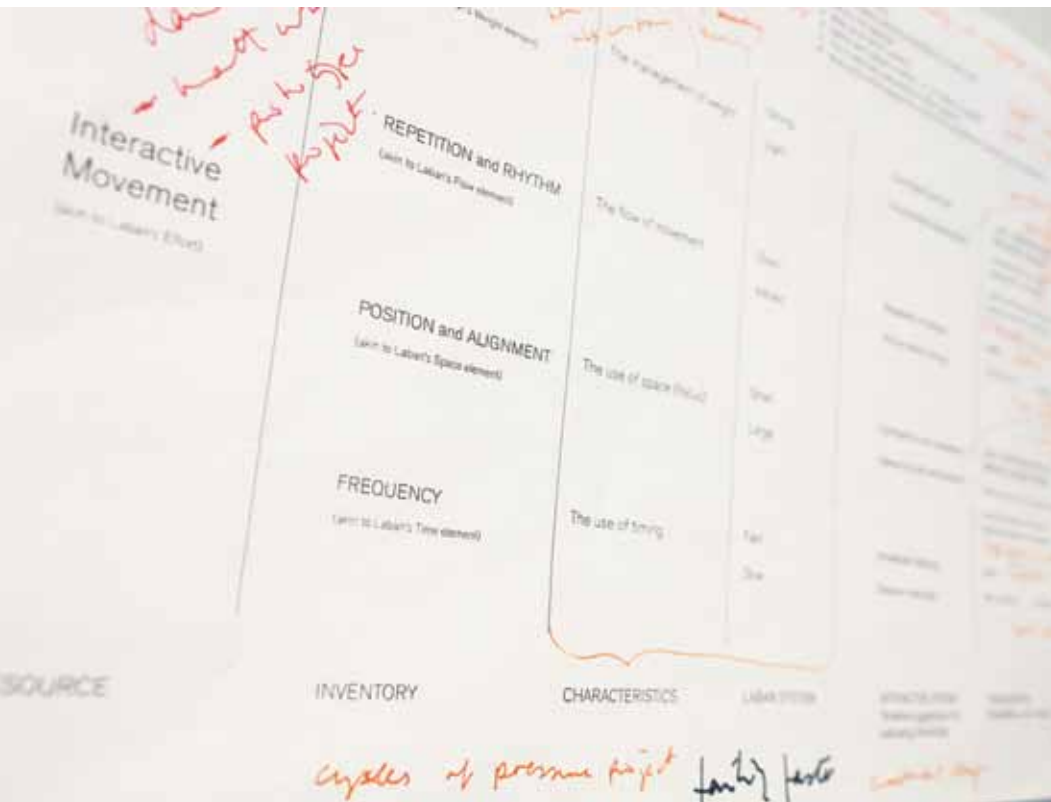


Figure 3.2f The *Movement Schema* went through a comparison with existing movement notation (e.g. LMA) and was further tailored to design through our design investigation into movement dynamic visualisations. This is an image of an early, annotated version of the schema.

visually identifiable qualities or elements in movement that constitute its communication. In other words, I wanted to identify visual distinctions in movement (as it appears visually to an observer) that contribute to its expression that could be perceived visually and thereby computationally.

In the schema, movement is described by its dynamics. This means that I focus on the movement itself, not on the posture (e.g. the result of a movement) nor the position (the start or end of transporting a body or a part of a body). As Sheets-Johnstone points out, what changes position are objects in motion, not movement. Movement is thus not equivalent to objects in motion (1999b). Specifically, I describe dynamics as the rate of change in a moving part of a body. This meant that I could look for ways to find patterns in all movement that could later be applied to specific contexts or specific

movement vocabularies (e.g. Wei 2002). This is a different approach to the work on parsing movement in order to identify meaningful movement by comparing gestures (e.g. Bevilacqua 2007) or through the identification of phrases (deLahunta & Barnard 2005).

Placing movement dynamics as the central communicating resource, I then turn to describe the constitutive modalities that may be visually observed (see Figure 4.1a for current version of the *Movement Schema*). In the schema, movement is mapped to an increasing degree of detail, from left to right. I identify four core qualities of *Communicative Movement*; *Velocity*, *Position*, *Repetition* and *Frequency*. These temporal modalities overlap (for instance, frequency can only be seen in repetition occurs), yet they are discrete modalities in that they can be identified and separately abstracted. These suggest central modes of movement dynamics e.g. the different visual qualities or characteristics that come together in movement dynamics, which in turn gives us an understanding of movement dynamics as communication.

The process of identifying these was influenced by Kendon's work on classifying gesture and greetings. Kendon found that there was no 'absolute' boundary for identifying a greeting and resolved to search for 'patterns of organization at the most inclusive level first' (1990: 10). In the schema, each modality is then described by its *Salient Characteristics*, which I suggest to be *Speed*, *Location*, *Continuation of Movement* and *Use of Timing*. I then further propose a *Visual Description* for each modality in *Size of Mark*, *Placing of Mark*, *Rhythm* and *Structure*. This is not meant to be an all-encompassing mapping of all the ways in which movement communicates but suggesting central aspects of full-body movement for exploration.

The development of the Schema was informed by the parsing of movement in *Laban Movement Analysis'* (LMA) *Effort Dimension*, where *Weight*, *Space*, *Flow* and *Time* are elements (see Laban & Lawrence 1974). This led me to an initial listing of the core modalities of *Force*, *Position & Alignment*, *Repetition* and *Frequency*, which in part mirrored LMA's *Effort Dimension*. However, as I describe in the next chapter, our design investigations challenged the schema as we explored movement data re-drawn in real time. We also specified the kinds of technological assemblages we were able to work within. Specifically, in my project, the *Movement Schema* serves as an analytical device for interaction designing. In this sense, the schema became a design brief, initiating and informing design explorations, which I describe further in the following chapter.

### Concept generation for design and through design

For the next stage of the research, I initiated a track of designing and concept generation in order to further explore the nature of movement data and its creative potential for design. This aligns with semiotic theory as van Leeuwen writes:

in times of rapid change and new communicative challenges, semiotics and design, theory and practice, can work hand in hand [...] I do believe that making theory-and-practice links of this kind, and learning to describe ‘what could be’ is the single most important job now facing semiotics (1999: 11).

Liestøl describes the same challenges in the humanities, describing a constructive humanistic approach to bridging the gap between theory and development as ‘digital genre design’ (Liestøl 2009: 24). He discusses the validity of such an approach by way of computer games, where central features of the relationship between digital media texts and users, such as manipulation and feedback, ‘are key features that cannot be adequately accounted for from within traditional, established humanistic perspectives’ (Liestøl 2003: 393).

Schön argued that designers and artists exhibit ‘a kind of knowing-in-practice, most of which is tacit’ (1991: viii). He proposed an epistemology of practice based on ‘reflection-in-action’ and ‘reflection-on-action’. This puts the focus on the process of making and an iterative, experimental design process, which he called ‘back talk’, whereby materials give feedback to the practitioner e.g. the designer or artist. He argued that the designer would be able to articulate a specific activity (reflection-in-action) or reflect on actions afterwards (reflection-on-action), and from these it might be possible to articulate knowledge from practice. Dearden has discussed these concepts further with regard to the nature of conversations with digital materials and suggested that if,

digital designing differs from other forms of designing, then accounts for the differences should be sought in the material properties of digital systems and the genres of work practice that surround their use (2006: 418).

Thus, in order to inform digital design, I wanted to explore the material properties of movement and movement data in order to be able to discuss what this entails for practice. This was the next step in the project, through design investigations of movement and movement data (see Figure 3.2g). This asked for an account of the explorations and iterations that we undertook



Figure 3.2g Image from our last workshop in Oslo 2013, where Joel is writing code for a new Graphic User Interface in *Sync*. It is also a reminder that code is hand-made.

as part of this research process and that will be described next. The design investigations were a reflective practice where the challenges were met by ‘working it through, rather than just thinking it through’ (Klemmer et al. 2006: 142). This approach to designing resonates with Stolterman’s call for research to have an anchoring in practice:

Any attempt by interaction design research to produce outcomes aimed at supporting design practice must be grounded in a fundamental understanding of the nature of design practice (2008: 55).

This motivated my choice to collaborate with interaction designers Hellicar&Lewis to explore movement and movement data by way of workshops, by moving, programming, discussing and making. These are described below.

### 3.3 DESIGN TECHNIQUES

In this section, I describe design techniques undertaken as a designer researcher and in collaboration with design practitioners. I will briefly outline the set-up and developments by way of design workshops.

#### Design collaboration

For the design investigations, I collaborated with interaction designers Joel Gethin Lewis and Pete Hellicar (see [www.hellicarandlewis.com](http://www.hellicarandlewis.com)). I knew of Lewis' work in the openFramework community and met him when he presented at a design conference in Oslo. We decided to work together for several reasons: we shared a similar background in that Lewis also went to the RCA and the three of us also shared a working style of wanting to figure things out. They have an open source ethos whereby they publish all their projects and this enabled the project to be part of a community of practice. Perhaps most importantly, they could see that it would be worthwhile for them to find the answers to the kind of questions I was asking, for their own interaction design practice. Hellicar&Lewis are based in London and the first phase of our project started with online exchanges of articles addressing modelling of movement in computation and references to other media using movement as a central element such as earlier work in physical comedy in films of Keaton and the Marx Brothers, performances by Louis Fuller or Merce Cunningham as well as contemporary installations and performances. This primed our collaboration in that we built a shared understanding of the kinds of tools, software and hardware we had at hand as well as the use of movement in interactions and as communication, which we could draw upon or build upon.

The design processes in our workshops reflected the kind of collaboration processes that we aimed to inform (Sanders & Stappers 2008). We had a shared understanding of what we wanted to explore, yet we also had different skills with which to approach the query. Lewis has come to interaction design with a background in mathematics and Hellicar came to graphic design through professional skateboarding, while I went from dance training to visual communication.

#### Design workshops

As discussed previously, whilst theoretical concepts from related fields and related approaches may inform practice, there is also an argument for developing concepts through material practice and through designing (e.g. Koskinen 2011). This motivated me to organise several collaborative design workshops in Oslo as a means of creatively exploring digital media, both for

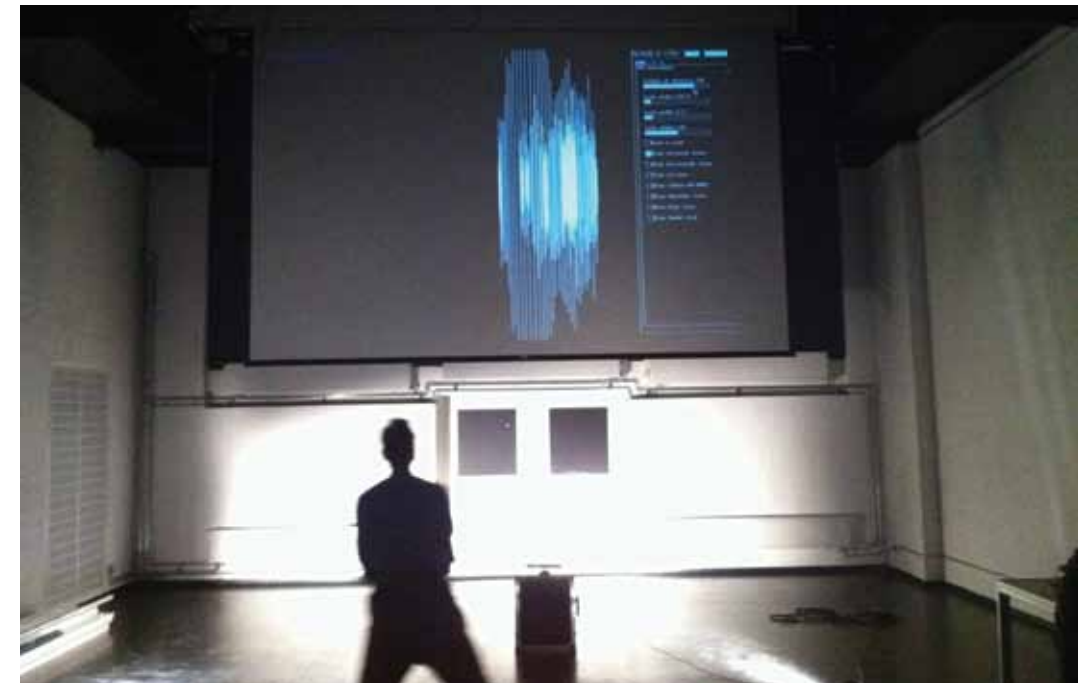


Figure 3.3a In the workshops we were moving ourselves to see what the data could look like, with settings visible in (an early version of) the menu to the right on the screen.

finding out as well for reflection. The workshops gave us the opportunity to 'represent aspects of temporality, dynamics, and interaction [...] through talk and embodied action such as walking and gesturing' (Tholander et al. 2008: 453). I also observed that 'sandbox' sessions like these are increasingly part of larger research projects or conferences engaging not only an educational audience but also practising artists and creative developers (e.g. in the Motionbank and Resonate conferences). Below, I describe the main techniques and developments of our workshops.

#### Workshop 2010

In our first workshop, we started by discussing the current role of movement in interaction design. We questioned how we could approach movement for digital interaction to explore what qualities or elements of movement could be interesting for digital interaction design and in what ways. We employed a range of design techniques, from sketching with pen and paper and discussing concepts between ourselves to acting out movements to see and make bodily sense of what a movement or movement abstraction could be (Figure 3.3a).



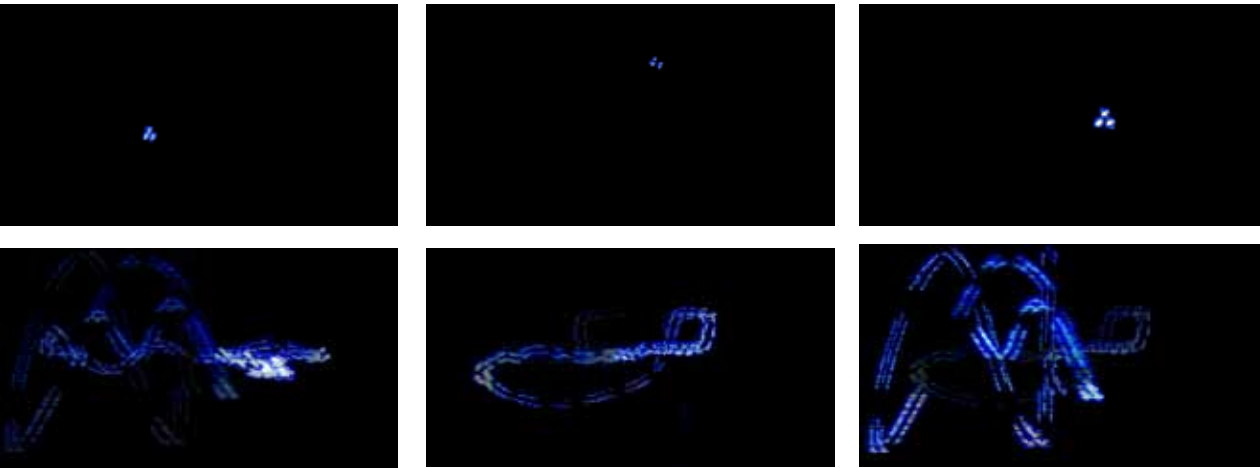


Figure 3.3b This set of images are from an initial workshop of balancing exercises with LED lights placed on the body. Initially I was interested in how gravity and balance informs movement. This line of enquiry was recently taken up by Palazzi and Shaw (2013) as *Risky Weight* in their work with choreographer Bebe Miller as part of the Motionbank project.

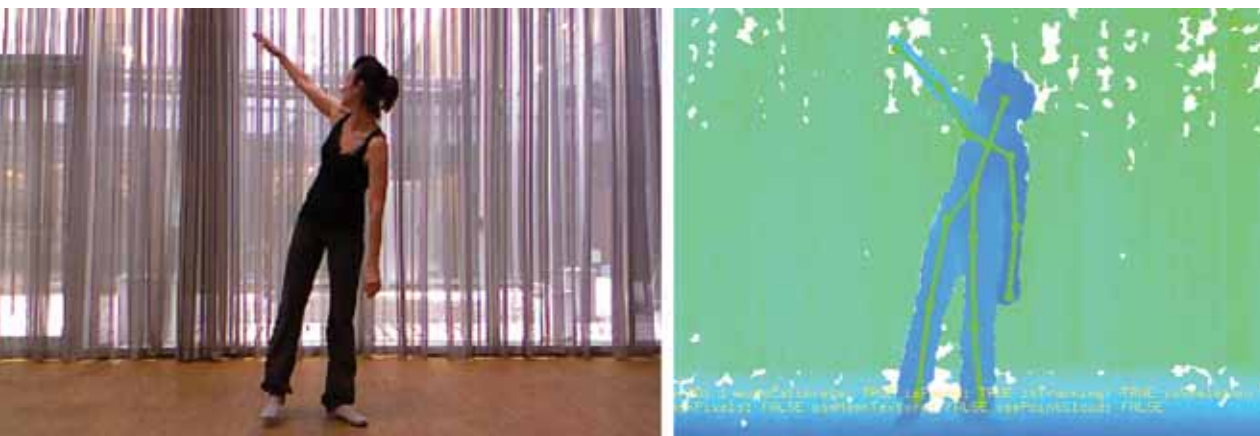


Figure 3.3c The *Kinect* identifies body position by first computing a depth map to infer body position. In turn this allows for an identification of 15 points referring to joints or body parts e.g. feet, knees, hips, hands, elbows, shoulders, head, and a centre for hips and shoulders, here of Bech-Hanssen.

In other words, we were sketching in several modes (e.g. Buxton 2007). Craft and Cairns found the use of sketching, particularly in the early phases of a design process, as beneficial for ‘improving design, supporting the design process and enhancing collaboration’ (2009: 71). In addition to sketching, we continued to share references and tools for the existing use of movement in interaction, film and communication.

For this workshop, much of our attention was on background abstraction and the calculation of body outline and the kinds of visuals this information could generate. I had previously explored visuals of the centre of gravity to unfold notions of balance and gravity. This came from an idea of approaching movement as the handling of weight (see Figure 3.3b).

As a starting point, we used an early version of the *Movement Schema* (see Figure 3.2f). We sketched out ideas based on the schema in the sense that Buxton describes it, where the aim of a sketch is to explore ideas, question and provoke, as opposed to prototyping, which is used to test, refine and give us definite answers (2007). The ideas were evaluated in view of our practice as designers; thus, we knew that in order to inform practice, we needed to present movement in a variety of visually available ways in relation to the procedural processes of making, from concept to sketches.

#### Workshop 2011

Shortly after our initial workshop in 2010, Microsoft’s *Kinect* sensor was released and we saw that our design investigations could benefit from drawing on the possibilities that this technology offered. Specifically, we wanted to build upon Microsoft’s body part identification, the x-y-z points of tracked joints or parts, despite its limited scope (for exact measurements see Dutta 2012). The *Kinect* was initially not made available for developers; however, Microsoft soon decided to welcome creative developers. We were aware that there is no such thing as raw data (e.g. Gitelman 2013), yet we decided that the *Kinect* enabled us to focus our efforts on movement qualities and not on movement identification and tracking (see Figure 3.3c). Thus, we saw the *Kinect* as a tool as well as a technique.

We revisited the *Movement Schema* as we explored the actual materials e.g. our own moving bodies and the data. Initially we worked with imagined visualisations of the movement data; in other works, we sketched out possibilities and projected what was possible based on what we had seen in other movement visualisations and movement abstraction processes. We worked on calculations of the centre of mass, yet realised in comparison to

‘real’ movement that the visual generated became too abstract and too far removed from the movement itself (see Figure 3.3d). In other words, we could not ‘work our way back’ to the original movement from the visual. We decided therefore to work with all tracked limbs and make available they ways in which they could be visualised.

#### Workshops 2012 & 2013

In the following workshops, we explored how to visualise movement in ways so as to make available a variety of visualisations of movement. To do so, we worked with 1:1 representations of movement data in real time in order to leverage human expertise in interpreting movement (in relation to how sensors register movement) so that we could get to know the data that we were working with (see Figure 3.3e). This was an instrumental move to consider movement data visualisations at a 1:1 scale, as our bodies do not scale in the sense of how we read and interpret and move.

As we progressed, we were increasingly able to work with real-time visualisations of our own movements in this manner and we could start tweaking code in the sense of scripting out ideas to see what kind of dynamic visualisations we could then generate. We deliberately approached the research and in particular the *Movement Schema* with the aim of experimentation rather than to find a direct translation or solution. This was similar to Foster’s description of a choreographic workshop:

during this playful probing of physical and semantic potential, choreographers’ and dancers’ bodies create new images, relationships, concepts and reflections (1995: 15).

This in turn informed how we could open up movement data’s material possibilities for others to see and explore. We explored by moving and making and eventually settled on a set of parameters that in turn generate visualisations. These came out of our explorations as we saw the variety of ways in which movement data could be seen, and we started to find some ranges of possible visual qualities. In this sense, the developments in the workshops are initial steps and by no means exhaustive. Yet, by focusing on presenting ranges of possibilities, we could create space for visualising a potential in movement as a creative material.

There were several decisions that came out of moments of freely exploring and trying things out. For instance, we looked into the idea of a continuous banner to represent the moving points, with the width of the banner representing a movement’s dynamics e.g. the rate of change in any x-y-z

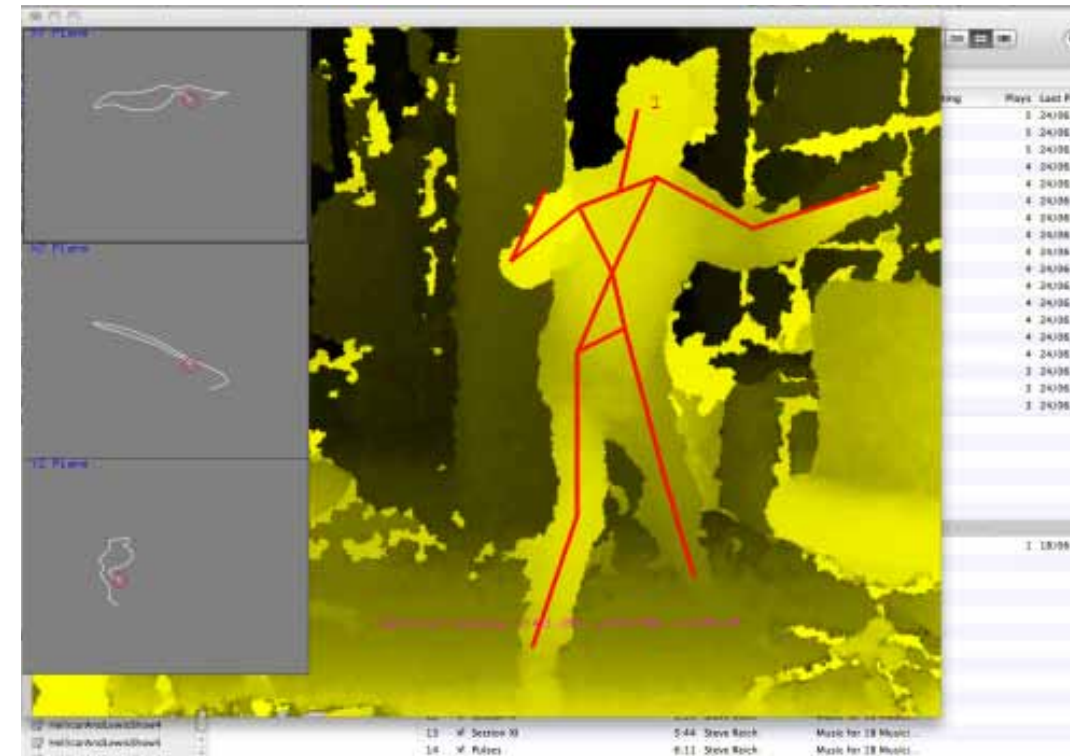


Figure 3.3d Stills from our early work on exploring the centre of gravity. Movement is presented in each of the two-dimensional planes in xy, xz and yz diagrams to the left.

number. However, we found that the calculations (e.g. from discrete data into continuous data) created an arrow-like shape in the banner (due to *Kinect's* setting). When we saw this play out, we found this to be a visual indicator of direction in certain setting (see Figure 3.3e and 3.3f).

We also had some challenges, such as when we wanted to look into positions of the trunk of a body by extending the line created by pairing the points for shoulders, hands and hips. Whilst the shoulders and hands were tracked accurately, we found that the data pertaining to the hips were hard to ‘move’. We found that the *Kinect* scripts smoothed out hip movements to the extent that we had to do a lot of moving to shift the data. As mentioned above, the data we worked with were generated by *Kinect*. The *Kinect* was created for *Microsoft's* games to be played in a living room, and in such a setting it is important to track and position hands and, to a certain extent, shoulders. Hips however give little information in a game setting and therefore one can imagine the *Kinect* calculations describing hips were smoothed out.

Through such experimentation, we then settled on and formalised options of visualisations in a graphic user interface and named the application *Sync*. As the application took shape, we also invited colleagues to try *Sync* in an informal manner as a complement to our own try-outs (see Figure 3.3e). In this manner our dynamic movement data sketches could be seen as ‘ordering devices’ in a creative process that showed the range of possible representations of the movement data (Tholander et al. 2008: 453).

#### A tool for investigation

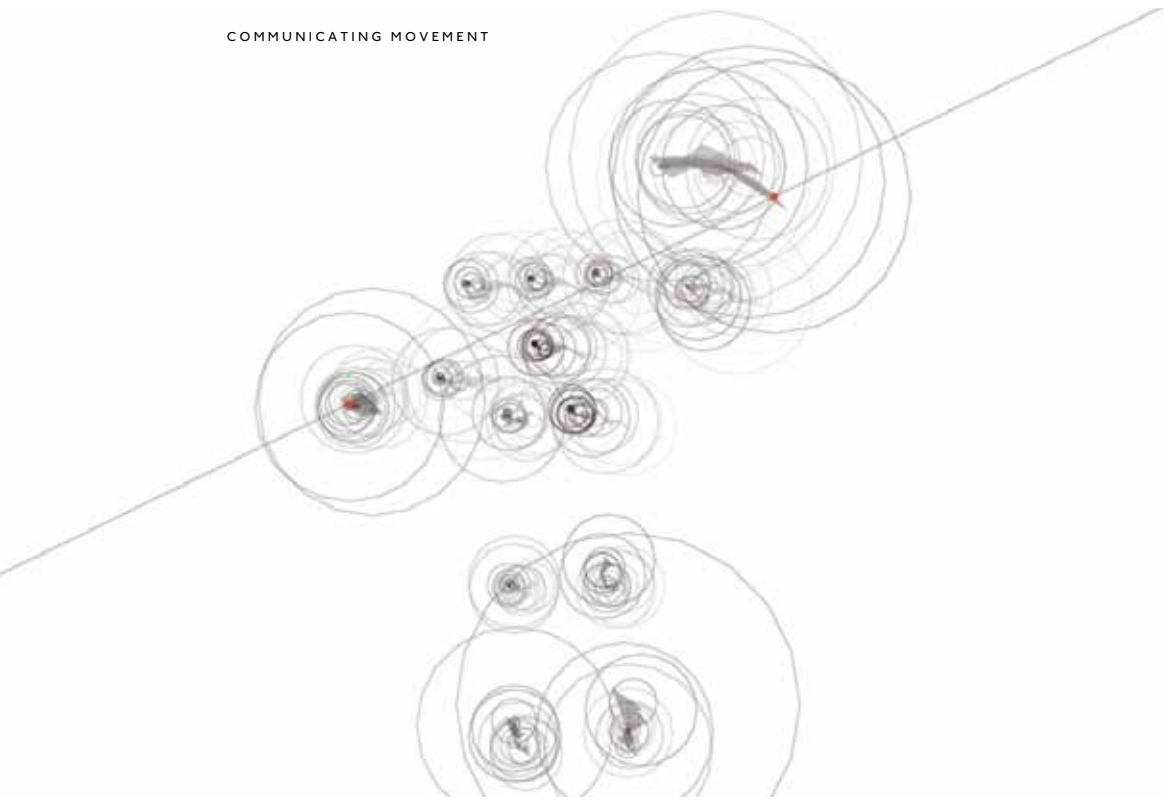
In this project, *Sync* is a research device applied in a similar manner to theoretically derived concepts, and introduced to enable discussions on the material properties of movement for interaction design. The application was created to enable insights into how we may materialise full-body movement data for interaction design. Also *Sync* is designed to draw equally well on other x-y-z data and is thus not limited to the *Kinect*. In this sense, *Sync* becomes an epistemic object, a tool for advancing knowledge by focusing on notions that may go beyond current knowledge and understanding (Morrison 2010).

My research draws on a theoretical contextualisation and positioning of *Sync* as opposed to user-testing or analysing the productions, designs or outcomes from such an application. The latter would require different techniques and answer a different query on the role of *Sync* in use rather than *Sync* as unfolding material possibilities, although these are intertwined for movement and movement data. My focus however is the material’s creative potential i.e. its range of properties. This is not a novel approach, as can be seen in Wade’s genealogy of optical devices (from the camera obscura to the zoetrope) and how they influenced the art of seeing as well as science (2004).

We published the code for *Sync* (<https://github.com/hellicarandlewis/Sync>) and made it an application available for download (<http://kinetically.wordpress.com/sync-download/>). By making the code available in this manner, *Sync* becomes adaptable. Its script can be altered, linked, chopped and changed. In this way the tool lives: ‘the only good classification is a living classification’ (Bowker & Star 1999: 326). The motivation for making *Sync* freely available was so that others could continue to build on and with it or alter it to suit another query.

Figure 3.3e The dancer Bech-Hanssen has participated in all our workshop. In this still, Bech-Hanssen is moving her own data around. At this stage we were working with a single x-y-z mark representing centre of gravity and we explored the ways in which the rate of change in position could be visualised.





This thesis provides an account of why *Sync* was made: ‘open source does not mean the unvarnished truth, but rather a specific communicative artifice like any other’ (Galloway 2011c: 383). Providing an account of why and how *Sync* was made and relating the account to Social Semiotics gives a focus on meaning-making, of processes of taking a material from medium to mode. In Social Semiotics, Baldry and Thibault have pointed to some requirements for computational (archiving) tools for analysis and developments:

- (1) transparency of cross-modal coding criteria whatever the modality in question; and (2) retrievability of inter-semiotic relations such as, for example, the copatterning of written text and visual image or spoken language and body kinesics among others (2006: 248).

In this sense *Sync* contributes to considerations of how Social Semiotics can study modalities, in particular multimodal, digital resources or scenarios. Zimmerman, Forlizzi & Evenson further points out that interaction design researchers must also

- articulate the preferred state their design attempts to achieve and provide support for why the community should consider this state to be preferred (2007: 499).

These concerns are discussed in Chapter 4.

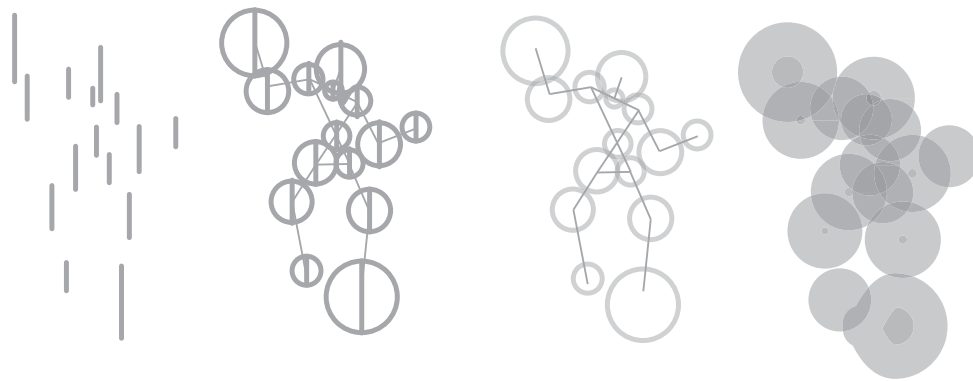


Figure 3.3g These images show a development from sketches to *Sync*'s movement visualisations.

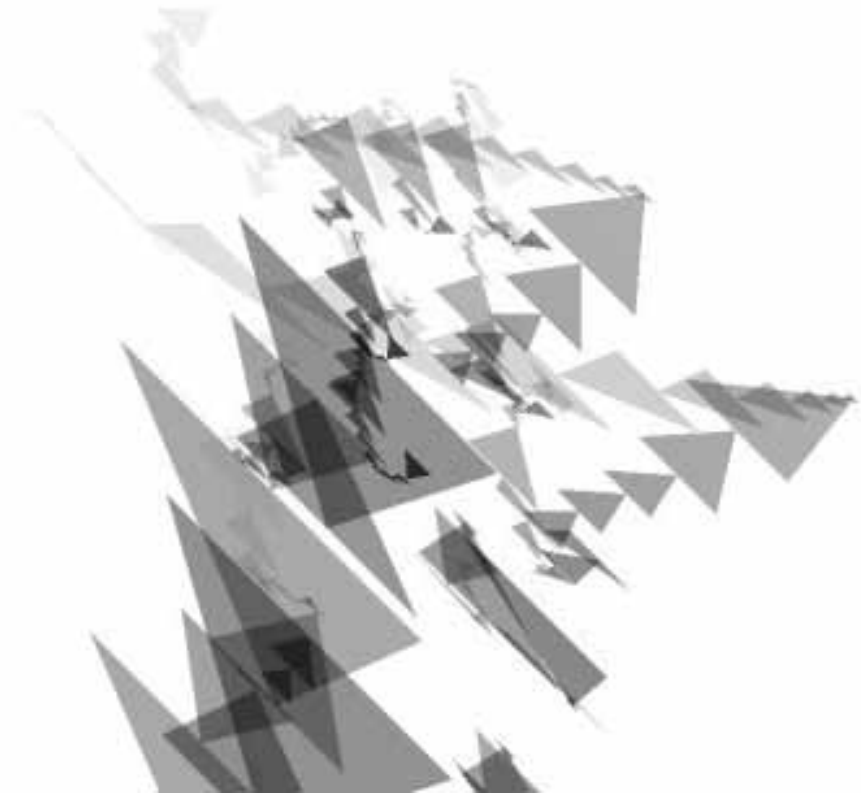


Figure 3.3f What we envisaged to be a continuous banner mark, became more akin to a row of arrows, due to the nature of the *Kinect* calculations.

### 3.4 REFLECTIONS ON SOME LIMITATIONS

#### Single, not yet social

I see the moving body as a complex system and a multimodal resource of communication. However, as Streeck pointed out, there is enough research confirming that communication is multimodal, now we need to see what these modes do (Streeck et al. 2011). For now, *Sync* focuses on a single body and does not register static surroundings. It allows for a bottom-up analysis of a singular body and we found that there was a lot to unravel at this scale. However, adding a next level by including another person or finding ways to compare the movement data is an exciting next step. In particular, with regard to these visuals, such available computational information on our bodies-in-code, can show the ways in which digital media may influence inter-personal relations.

#### Situated, not yet context

The tool has an easy, portable, unobtrusive set-up (see section 4.3). It enables a site-specific analysis of movement and thus enables designs for specific sets of movement to specific locations of movement. However, the tool does not (yet) analyse movement dynamics in relation to other information or data sets such as other full-body movements or surroundings. At this stage, the level of abstraction is bottom-up and singular. We saw that only finding ways to represent the x-y-z points gave us a myriad of options. This is then, a first step in understanding how designers may be able to understand and design for action as

the intrinsic organization of human action, which has distinctive forms of organization that are not encompassed within any semiotic modality as an isolated whole, or within the individual actor (Goodwin 2011: 192).

Thus, by being able to approach a specific space and explore the movement that takes place before a design is applied or implemented allows for an understanding of how people change their movements by comparing the movement that takes place after a design is applied or implemented.

#### Attention, not yet gaze

In the project we used readily available technology for tracking body movements. However, the motion capture specialist Brun argues that we also need to track eyes when we track movement and that ignoring vision in any motion capture is akin to ignoring a limb, because how we move is determined by what and how we see (2012). Brun presented work on

movement tracking for recreating body movement on screen such as in animation. It is important to keep this in mind, as technology is developed to be increasingly precise, our sight-lines will eventually also be available to be abstracted and explored. Eyesight and body direction can then be analysed through experimental uses of movement dynamics to provide insights into attention and intention.

### 3.5 REFLECTIONS ON EVALUATION AND FEEDBACK

#### Presentations and feedback

Throughout the project I presented my research as I attended workshops, arts labs and seminars (listed in Appendix B). The feedback from the other participants, the audience and fellow presenters was encouraging, educational and crucial in a field that is not only rapidly developing but is also made up of several fields spanning fine art and installation, dance and performance, computer science and high-tech development, linguistics and philosophy. I found the feedback from these different yet related fields central in informing my research and a constructive complement to the article review processes and supervision, in particular for practice: ‘Synthesis [making] at the concept level creates analysis [critiquing] at the object level’ (Liestøl 2003: 392). These events gave me the opportunity to discuss practice across fields and practices. Being exposed to a range of enquiries and discussions on these then increased my ‘methodological awareness’ in the sense that it increased my awareness of the methodological consequences of research decisions taken (Seale 2002: 108).

When I presented at such workshops, the audience contained people from a mix of fields, ranging from linguistics to computer science to visual art and choreography. I found people were often particularly concerned with the ways in which ‘their’ field of practice was adopted or appropriated in another field. This for me raised poignant questions with regard to the positioning and aims of my own research. As my work progressed, I was also increasingly approached to see how my work could be applied in other fields such as medicine (restorative physical work and individual adaptation to prosthesis etc.), theatre (teaching styles of body language to non-dancers) and dance (using the *Sync* data visualisation as part of a choreography). These are all interesting areas for future research and I discuss these further in Chapter 4.

#### Articles and peer review

This thesis is an article-based PhD with three peer-reviewed and published journal articles. These were written during the project and gave me the opportunity to articulate the various stages of the research as well as receive feedback through an anonymous review process. I found this to be an insightful and useful process to inform the future direction of the project and in particular to gain clarity in positioning concerns in the research in relation to the relevant though disparate fields. In the next section, I summarise the articles that can be found printed in full in the last section of the thesis.

### 3.6 SUMMARY OF ARTICLES

The articles address full-body movement for interaction design from different perspectives. The first article examines current practice-based research in choreography and digital technology in order to inform how designers may approach expressive movement for interaction design. The second article approaches movement as a semiotic resource by way of a *Movement Schema* and through the use of *Sync*, a digital application for dynamic visualisations of movement data. The third article focuses on digital tool making for handling movement data, thereby making a case for the handling of movement data as a creative resource for design.

#### Article 1

Hansen, Lise Amy. (2011). Full-body movement as material for interaction design. *Digital Creativity*, 22 (4): 247-262.

The first article explores my claim that interaction design practice relates to and overlaps with contemporary choreography practice, with a focus on digital tools applied in such creative processes. With computational technology and sensors infiltrating many aspects of our lives and urban surroundings, interaction designers' ability to visualise and generate designs is important in order to understand and explore movement.

I propose three concepts – *Accessibility, Immediacy and Generation* – as central to visualising movement for interaction design. Drawing on a social semiotics approach, I discuss contemporary choreographic research where digital tools are used to generate, explicate and communicate interactive movement. The article draws on three contemporary choreographic research projects, Forsythe's *Choreographic Objects*, Davies' *Replay* and Greco's *Double Skin | Double Mind*, to make a case for the creative potential of movement-based digital interactions by addressing choreographic practice.

I argue that by drawing on the particularities and potentials of the moving body as expressive and communicative, such as those explored through choreographic practice, designers may avoid imitating existing exchanges with technology and create novel interactions.

Available at <http://www.tandfonline.com/doi/abs/10.1080/14626268.2011.622284#.Unf2CHHUIH4>

#### Article 2

Hansen, Lise Amy & Andrew Morrison. (In press). Materialising movement: designing for movement-based digital interaction. *International Journal of Design*.

The second article explores my claim that movement data contain both computational and corporeal qualities, and that these may be made creatively available through materialising acts such as through digital tools for the dynamic visualisations of movement data.

Designers today have access to full-body movement data to explore the rich, interpersonal, non-verbal communication we read, interpret, enact and perform every day. This article describes an approach to movement as a design material where movement is seen as embodied communication. The article discusses the mix of qualities in data derived from full-body movement as it encompasses the corporeal and computational and how to present such temporal data. The aim of this exploration is to tease out the rich communicative potential of full-body movement for digital interactions by enabling an explorative engagement with movement data.

People increasingly move with, for and through technology. This article argues that designers need to be aware of the nature of movement data and how such data may be applied, addressed and influenced. The main analytical approach is communication and social semiotics, as we are concerned with the meaning-making design process of movement-based interactions. We suggest that for interaction design, movement may be parsed by *Velocity, Position, Repetition* and *Frequency*. We further describe the development of a tool, *Sync*, for generating dynamic movement data visualisations. We reflect on abstracting and visualising movement data in order to inform and enable the design processes of movement-based digital interactions.

Available at: <http://www.ijdesign.org/>

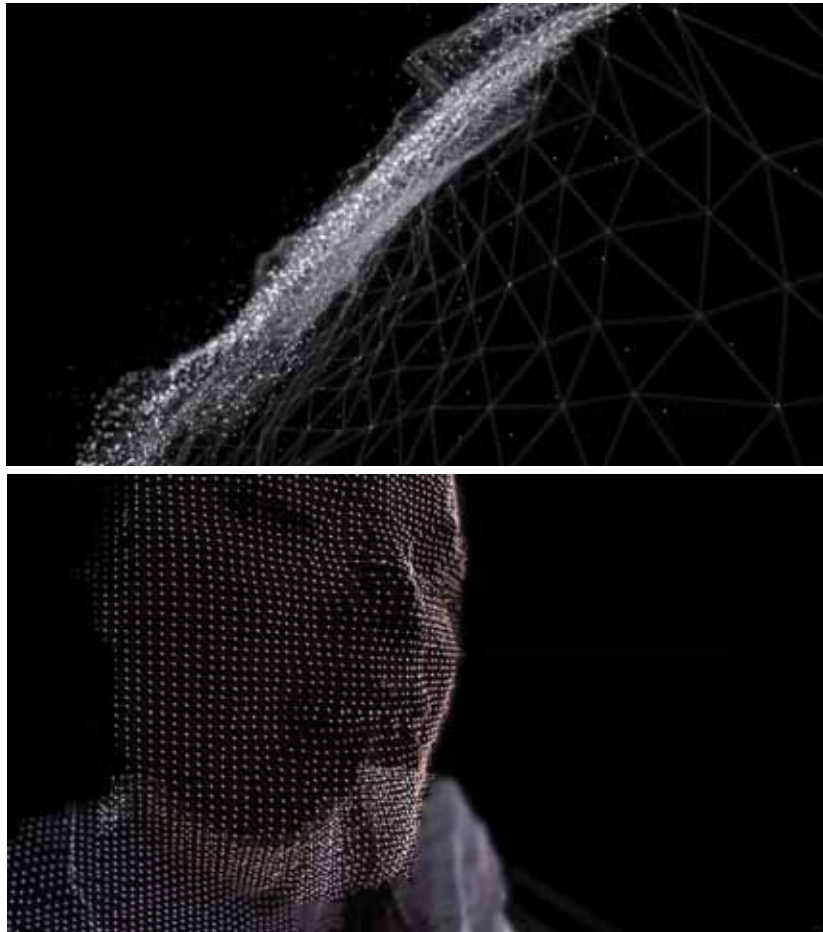


Figure 3.6 Article 3 discusses the presentation of movement data. These two screenshots are of RGBD Toolkit's 3D video (see <http://www.rgbdtoolkit.com/>). The software takes *Kinect's* depth data and combines it with video from a high-definition DSLR camera. This adds another dimension to the representation of movement; a dynamic point of view, whereby it is possible to choose the perspective in the video. Considering this with Forsythe's statement that movement starts from any point (e.g. Spier 2011), we can explore movement visualisations with a dual dynamic perspective.

### Article 3

Hansen, Lise Amy. (2013). Making do & Making new: performative moves into interaction design. *International Journal of Performance Arts and Digital Media*, 9 (1): 135-151.

The third article explores how new digital tools may give creative access to computational material by discussing the many stages and concerns of handling data in order to design, in particular with movement data.

It is now increasingly possible to digitally track and trace movement using affordable sensors and open source programming. This article queries how designers may creatively engage with movement data in order to explore the inherent dynamics in computational data when sourced from an expressive body. It proposes that designing intermediary digital tools may reveal the potentials and particularities of movement data. It discusses *Malleability*, *Visuality* and *Ambiguity* as central to the design of digital tools as these may be put to work to tease out the performative potential of movement data (see Figure 3.6). The concepts are presented in order to tease out and enable discussion on the many creative and pivotal decisions that are made at the materialising stage i.e. where the data is made into a material.

Available at <http://www.ingentaconnect.com/content/intellect/padm/2013/00000009/00000001/art00012>



# 4

## MATERIALISING ACTS

In this chapter, I expand on the notion of materialising movement for design by relating my research contributions to a broader discussion on the role of movement in design and movement as communication with and through digital technology in our increasingly digitised and algorithmic culture.

The overall query of the thesis of how designers may explore movement qualities and potentials as a design material for interaction design is discussed by way of materialising acts such as concept-building through both theory and practice as well as material exploration by way of intermediary digital tools such as in *Sync*'s dynamic visualisations.

I discuss the main contributions of my thesis before proposing some implications of the research. I also present visual stills of some of the possible movement data visualisations available through *Sync*.

#### 4.1 CONCEPT-BUILDING AS A MATERIALISING ACT

By making a case in Chapter 2 for how full-body movement dynamics or vitality can inform interpersonal communication on bodily qualities such as age, gender, and health and notions such as culture, identity and authenticity, I am proposing a potential for such qualities or communications to also be identified in data drawn from a moving body.

This approach encourages a critical view of movement data, that is to say, these notions from interpersonal communication are in part visual and thereby can be given a role in a digital interaction. Thus, my arguments contribute towards discussions about whether notions of age, gender or culture for instance are at play in the data that the designer is drawing upon and designing with e.g. towards a critical view of interaction design, particularly as it pertains to movement data. However, my research cannot answer absolutely how for instance age or gender is materialised or made meaningful; these are empirical questions that need to be articulated through particular cases.

In the practice of interaction design, the notions of movement communications and bodily qualities are in part introduced through language, that is through an identification of and discussions on what movement and movement data may be. It is also worth noting that concepts in choreographic research are created with dancers or performers in mind.

##### Movement visualisation concepts

The first article in this thesis addressed the use of digital tools for choreographic practice, with the overall argument that an interaction designer's practice is increasingly related to that of a choreographer in the design of movement-based interactions. Therefore, design could benefit from a look at contemporary choreographic practice and research and in particular at the digital tools being developed in this field. From this work I suggested *Accessibility*, *Immediacy* and *Generation* as central concepts in the consideration of the role of movement in the design of digital interactions.

The notion of *Accessibility* proposes that there is a range of relevant qualities and modes for movement visualisations. *Immediacy* pertains to the design process and allows the designer to explore in a rapid, iterative manner whether and how the chosen movement qualities and modes could serve a communicative purpose. The concept of *Generation* refers to how designers need to alter and augment parts of the visualisations in order to test, probe and explore i.e. to sketch. Together, these concepts point to a complexity

in abstracting movement in a design process that usually takes place apart from the source – a moving body – which will also eventually perform the interaction. As I discuss in the article, these concepts can guide how movement is visualised for design in order for movement to be a part of a practical sketching and conceptual exploration at the idea stage. These can inform designers of the expressive potential in movement, in turn informing the design potential. This comes from the observation that for interaction design, 'function resides in the expression of things' (Hallnäs & Redström 2006). Currently, there are only a few tools that specifically deal with movement data for exploration and these few, in the main, inform the 'mover' e.g. RAM Toolkit ([http://interlab.ycam.jp/en/projects/ram/ram\\_dance\\_toolkit](http://interlab.ycam.jp/en/projects/ram/ram_dance_toolkit)) or generate work for the stage e.g. Whatever Dance Toolbox (<http://badco.hr/works/whatever-toolbox/>), Creation-Tool (<http://tkb.fcsh.unl.pt/ctkb-introduction>), Piecemaker (<http://motionbank.org/en/event/pm2go-easy-use-video-annotation-tool>) or for performance e.g. Field (<http://www.openendedgroup.com/field/>).

By proposing concepts and discussing how designers may work with movement in digital interaction, I present movement as a material for design with the aim to inform a 'professional vision' (Goodwin 1994) specifically on movement for design. By introducing a design-sensitive approach in the conceptualisation of movement, a potential in variation and expression can become apparent and thereby available for design. The concepts as published in my articles are a way to present and discuss the challenges of working with the abstractions of movement dynamics in communication. The concepts also address the challenges of designing with an immaterial material required to be continuously materialised, in particular as it draws upon, addresses and affects bodies.

##### Movement data tool-making concepts

In the third article, I proposed the concepts of *Malleability*, *Visuality* and *Ambiguity* as central in the consideration of how to handle movement data. I describe the acts that visualise movement data and thereby materialise movement for design. I use the example of designing Sync, but draw on wider considerations from software studies and digital design. *Malleability* refers to flexibility in the decision of what movement data is of interest or is usable. *Visuality* addresses the communication of potential in movement data as a necessary part in a collaborative, explorative process. *Ambiguity* refers to an openness of application or appropriation of possible functions of the movement data.

Together, these concepts form an argument for data handling as a creative act. I unfold many of the considerations and decisions that come from visualising movement data and thereby show a creative potential in how movement data is presented and movement is re-presented; in how the data is called upon and how it is made visual. In this way, I make a case for considering these decisions as motivated and culturally situated, by pointing out that there are many ways in which data is collected, stored, retrieved, calculated, organised and presented.

### The role of concepts

By discussing variation and potential in the processes of making movement data and movement visuals specifically for digital interaction design, I argue that movement data handling is a *materialising act*. I also argue that this should be a part of a designer's creative repertoire, as opposed to a technical issue.

It is only through the act of materialising that data can become a material. This is a simple statement with several implications. Galloway (2011a) argues that data has no necessary form. This freedom is however inevitably restricted by the fact that data needs another material to come to expression (Vallgård & Redström 2007). How data is brought forward to become a material then is chosen and motivated. For design practice, it needs to be presented and materialised in ways that are intelligible or sense-making for designers (akin to how a biologist would want movement data that pertains to the practice of a biologist). This implies that interaction designers themselves should participate in generating concepts that are purposeful for their particular expertise, practice and research. In this sense, I see my project adopting 'a concept-driven approach [that] aims at manifesting theoretical concepts in concrete designs' (Stolterman & Wiberg 2010: 95). My research can be seen to deliver 'designerly' tools:

We define designerly tools as methods, tools, techniques, and approaches that support design activity in way that is appreciated by practicing interaction designers (Stolterman et al. 2008: 1).

Sennett addresses such a connection of material and its representation as 'engaged material consciousness: we become particularly engaged in what we can change' (2008: 120). In other words, these need to be communicated in order to understand the possibilities and potentials of a material. In order to do so, Berry argues we need to 'unpack different modalities of code as digital forms and allow us an understanding of how it [code] is used in computer technology' (2011: 51).

Seen in this way, building concepts, naming qualities and concerns central to understanding a material for design is part of creating the material as well as an understanding of it. With new computational materials, these concepts need to be found or indeed made before they can be understood or studied. This concern is addressed in my third article regarding balancing what a designer has at hand with what a designer thinks is possible to make. In a design process with movement data in particular, I argue that 'there are high expectations, yet few conventions' to build on (Hansen 2013: 147). My suggested concepts enable a design practice where concerns regarding movement can be identified and addressed at a conceptual stage:

The possible that each individual can conceive thus largely depends on an exchange of information, a capacity to establish contact with those who know how to perform certain other processes (Manzini 1986: 62).

Schön's much cited conversations *with* materials are described through just that – conversations *on* materials (Schön 1991). One could argue that a communication potential lies in the fact that data must be *made* a material, must be made to make meaning. Thus, by the fact that it is not a given, we can explore how it may be as opposed to what we presume it to be. Jill Sigman addresses a similar concern regarding dance:

Signification cannot be equated with representation. What is signified by a dance depends on what is represented and how it comes to be represented [...] although dance doesn't signify like ordinary language, it still has the potential to signify. In fact, it is perhaps this complexity of its signification that makes it so rich and powerful a medium of expression (2000: 523).

As I have proposed, one way to explore possible roles for movement in digital interaction is through materialising acts. Dearden also writes that if we are to know how to design or work with digital material, we need to explore design activity oriented towards future material expressions to involve a different audience e.g. the ways in which digital materials may be made to matter for designing (2006). The assumption that this will help the field advance is based on the notion that new digital devices introduce 'new practices, new terms and metaphors [...] new work patterns and practices [...] new forms of organisation, new specialisms' (Coyne et al. 2002: 271).

### Temporality and agency

By proposing concepts central to temporal communicative qualities of interaction, I foreground particular kinds of communications that exist only as interactions that play out over time. This is in part because corporeal qualities in movement data become apparent or available as they appear over time. This is a simple statement with several implications. Traditional notations distil positions and computational tools focus on a detailed mapping e.g. LabanWriter (<http://dance.osu.edu/labawriter>). These are instructional for dance and yet, as Sheets-Johnstone previously argued, a description of an object's positions is not a description of movement (1999b). Similarly, a music score does not contain information about the mechanisms or processes of performing beyond the 'formal characteristics' specifying the music to be realised (Puri & Hart-Johnson 1995: 162). Thus, movement notation as a score or a process for interaction design in some ways falls short in informing practices of design.

Farnell points to a similar critique of representing a body when she asks anthropology to consider the moving body, because 'the way human agency works is in terms of the signifying enactments of moving persons' (2011: 154). In other words, the communicative qualities reflecting human agency occur temporally. This gives an impetus for the abstraction and conceptualisation of these qualities also to be considered and represented temporally. Arvola argues that dynamic and temporal elements in interaction designing can be represented through enactments (2007).

I now turn to my explorations of visualising movement dynamics as part of conceptualising movement and movement data for design.

### A Movement Schema

I propose a conceptualisation of movement dynamics in order to be able to explore how design may address movement as communication in a *Movement Schema* (see Figure 4.1). For interaction design, it is essential to explore possible expressions as a way to address function and design (Hallnäs 2011). By foregrounding the dynamics of movement as a central organising dimension of how movement communicates, I drew on Halliday's functional linguistics (Halliday & Matthiessen 2004), where the meaning of language can be understood by way of the use of language, that is, by how it is applied. By focusing on choice within a system rather than on an all-encompassing system, Halliday enabled a new reading of language. With movement, a similar shift can be envisaged in digital interaction, where it can be made to matter not only what you do (e.g. the possible movements of a body) but

where we can make it matter *how* you move or perform which as I have argued is a central dimension in interpersonal communication.

By focusing on the communication of a temporally unfolding material in a bottom-up manner, I suggest concerns and challenges as well as potential and possibilities of movement as communication. Mapping out a system network proposes a way of unfolding how a material may go from medium to mode in Social Semiotics. The *Movement Schema* is one suggestion of such a transition. The schema parses movement into categories or modalities. It becomes an analytical tool for mapping a range of movement modalities in a semiotic resource and thereby options are made available by each modality, by seeing movement as a mode. As such, the schema becomes a starting point or a design brief in a sense for how such a textual parsing of movement could be visualised and may inform a specific technological assemblage or setting.

The *Movement Schema* provides an analytical link between the body as an expressive source of data to movement data as a visual or rather as a semiotic resource in itself. It is also a device to apply to the movement data as a semiotic resource in its own right. The moving body has previously been extensively mapped, such as in Labanotation and other notation systems (e.g. Guest 1989, 2005). Labanotation is currently under development towards a digital writer or animation of notation scores e.g. DanceForms (Calvert et al. 2005). Yet, in concert with such extensive and detailed mappings and representations of the moving body, as I have argued above, we need to also articulate how a mapped body differs from a physical body. In particular, we need to explore the transitional processes of abstracting and re-presented movement. It is to add to such explorations that I propose a *Movement Schema*.

It is important to note that my development of the *Movement Schema* went through several iterations as we designed the digital application *Sync*. The design workshops informed the schema and allowed me to adjust its categories: *Force* became specified to *Velocity* or rate of change, for instance. Several categories were renamed and refined and the relation between the categories also changed as they inevitably overlapped. For example, the category *Position* was initially called *Position & Alignment*. Yet, as we worked with movement visualisations (described in the previous chapter), the positions of movement dynamics visualisations were placed in relation to other movement dynamics visualisations within the body rather than in relation to the setting or context in which the movement took place, so the alignment became superfluous. Another category was initially labelled *Flow*,

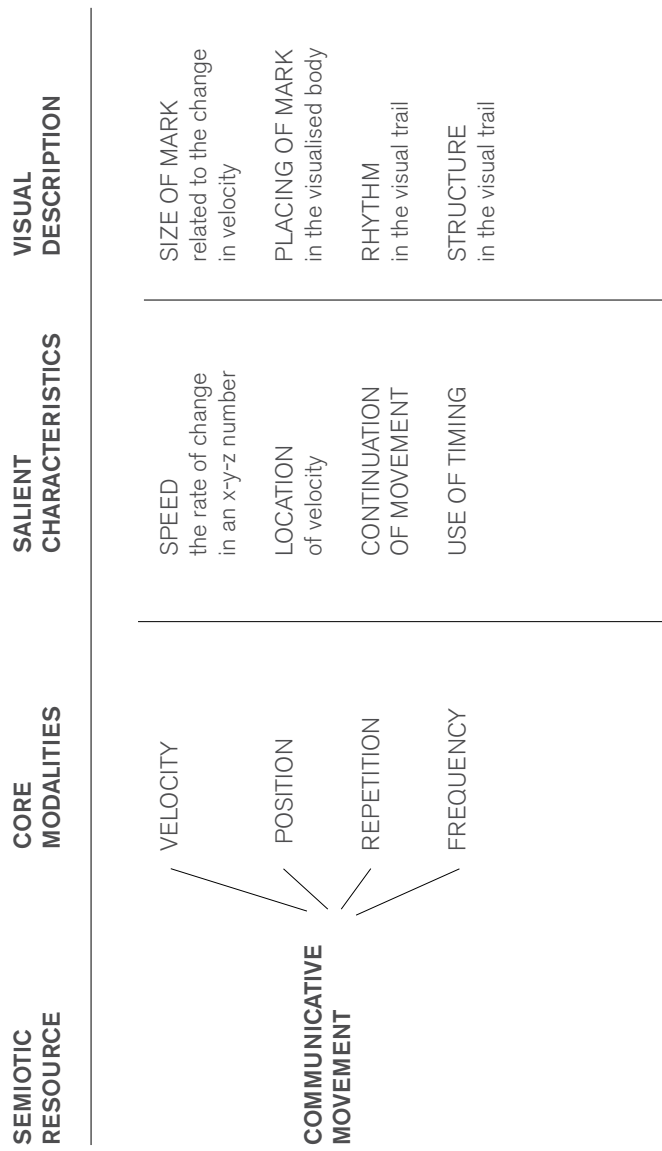


Figure 4.1 The *Movement Schema* identifies *Core Modalities of Communicative Movement* by way of a diagram which lists them as *Velocity, Position, Repetition* and *Frequency*. These modalities are then further described by way of their *Characteristics: Speed, Location, Continuation of Movement* and *Use of Timing*. As the purpose of the diagram is meant to inform the design of movement-based digital objects and systems, I also describe a possible *Visual Description* of each modality: *Size of Mark, Placing of Mark, Rhythm* and *Structure*.

but was changed due to the specific meaning that *Flow* has as a part of Laban Movement Analysis (LMA). Here the Effort-Shape theory is described as *Free* or *Bound*, terms shaping expression in movement as dance (see Newlove 1993, Newlove & Dalby 2009). I found that this naming characterised a specific reading as an effort-shape element, which did not service our visual parsing of dynamics. I therefore renamed the category *Continuity*. In these ways, the *Movement Schema* emerged from an interdependent relationship between theory and making.

The *Movement Schema* provides an account of the inevitable cuts or boundaries through which technological systems are made (Suchman 2007). This is so in the sense that it gives an account of a unit of analysis, full-body movement, not determined by the body or technology but by how full-body movement may come to matter with technology.

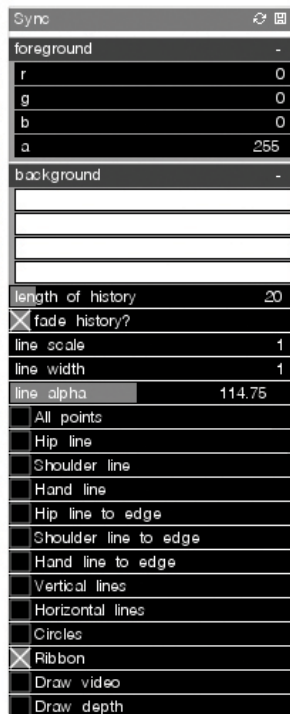


Figure 4.2 The *Sync* menu allows for movement data to be visualised according to several parameters such as the mark; by a circle, vertical line, horizontal line or banner. The mark is further decided through its thickness, scale and alpha (density). It can set the length of history and whether it fades. *Sync* also gives the option to link shoulders, hips and hands, either by a line between each, or by an extended line to the limits of the frame. RGB sliding scales allows choice of the colour of the background (e.g. the screen) and foreground (e.g. the visualisations).

## 4.2 MATERIALISING MOVEMENT DATA THROUGH SYNC AS A MATERIALISING ACT

Just like a designer draws upon a moving body in the making of movement-based digital interaction, a designer also draws upon available digital technology. The capacities of the technologies may be taken as a given, but their application is made. My discussions of movement data handling as a creative act and as a materialising act also contribute towards a critical understanding of not only what movement data is but how we may assemble and apply it. By showing a variety of ways that different movement qualities can be foregrounded (shown in section 4.3), I make the case that the visualisation or materialisation of movement data matters. There are cultural and pivotal choices made at this stage in a design process, such as the placing of sensors to collect movement data.

As described in the previous chapter, I designed *Sync* in collaboration with Hellicar&Lewis over several design workshops. The aim of the design investigations was to explore how movement and movement data may be seen as a design material from a practice perspective. The aim was also to explore how corporeal qualities and dynamics in movement data could be presented in dynamic visualisations.

I will now briefly outline *Sync* in light of Chapter 2 wherein I discussed movement as a resource for communication. I will focus in particular on the abstraction and representation of movement in order to make a case for movement data handling as a creative resource in design.

### Sync

*Sync* is a digital application, a tool that allows designers to visualise movement data. We wanted to create a tool that could aid a process of meaning-making, of semiosis, rather than imposing a pre-set system of signification on movement as a communicative resource. van Leeuwen described how semiosis develops from the bottom up: ‘There has to be a “medium” before there can be a “mode”’ (1999:193). In this sense, *Sync* enables movement data to go from medium to mode as it presents movement data and represents movement.

Today, *Sync* is drawing on the data from Microsoft’s *Kinect* but may equally adopt other data sets of x-y-z positions. *Sync* allows movement data to be dynamically visualised according to a set of parameters in the menu or Graphic User Interface (see Figure 4.2).

*Sync* aims to highlight movement dynamics over posture or function i.e. emphasising *how* we do something as opposed to *what* we do. *Sync* does this by visualising the velocity or the rate of change in the position of a body part. The movement data body is (for now) made up of a *Kinect* skeleton, with 15 points identified and tracked as feet, knees, hips, hands, elbows, shoulders, head, and a centre for hips and shoulders. Each of these points may be visualised in four different ways by a banner, a circle, a horizontal or vertical line, in all these ways or as a combination of any of these elements (see pages 109, 111, 113 and 115, respectively).

Studies on movement in computer science focus on a mathematical modelling for imitating, predicting and identifying physical movement (e.g. Calvert 2005). *Sync* gives near real-time visualisations of movement, with a comparative video feed of the actual movement. In this way, designers may see which data was captured in comparison to actual movement. It is also important to point out that we get access to the ways in which movement data is different from actual movement. 'We always see less than is there [...] We also always see more than is there' (Bleeker 2008: 18).

*Sync* currently makes no distinction between whether the movement or the rate of change occurs on the x, y or z plane. Equally, it identifies where there is less or little movement. There is an option to show history, which is a visual trace of a point. With little movement, one gets a build up of visuals, creating a denser mark the longer there is stillness (see page 111).

All points are (for now) seen in relation to the 15 points mapped on the body. We further added the possibility to pair hips, shoulders and hands with a line between the points in order to highlight the relation between the two. The paired points may also be extended to infinity (on the screen) as an alternative to highlight the movement of the pairing (see page 107).

The *Kinect* software uses depth data i.e. a body outline to calculate, identify and track the various points to make up a skeleton. However, as has been pointed out by several in performance studies (e.g. Woolford 2013, Drewes 2013), it is not a skeleton in the sense that it is calculated based on information about how a body's boundary changes – it does not act the way a skeleton acts.

#### **A situated look at movement data**

By its very nature, movement exists in time and, as I have argued, it has temporal qualities such as repetition and frequency, which favour a temporal

representation. With a real-time visualising tool like *Sync*, temporal qualities may be viewed, identified and named as they occur. Like Wei's *TGarden*, *Sync* does not decide what a movement means according to a pre-determined system of signification and thereby provides 'glimpses' of what may 'be shaped and made palpable by gestures' (Wei 2002: 452). *Sync* allows you to track movement in various ways, thus allowing the scripts that call upon the data to become apparent. *Sync* itself can also be altered, with the code available (<https://github.com/HellicarAndLewis/Sync>).

These dynamic visuals of movement data are sketches and as such can be seen as a material anchor (Hutchins 2005). Arvola suggests that for complex design concepts and their implications, such sketches can hold the design in place and make it 'stable enough to reason about' (2007: 106). A material approach to movement data shifts the focus in a design process from objects to the communicative agency of our bodies:

Interaction design aesthetics, as a logical foundation of design practice, also introduces a shift of focus, moving from design by drawing to design by act defining (Hallnäs 2011: 74).

This is a meaning-making activity that has had limited research. Prior points out that earlier texts on multimodality have

provided valuable perspectives and observations, but have focused on multimodal objects rather than multimodality as situated activity. Attention to multimodal production and reception is limited' (Prior & Hengst 2010: 6).

By focusing on the dynamics of movement as it is expressed over time, I open up a different understanding of movement from comparing it to or building general systems of signification. In the *Movement Schema*, the dynamics of movement is the central communicating resource divided into Velocity and Position, and these are again seen in Repetition and Frequency. Tools such as *Sync* allow an analysis of what Norris identifies as a 'complex interconnectivity of events' (2012: 170). *Sync* does this by its near instant visualisation of data coupled with a recording function.

In Chapter 2, I described how designers and programmers work in studios where they create interactions often removed from the people that will perform them. With *Sync*, however, designers may gain access to movement closer to the action. There is a low threshold for accessing and setting up the technology, which makes trying out and altering the collection of data easier. Together, this brings designers closer to the movement (see page 104).

By adapting *Kinect's* calculations to identify a body by way of 15 points, we are able to use existing technology as a technique informed by interaction design practice to materialise movement and explore how communication systems may be built for a variety of movements and a variety of bodies.

### Materialising applications

The tools with which we materialise are instrumental in communicating the potential of the material. I found that there are a few ways to address movement data. *Sync* suggests how we may start to explore movement data for design. It can work as a boundary object (Bowker & Star 1999) in a practice where collaborative projects are the norm and where software expertise is rapidly developing and evolving. It provides a glance into movement data for designers.

*Sync* also provides an argument for a design-sensitive approach to computer expertise and likewise to movement expertise. If interaction design is to truly draw on the fields that make up its practice – human practice i.e. movement communication and computer practice i.e. collecting, storing, retrieving, ordering and calculating and presenting information, then we need to find ways to communicate this kind of expertise. This is important as, we can interact with digital elements by gesturing and body movement, by manipulating everyday objects, and even by training brain activity to control interfaces. To understand the design principles of such a world requires that we become familiar with the ongoing developments in embodied, distributed, and situated cognition, and build closer relations to their research agenda (Kirsh 2013: 26).

On a larger scale compared with an individual body, in airports today we can see people move through elaborate, invisible mazes, getting tickets registered, baggage tagged and delivered, getting passports checked and boarding passes printed. In part, the role and implementation of software in such scenarios are motivated by economical measures. As such, we need to develop a critical view of the conceptual processes shaping how computational structures and scripts are created and applied. By the time we analyse the impact of larger software infrastructures, many decisions may be beyond change. Blanchette argues that:

abstractions, embedded in software, hardware, and institutions, endure across decades, acting as conservative forces on infrastructure evolution (2011: 15).

I mention these arguments to make the case for why a critical approach to movement data is needed. Software may seem materially invisible and removed in comparison to a physical object. However, invisible software is made visible precisely in our actions; we are the ones performing the scripts, we are the ones substantiating the code when we yield and adjust, for instance, as we try to get a scanner to see what it is *supposed* to see. A critical view on these digital developments are important because the future development of technology is not a given (e.g. Zielinski 2006) and how we move matters (e.g. Cuddy 2012).

### A repeated and revealing look at movement scripts

In Article 2, I describe the detailed and complex work involved in mathematically calculating movement and that this indeed is no new research trajectory (e.g. Badler & Smoliar 1979). However, as I found, in HCI, each model of movement is evaluated on the precision with which it can imitate or predict movement. For design, it is the move *between* these models, the shift between each materialising abstraction, that can tell us about the nature of materialising movement data and in turn can tell us about the nature of our future design processes. *Sync* can provide a wide variety of dynamic visuals through repeated calls on the same movement data. By exploring these various ways, we also get a sense of the scripts at work, the parameters or boundaries in how the data may be called upon.

Leonardi discusses the immaterial nature of computation and argues that especially in the case of digital artefacts, what may matter most about 'materiality' is that artefacts and their consequences are created and shaped through interaction (2010). I argue that *Sync* is one way to get to the materiality of movement and movement data, exactly so that we may start to explore what can be shaped and *made to matter* in an interaction at a conceptual as well as a practical level.



### 4.3 SYNC MULTIPLES

In this section, I show a series of full-body movement representations generated by *Sync* in order to offer a printable representation of *Sync* at work. Visualisation choices can be seen in the menu on the left of the *Sync* screengrab and the image captions further aid a reading of each still.

I chose a hand wave and a jump because these are simple movement phrases that we have all performed. They are also movements that we are expert in reading – is it a friendly or a frightening wave, a warning or a welcoming wave? It leads to the question of what it is in a wave that we observe, in the way that it is performed, which enables us to understand what kind of a wave it is. For each data presentation and movement representation, I describe the choices made in *Sync* (shown by way of the menu on the left hand side). I also describe what this in turn foregrounds in the movement data visualisations.

At the heart of quantitative reasoning is the following question:

Compared to what? Small multiple designs, multivariate and data bountiful, answer directly by visually enforcing comparisons of changes, of the differences among objects, of the scope of alternatives.

For a wide range of problems in data presentation, small multiples are the best design solution (Tufte 1990: 67).

It is worth noting that I do not aim to settle on what these movement representations may mean. As I argue in this thesis, the meaning depends on the design task at hand, on the context of the movement and so on. Rather, by showing the variety of ways in which the movement data may be presented and thus the variety of ways in which movement may be represented, I make a case for these processes of presentation, of materialising as creative acts, because there are choices made in what qualities of movement are foregrounded. Referring to Sennet's material consciousness, we become engaged in what we think we can change (2008). Thus, by showing that the way we present movement matters and that its presentation is conditioned by design practice, I wish to present a critical view and a creative engagement of the role of movement and, by extension, of how bodies are addressed in interaction design.

In order to attend to these visuals as a material for interaction design, I also account for the visuals directly in this section. This is rarely an explicit concern in studies of visual culture (Rose 2001) and is yet an important step in building a critical approach to visual imagery and in particular for dynamic images such as those generated by *Sync*.



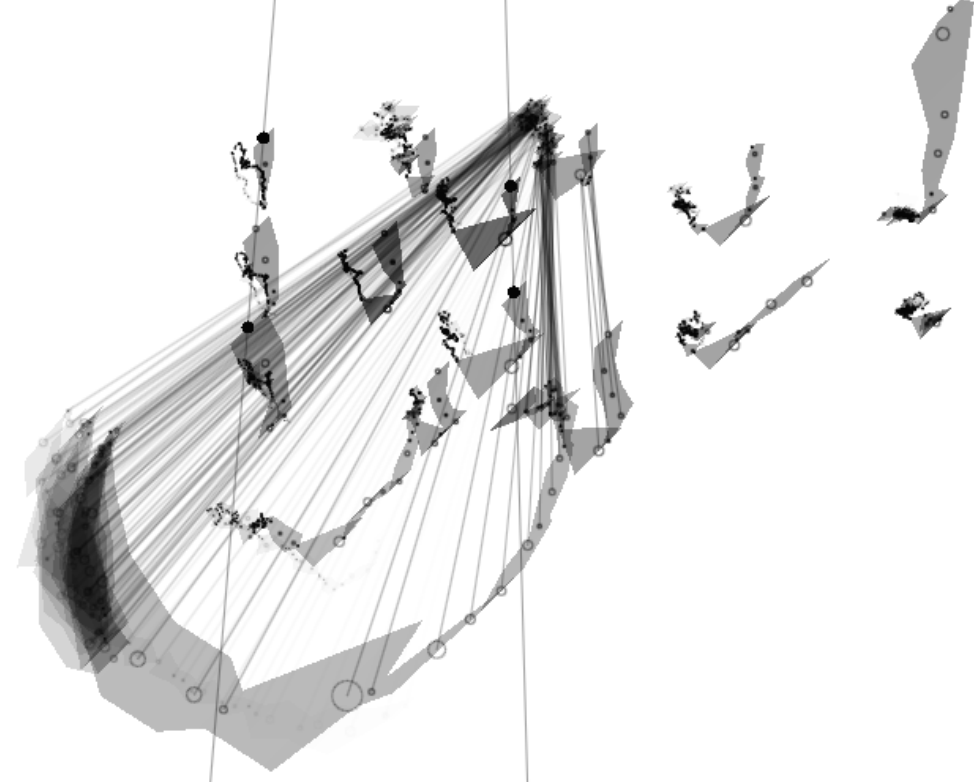
The image above shows an overhead view of the scale and simplicity of a *Sync* set-up, as we register a wave directly to the *Kinect* sensor.

The movement data visualisations are layered over the video allowing for comparison. In this still each point is traced creating a line. With no mark choosen, it shows the path of the movement without any visual information as to its dynamics. It does however show an invisible relation by drawing a line between the hands, highlighting the waving hand and the lack of movement in the other hand. In this phrase Bech-Hanssen is walking out of frame e.g. beyond *Kinect's* scope and making the limit of the sensor visible.



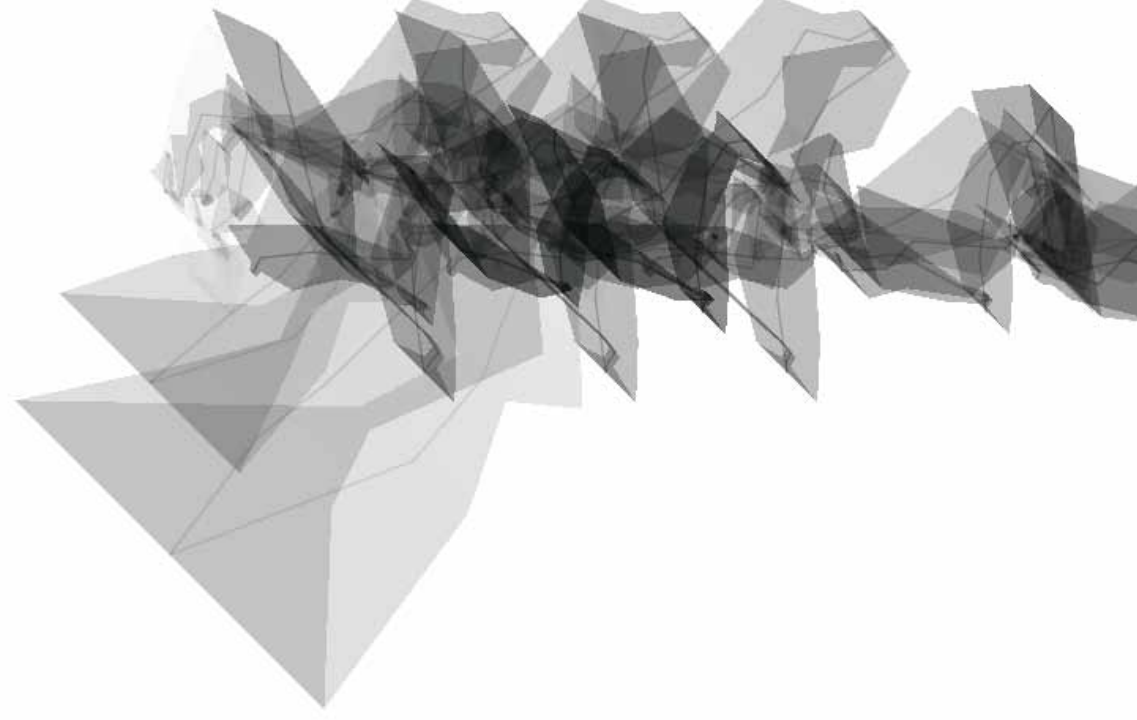
In this still the same waving phrase has its movement data further unfolded. The marking of each point by a banner mark and to some extent the circles varying sizes show the rate of change, the movement dynamics. The position of the body is still present in that all points are tracked and can also be glimpsed from the extended shoulder and hip lines.

Sync	🔄
foreground	-
r	5
g	5
b	5
a	7
background	-
length of history	142
<input checked="" type="checkbox"/> fade history?	
line scale	1
line width	1
line alpha	00.175
<input type="checkbox"/> All points	
<input type="checkbox"/> Hip line	
<input type="checkbox"/> Shoulder line	
<input checked="" type="checkbox"/> Hand line	
<input checked="" type="checkbox"/> Hip line to edge	
<input checked="" type="checkbox"/> Shoulder line to edge	
<input type="checkbox"/> Hand line to edge	
<input type="checkbox"/> Vertical lines	
<input type="checkbox"/> Horizontal lines	
<input checked="" type="checkbox"/> Circles	
<input checked="" type="checkbox"/> Ribbon	
<input type="checkbox"/> Draw video	
<input type="checkbox"/> Draw depth	

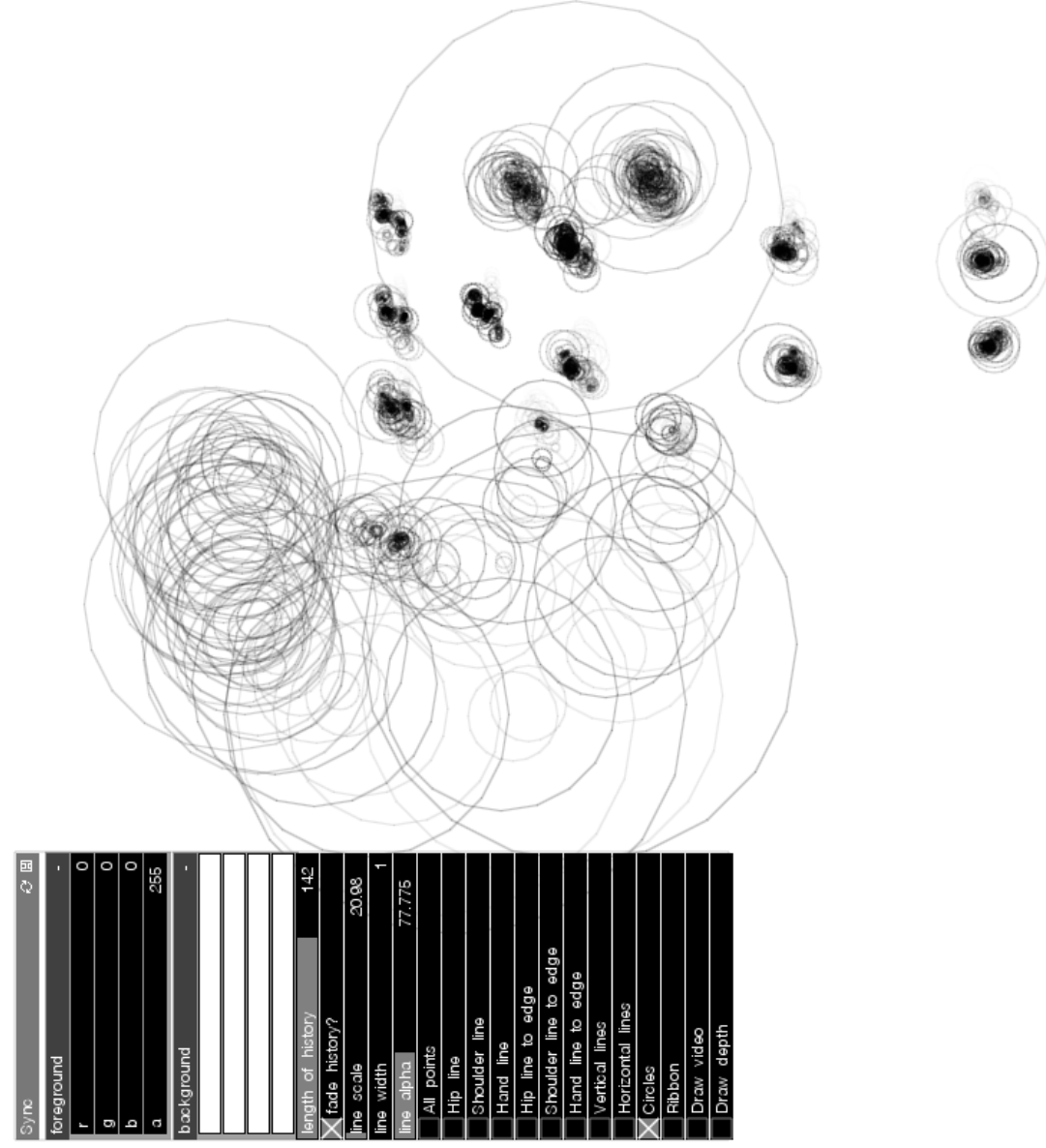


In this still the movement data is from the same wave, but from a shorter fragment of the phrase. Velocity is shown by the banner mark. The line scale is increased compared to the previous images, i.e. each rate of change generates a larger visual change. In other words, it takes less movement to make a visual impact. With these settings there are few visual features with which to reconstruct the body.

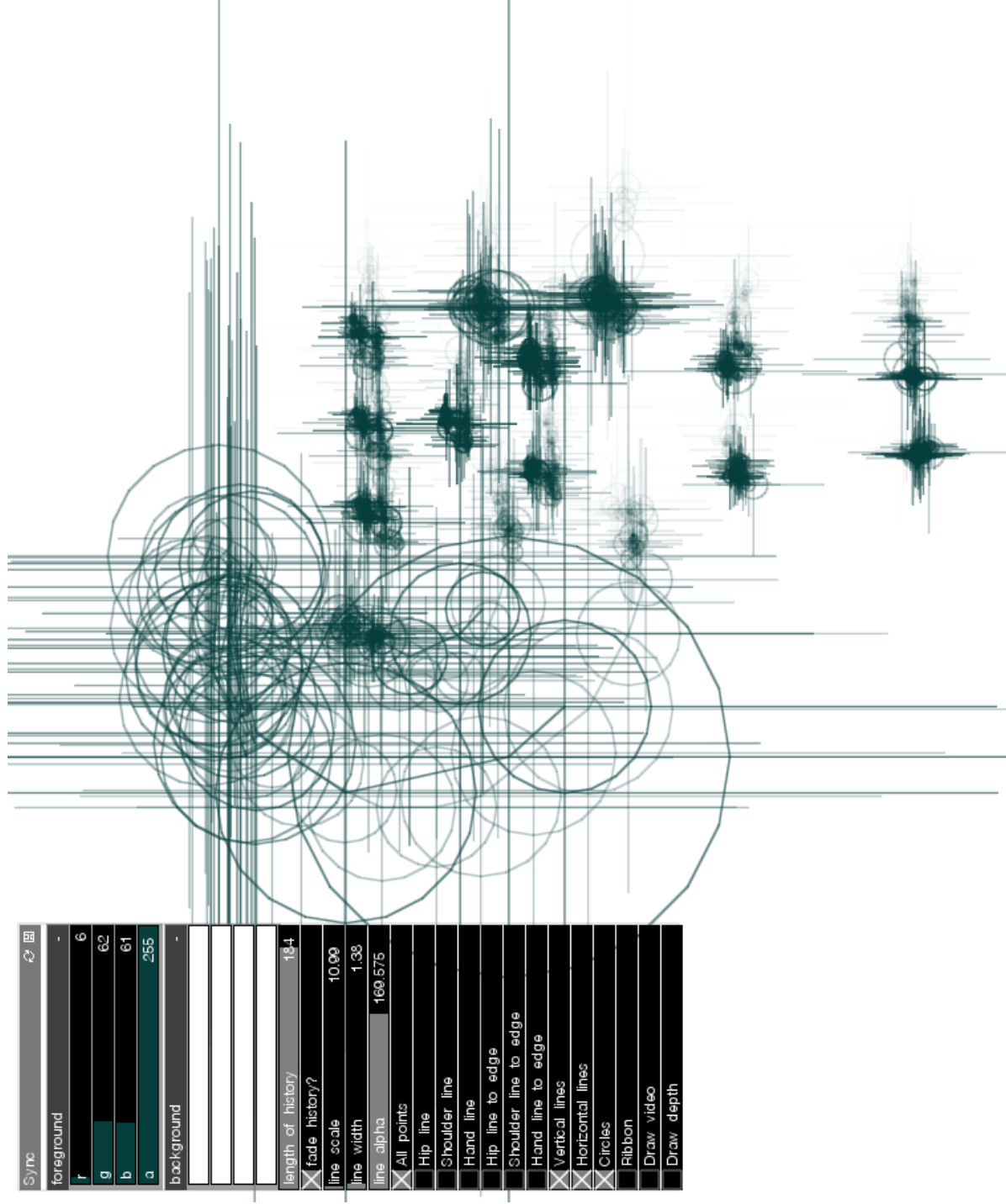
Sync	☺
foreground	-
r	7
g	10
b	10
a	11
background	-
length of history	41
<input checked="" type="checkbox"/> fade history?	
line scale	10.00
line width	1
line alpha	87.975
<input checked="" type="checkbox"/> All points	
<input type="checkbox"/> Hip line	
<input type="checkbox"/> Shoulder line	
<input type="checkbox"/> Hand line	
<input type="checkbox"/> Hip line to edge	
<input type="checkbox"/> Shoulder line to edge	
<input type="checkbox"/> Hand line to edge	
<input type="checkbox"/> Vertical lines	
<input type="checkbox"/> Horizontal lines	
<input type="checkbox"/> Circles	
<input checked="" type="checkbox"/> Ribbon	
<input type="checkbox"/> Draw video	
<input type="checkbox"/> Draw depth	



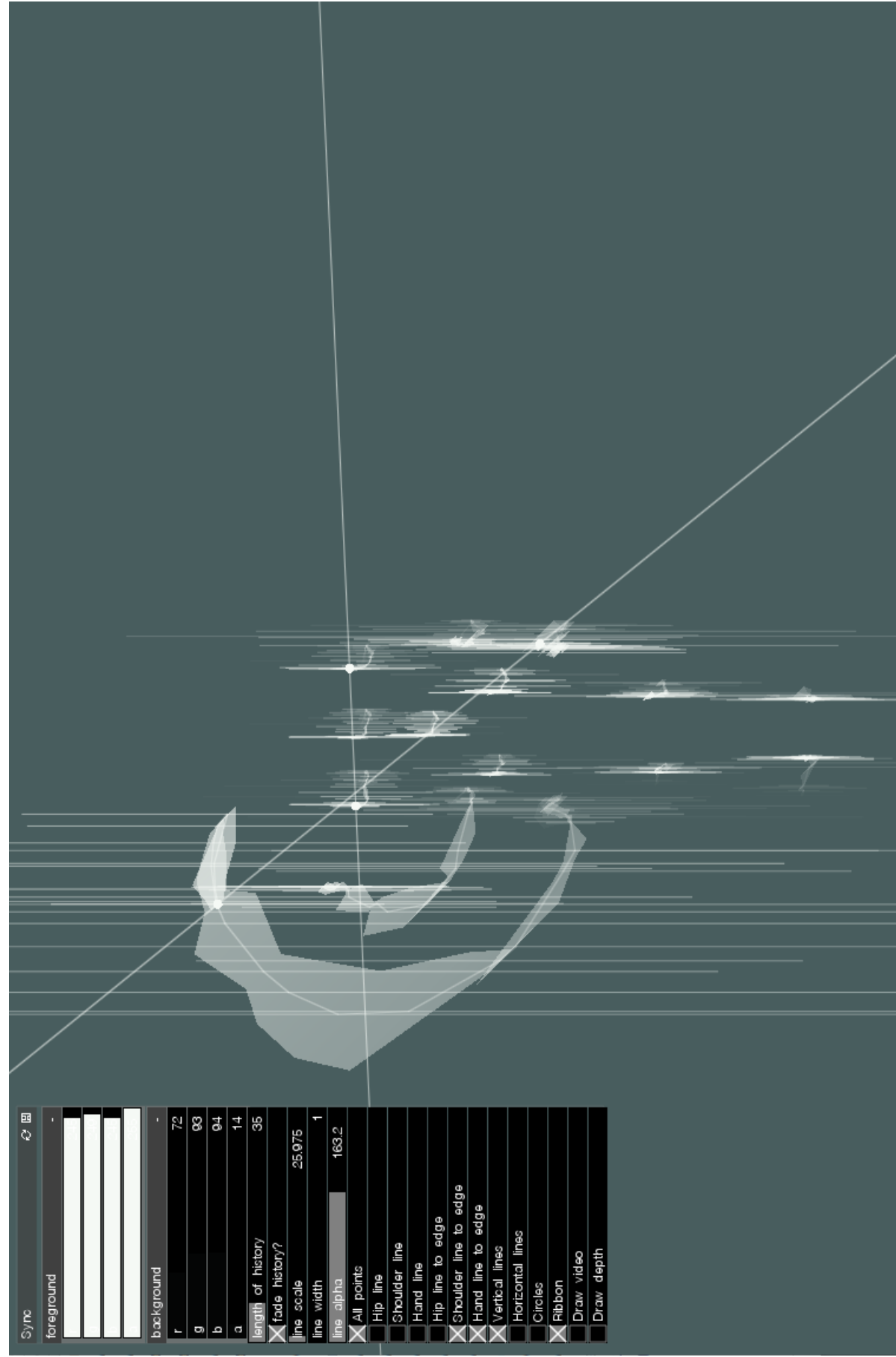
In this visual of the same wave, the points are marked only by circles. Although movement is clearly seen in the waving hand to the left, the movement trajectory of the hand is less identifiable. This setting does however offer a location of points that do not move through the build up in visual markings, thereby reconfiguring the body.



In this visualisation the dynamics is marked by circles as well as vertical and horizontal lines creating a denser picture. The pinpointing of the lines work to locate non-movement, however, for the moving hand they start to offer a more abstract density. In other words, it becomes harder to re-trace the exact movement trajectory, whilst offering a location of repeated movements where there is a build-up of longer lines.



In this still the line is extended through both shoulders and hands. All points are marked by banner, vertical line as well as tracing a short movement path. The line clearly shows the path and the banner shows the change in speed as the arm is lifted to start a wave. Whilst the vertical lines also indicate movement, the comparative change is less apparent, as well as the location of the change.

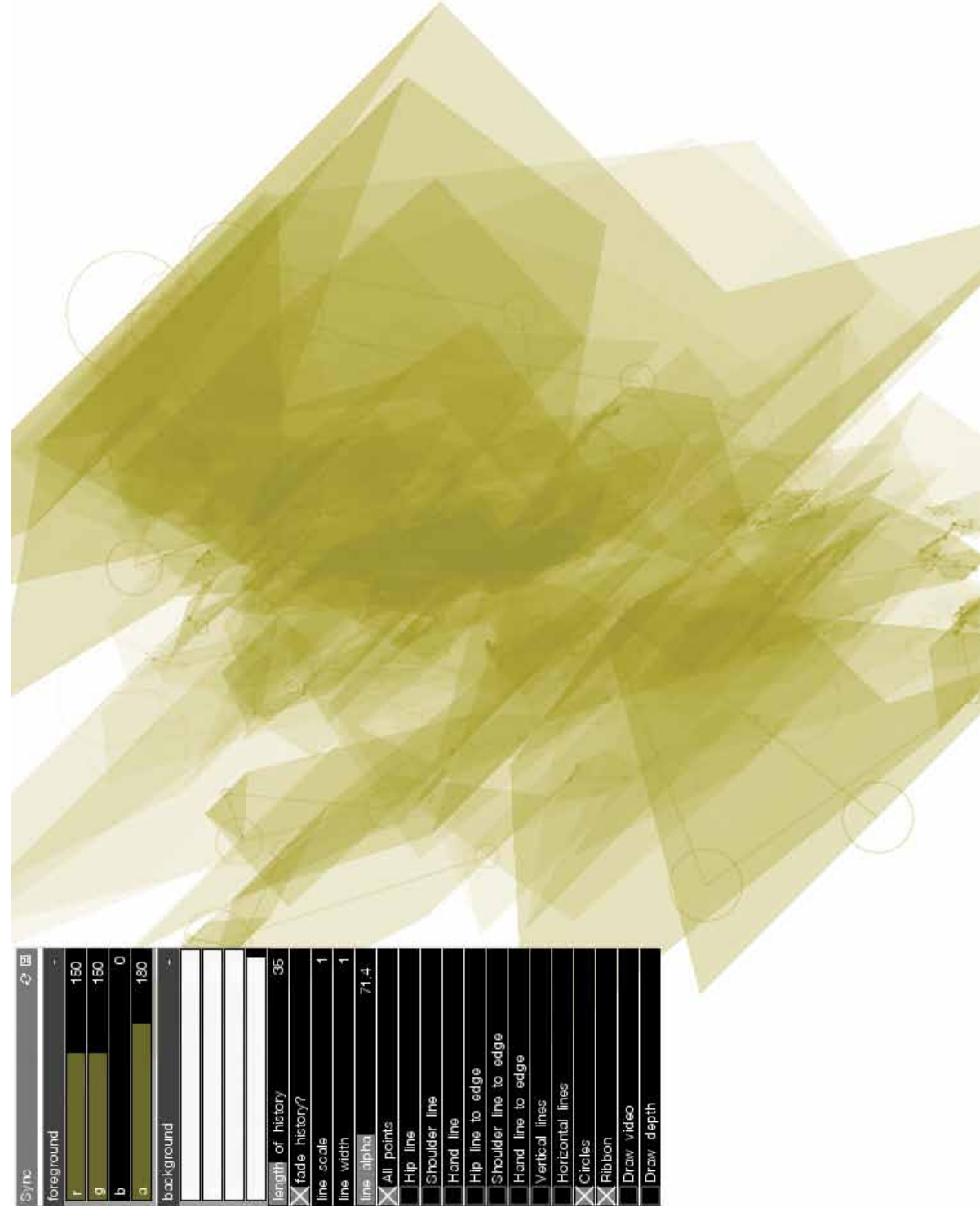


Sync	🔄
foreground	-
background	-
r	72
g	03
b	04
a	14
length of history	35
<input checked="" type="checkbox"/> fade history?	
line scale	25.075
line width	1
line alpha	163.2
<input checked="" type="checkbox"/> All points	
<input type="checkbox"/> Hip line	
<input type="checkbox"/> Shoulder line	
<input type="checkbox"/> Hand line	
<input type="checkbox"/> Hip line to edge	
<input checked="" type="checkbox"/> Shoulder line to edge	
<input checked="" type="checkbox"/> Hand line to edge	
<input checked="" type="checkbox"/> Vertical lines	
<input type="checkbox"/> Horizontal lines	
<input type="checkbox"/> Circles	
<input checked="" type="checkbox"/> Ribbon	
<input type="checkbox"/> Draw video	
<input type="checkbox"/> Draw depth	



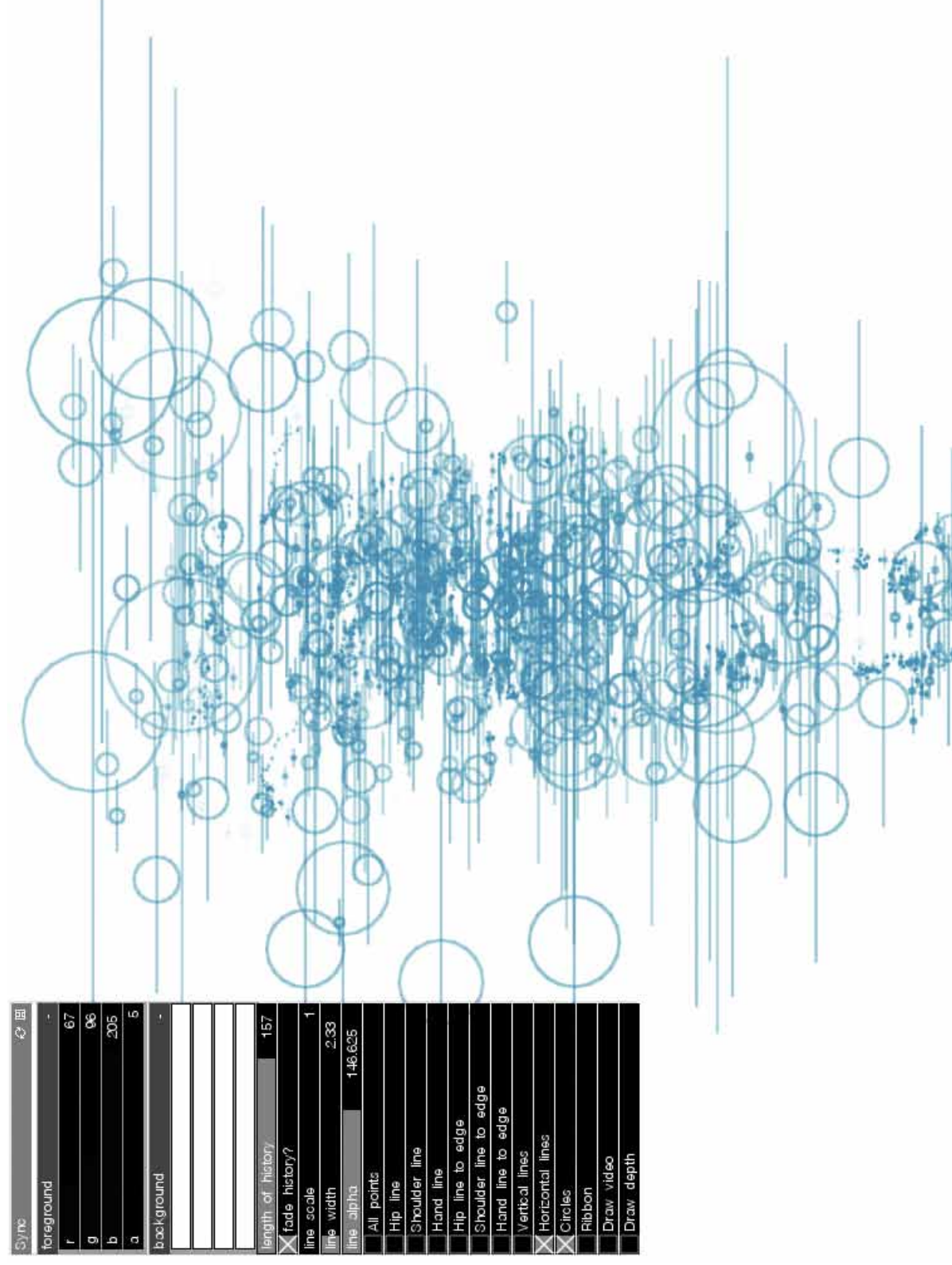
We explored many kinds of movements with the *Sync* set-up and could not resist registering our jumps. The preparatory moves to get off the ground were necessary fast and difficult to perceive with our eyes, making the data all the more interesting to both unpack and to layer.

This image visualises a jump with all points tracked, as well as marked by a circle and banner visual. The length of history setting gives a layering of movements that overlap. This enables a build-up of densities referring to a rhythm and repetition we would otherwise not perceive.



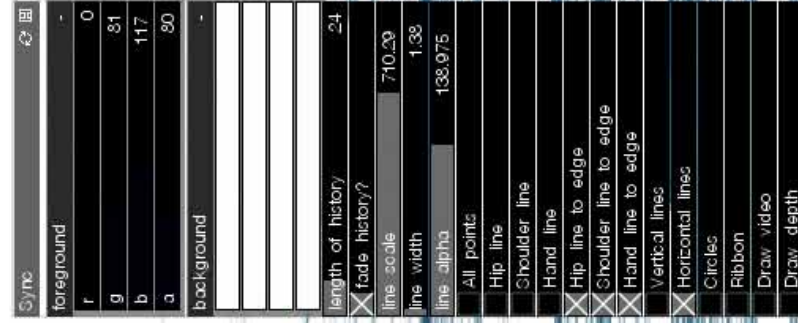


This is a visual of the same jump, whereby all points are marked by the circle mark as well as the horizontal line mark. It has a long history setting which gives a layering of movements, though we can see that the most dynamic movements were the preparatory moves, not the actual jump, seen in the large circles generated by the arms.



Sync	☺
foreground	-
r	67
g	06
b	205
a	5
background	-
length of history	157
<input checked="" type="checkbox"/> fade history?	
line scale	1
line width	2.33
line alpha	146.625
<input type="checkbox"/> All points	
<input type="checkbox"/> Hip line	
<input type="checkbox"/> Shoulder line	
<input type="checkbox"/> Hand line	
<input type="checkbox"/> Hip line to edge	
<input type="checkbox"/> Shoulder line to edge	
<input type="checkbox"/> Hand line to edge	
<input type="checkbox"/> Vertical lines	
<input checked="" type="checkbox"/> Horizontal lines	
<input checked="" type="checkbox"/> Circles	
<input type="checkbox"/> Ribbon	
<input type="checkbox"/> Draw video	
<input type="checkbox"/> Draw depth	

This is a visualisation of the jump with all points marked by a horizontal line. It generates a different kind of density, revealing height location of repeated movement by way of denser horizontal lines. It is combined with hand, hips and shoulder alignments which are the only references with which to reconstruct the body.



#### 4.4 MATERIALISING ACTS

Overall, my research reveals that how our movements come to have meaning in digital interaction is a choice that is increasingly facilitated by design as our surroundings are built and structured. It is also a choice that takes up how we all choose to act and how to move with and within these structures. As I have argued, meaning in movement can only in part be informed by our physiology and the technology.

The motivation for naming and conceptualising movement is to enable an understanding of how movement can be made to matter for design. Designers can then make critical choices on whether notions of age, gender etc. are a part of a design, through the particular and individual ways we all move. This is vital because designers aware of movement material potential can leverage an agency in full-body movement. In other words, designers can *make the way we move matter* in digital interaction by leveraging the sophistication with which we move in interpersonal communication. Below, I discuss what these issues and what the notions of choice and movement may entail.

#### Conceptualising embodied movement

In describing our design investigations in Chapter 3, I approached digital media through design techniques. We drew on our skill sets from our training in mathematics, dance, skateboarding and visual communication in the sense of skill not as an attribute of a body but of a system of relations and skills, on our individual 'capacities of awareness and response' (Ingold 2000: 5).

In this chapter, I have applied a similar argument to the role of digital media, in that it does not merely present us with possibilities but that digital media is a skill, as the relation we build or the connection we form with and through digital media is enacted (both in the making of and the use of designs). It is precisely in this enactment, Noland argues, that we can find an account of human agency. Noland asks, if we are 'no more than products of social conditioning, then why do we not simply repeat what we are conditioned to do?' (2009: 1). Noland seeks to understand agency by attending to the felt dimension of kinaesthesia:

Ultimately, it is because we experience differentiated movement qualities in the course of performing gestures that we are inspired to alter the rhythm, sequence, and meaning of our acts (2009: 7).

This is central in a study of the effect of digital media; however, as I have discussed, this approach will only in part inform the *designing of and with* digital media.

With a design process in mind then, my focus has been on the steps that lead up to such enactments. My work has been to present a case for movement as a material by attending to a ‘variance of performance’ (Noland 2009: 2) not through accounts of felt experience but by expanding on what designers may account for and by exploring what designers may make a material out of. In this way we can then explore what may be made to matter in design.

Specifically, I have argued that the treatment of movement data (its abstraction as well as its presentation) is pivotal in design work. By teasing out ways to address variation in movement, by way of dynamic visualisations, we may reconsider the role of movement in interactions and the body not only as a given and mapped object but as a sensate origin of action (Farnell 2011). By reconsidering I mean to attend to and acknowledge the agency by way of the communicative potential of a moving body at a conceptual design stage.

My research contributes to a critical discourse on the design of digital interactions where movement is central. The research ‘highlights’ movement in the sense of Goodwin’s comment about making ‘specific phenomena in a complex perceptual field salient by marking them in some fashion’ (Goodwin 1994: 606). To this end, Sheets-Johnstone proposes that in order to trace meaning in movement, we need to first ‘make the familiar strange’ (2009: 379). This is to think anew when we draw on the dynamic body and to avoid language-dependent thinking. Sheets-Johnstone makes a case for thinking in movement, such as when we walk over a stone or obstacle in our path, the movements we know to perform are pre-linguistic. In this sense, Sheets-Johnstone argues that we need to learn to ‘see’ movement anew.

Thrift provides a similar argument for software. Just as our sophisticated and continuous handling of ourselves, of our bodies, fades into the background by its inescapable, permanent nature, Thrift suggests that

software has come to intervene in nearly all aspects of everyday life [...] software very rapidly takes on the status of background and therefore is rarely considered anew (2005: 241).

Movement data then, presents us with a double blind in that movement disappears as it is continuously substantiated anew, and data is beyond our perception until we materialise it. To this end I have provided two ways towards ‘making movement strange’ that I see as materialising acts. One is the *Movement Schema* which (albeit still through language) concerns a different boundary or unit of analysis to that which is given in language (e.g. through

our existing grammar in English) by proposing that designers can focus on qualities and properties that could reside in dynamics, in a visually available form resulting from our embodied, relational and near constant movements.

The other is *Sync*, which provides another strange-making possibility. The digital application allows movement to be abstracted to various levels of detail as well as to compare the collected and calculated movement data to movement video. By deciding how movement data is called upon, *Sync* generates dynamic visuals that in turn allow designers to explore what Wei calls ‘a magmatic domain in which signs as things and things as signs evolve without, or perhaps prior to, meaning as language’ (2002: 452). It also allows for a comparison to actual movement as the tool can be applied in real time (see page 103 & 104).

### Designing for variation

My research suggests that we may abandon the normative pressures of designing for an average body, in particular in view of the computational power we have available today. This shifts a design focus from the aim of including everybody, to attending to a variety of abilities as well as a variety of settings and cultures. This is important as designers can then work on how we can harness variety and difference in interaction, thus making it less necessary to adjust our actions to fit a norm:

Social diversity requires attention to the careful design in representation. The increased availability of resources and the facility for the design message bring the need for careful questioning of what meanings are to be transcribed and what resources are best suited for their transcription. In this, the presence of digital media, if anything, adds complexity and urgency (Kress 2010: 102).

Computational tools like *Sync* enable designers to design with and for movement that is specific to a certain location or context, such as a training centre, a café or a court room. This shifts the focus in the design process from a general application to a more specialised application of movement in designs. This enables designers to focus on supporting and intervening in the processes of systems and users rather than settling on and communicating an interpretation. Regarding the body in particular, computational power offers multiple ways in which designers may conceptualise movement. This allows designers to abandon the tendency to ‘generalise reality’ and design for particular bodies (Silver 2003: 109). In this sense, design also gains access to a variety of bodies that move in a variety of ways.

There are further implications for practice in that *Sync*'s dynamic visuals can be seen as a mapping of variety and variation, whereby they inform design briefs for future designs: 'The map has a powerful recursive quality; it acts as a memory device that is also the basis for projective action' (Cosgrove 2003: 137). In this sense, the various ways of materialising movement data also open up for a variety of ways of seeing movement. In turn, this allows for the design of open-ended systems,

where evaluation shifts from determining whether an authoritative interpretation was successfully communicated to identifying, coordinating, stimulating, and analyzing processes of interpretation in practice (Sengers & Gaver 2006: 106).

In practices such as choreography and dance, it is a given that movement *has* meaning, that movement *is given* meaning and to a certain extent that it matters *who* performs the movement (e.g. Foster 1996). However, to account for movement as performed by a specific body is complex to address conceptually or to abstract mathematically such as in work on the computational modelling of movement in HCI. Kirsh writes the following:

the view that tools modify our perception, conception, and even our bodies is one that the HCI community has accepted in one form or another for some time, though without adequate empirical and theoretical support (2013: 27).

### Implications for the interaction field

In domains of interaction design where movement is a central element, designers require an analysis of full-body movement for designing. Below I suggest a few implications from a material approach to movement for several domains relating to interaction design.

In medical care, there are scenarios where interactions that encourage certain movements are needed, such as after a stroke or with injury rehabilitation. Situations occur where there is a need for tailored-made adjustments in moving with a prosthesis for example. In such domains movement plays a central role in recovery and a material approach to movement through dynamic visuals can present explicit movement patterns and relations, which in turn can encourage specific movements. This is relevant also for encouraging certain movement in children on the autistic specter. An example of this is Hellicar&Lewis' *ReacTickles* (<http://somantics.org/>), a suite of applications that use touch, gesture and audio input to encourage interactive communication.

For interactions that focus on automation, it is central to identify and consider different kinds of movements. For instance, the design of an automatic door could take into consideration the notions of age and intent by way of movement data; a slow approach towards an automatic door, could allow the doors to stay open longer, for instance, to let an older person to enter. A fast approach to the door could mean that the person is in a hurry: in response the doors could open more quickly, but stay open for only a short amount of time. Considering different kinds of movements is particularly interesting in regards to general automation, i.e. for generally applicable designs to accommodate a range of movement, thus challenging the normative body in design. The automatic door has been discussed in particular by Latour (1992), Ju & Leiter's (2008) and Ju & Takayama (2009) to illustrate the role of technology in a social context. However, movement itself and the conceptualisation of movement as material is not taken up.

The notion of identity being marked, signaled and constituted by way of movement is also an area for consideration in interaction design. Here identity may be informed by conceptualising movement dynamics, as we all move in particular ways. Such interactions could be developed and applied further, beyond face recognition, for security measures or in more controlled and ritual environments, such as in banks or court rooms. In such contexts, designers need to evaluate boundaries for relevant data. Such application may be limited today, however, as work on facial recognition has shown, there is much to be gained in allowing the boundaries for the data and in the unit of analysis being made available, e.g. McDonald's *FaceOSC*, a tool for prototyping face-based interaction (<https://github.com/kylemcdonald/ofxFaceTracker>).

For interactions as expression of style and performance, one can also envisage an application of materialised movement. Abstracting body communication offers opportunities for comparison and collection, as well as delays and distortions in the presentation of a performance piece. I have been asked to consider *Sync* to be included as a teaching aid for theatre students and their use of movement. While this is only a partial and provisional list, it is important to note that the above suggestions for implications have come about from discussions after presenting my research and *Sync* at conferences and the wide range of interdisciplinary projects, designers and researchers I encountered and who responded to my presentations (see Appendix B).

### A critical role for designers

Together these materialising acts can contribute to a critical view on the designer as well as their designs. By highlighting a variety of ways in which designers may present movement data and represent movement allowed me to conceptualise movement and movement data in terms of both material and practice. In this sense, it is possible to gain insights into designers' decisions through material knowledge as 'design representations do not carry meaning in themselves but *are made* meaningful through design activity' (Tholander et al. 2008: 453 original italics).

This is particularly so for interaction design, which includes temporal and corporeal qualities that communicate in particular ways or through particular processes. In order to understand the processes that lead to designs, Margolin argues that the processes must be seen as situated and cultural themselves:

If designers are going to realise the full potential of design thought, then they should also learn to analyse how the situations that frame design practice are themselves constructed (2002: 241).

Based on an investigation of multimodal practice, Norris advocates that we need to develop new analytical techniques in order to study the 'complex interconnectivity and interdependency of events' (2012: 170). Thus, by creating new materials and tools, we can analyse movement-based interaction anew. In this way, new designs may leverage the body as a complex system:

Humans are adaptive systems. Internal processes are structured so that they integrate well with structures in the environment, including the structures of human-made symbolic environments (Streeck 2010: 238).

As I have argued, the explorations and materialisations in this thesis also extend the landscape, as with new materials and new tools come new movements. This development needs a critical approach, as Wood points out:

The numbers of technological interfaces that frame how we see the world are rapidly expanding their influence, and there are questions to be asked about who controls and creates those interfaces and for what reasons (2007: 163).

By exploring materialising processes, conceptually and practically, we may gain an understanding of what underlying motives are at play, and as I argued this is important because with computational material, meaning is not a given – both the material itself and its meaning are made.

It is perhaps here that design research comes into its own. Whilst other fields analyse existing technology in use, a designer researcher may also be able to see technology and its use in the context of material possibilities and thus be able to suggest alternative uses or alternative designs. As Redström argues, through an experimental research approach, designing has the possibility to contribute a concrete vision of possibilities as opposed to other research, which contributes abstract images of the concrete (2007: 171). In addition, by seeing material possibilities, a designer researcher can also question the design choices made and thus question the underlying assumptions of a design. Haraway proposes that by reflecting on where we see from 'we might become answerable for what we learn how to see' (1991: 190).

Interaction design research is positioned to explore the gap between representation and being, between textuality and embodiment, between system and event and logic. This is because for digital media and in particular in movement-based interaction, analytical categories come into play, such as 'intuition, imagination, perception, and sensation as tools in understanding' (Csordas 2002: 8).

Thrift writes about software as 'a means of sustaining presence which we cannot access but which clearly has effects' (2005: 241). In order to understand how we shape and influence software, despite its inaccessibility in everyday life, we need language to address aspects, elements or qualities of software as well as tools to explore what is yet to be named or what may be addressed.

By making a case for movement and movement data as a creative material for design, I put a focus on what I have called *movement scripts*, the lines of code written to run as software that increasingly perforate our surroundings and increasingly inform and alter our movements. Thrift discusses how

human embodied experience – that experience which is still so often considered to be a constant even as surfaces like screens and software have questioned its reach and meaning – is being decisively changed. Key human affordances are now being altered (2005: 248).

In this chapter I have presented ways to contribute to a critical discourse by opening up to dialogue and practice, on how a materiality of software and a materiality of movement can be addressed. I also proposed how these aspects may be brought into play in our everyday lives.

# 5

## CONCLUSION

The main aim of this thesis has been to explore and present a creative potential of full-body movement by way of movement data for movement-based digital interaction. The goal has been to use concepts and tool-building as a way to both explore and communicate full-body movement as a design material, that is, as a communicative resource for meaning-making in digital interactions.

My main argument is that there are creative and pivotal decisions in adopting such an approach: in the handling of movement data, from how it is captured and stored to its retrieval, ordering and calculating in the ensuing presentation and its perception. By unfolding these stages of materialising movement, designers can reconsider the role of movement at a conceptual level and enable interactions to be built that are informed by a critical view on movement and, by extension, the role of our bodies.

I have shown that in part this comes from attending to the corporeal qualities expressed through the way we move. Movement requires a body and this body is gendered, aged, cultured and conditioned as well as sensate, expressive and performed. Guided by concerns in performance studies, anthropology and linguistics, I argue that because movement is performed, it allows us to see

the way we move as a result of a choice of movements. From this we may gain (tenuous yet real) access to an agency of a 'mover'.

However, this access to a mover's agency is conditioned by an observer's awareness of the possible choices of the mover. In other words, when we know what possible movements there are, we can start to gain an understanding of the choices taken. Then, in turn, designers can draw upon these by way of their design of digital interactions.

I have argued that the way we move is in part conditioned by our surroundings. This includes our physical context as well as the ways in which we are (or think we are) seen or observed, whether this is by another person or by an information system. By framing movement as a relational and compositional, a performed, composed and expressive resource, I have highlighted a creative potential for interaction design to influence the ways in which we move.

I have shown that there is creative potential for movement-based digital interaction in how data is drawn and selected from a moving body. Further, I have presented variance in how this data again is retrieved, calculated and combined in order to be presented. I have suggested that we may take up real-time analysis and recording to enable special insight. In comparing repetition and revelation we can start to outline boundaries for relevant data and get a feel for the scripts that call upon the data and how the scripts visually appear.

### Main contributions

My thesis presents several contributions. Firstly I have proposed the concepts of *Accessibility*, *Immediacy* and *Generation* that address how movement needs to be visualised for interaction design. Secondly, I suggest a conceptualisation of movement dynamics in a *Movement Schema*. In the schema, I identify *Velocity*, *Position*, *Repetition* and *Frequency* as modalities that address how we use movement dynamics to communicate. Based on this textual level of treatment, I collaborated with Hellicar&Lewis and held workshops in which we explored these modalities and dynamics in movement data and how to present a breadth of possible visuals from corporeal data. Thirdly, as practice and product, this work resulted in a digital application, *Sync*, which allows for a dynamic presentation of movement data. The temporal visuals play out according to parameters that may be adjusted and changed in the tool (such as choice of marker, choice of line and its density, length and sensitivity). Fourthly, I also devised the concepts of *Malleability*, *Visuality* and *Ambiguity* regarding the materialisation of movement data, highlighting the overlap

of practical and conceptual considerations of handling data. Fifthly, I offered a model to position these concepts and considerations in a design process.

Taken together, these aspects have been presented as a blend of theory, practice, interpretation and ethical reflections. There are few such studies in design addressing full-body movement as a material for digital interaction.

### Moving ahead

The material exploration undertaken in this project suggests ways in which designers may address a moving body at a conceptual stage of designing, through sketching and discussing design options (pertaining to the particulars of movement) rather than as a post-design occurrence.

As Hollan and Stornetta argue, we all need to communicate, but the mechanisms with which we communicate are specific to the media through which we communicate (1992). The mechanism for communication is different depending on whether we use a phone or a megaphone, in the sense that media conditions what we express and convey. This understanding formed my motivation in exploring how movement may be materialised in digital interaction design. What follows from this argument is that we may then design interactions particular to the data we have rather than imitate or approximate that which already exists. With regards to digital media and communication, this research contributes to an understanding of movement by positioning movement as an expressive and agentive material in interaction. I have suggested a conceptualisation of movement dynamics as it appears visually.

The question that arises for further consideration is whether we can keep making movement-based interaction without a critical understanding of what movement data is and a critical understanding of how it comes to be materialised. My argument is that without an understanding of our design materials, this would result in designs to which people must yield and adjust. I have shown that by exploring what is particular to bodily movement and what is particular to movement data, designers may leverage agency and communication in and through movement. Instead of using computational material to imitate 'reality', designers may build interactions particular to their materials and digital properties and thus create 'reality'.





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## APPENDIX B

### Workshops, artlabs and conferences

Kedja 'Dance and New Media' in Oslo, October 2010,  
see <http://www.aho.no/no/AHO/Aktuelt/Kalender/2009/Konferanse-keja-Oslo--Dance-and-New-Media-10-12-oktober/>  
and [http://www.kedja.net/wordpress/?page\\_id=44](http://www.kedja.net/wordpress/?page_id=44)

Simula & UiO 'Art-on-Wire' in Oslo, May 2010,  
see <http://www.uio.no/english/research/groups/fourms/projects/sma/events/seminars/2010/art-on-wires.html>

Transmedia Knowledge Base 'Lab 1' at O Espaço do Tempo in Portugal,  
May 2010, see <http://tkb.fcsh.unl.pt/>

Ircam-Centre Pompidou & LIMSI-CNRS 'Movement Qualities and Physical Models Visualizations' in Paris, September 2012,  
see [http://imtr.ircam.fr/imtr/Workshop\\_on\\_Movement\\_Qualities\\_and\\_Physical\\_Models\\_Visualizations](http://imtr.ircam.fr/imtr/Workshop_on_Movement_Qualities_and_Physical_Models_Visualizations)

Motionbank 'Whiskers wax and tender ties', Frankfurt in May 2012,  
see <http://motionbank.org/en/event/motion-bank-workshop-no-4>

University of Surrey 'Corporeal Computing', Guildford in September 2013,  
see <http://www.ias.surrey.ac.uk/workshops/corpcom/>  
My presentation 'Materialising acts: exploring movement data for digital interaction through the *Sync* application' is available online,  
see: <http://vimeo.com/77527715>

Motionbank 'Live & OnLine' in Frankfurt, November 2013,  
see <http://motionbank.org/en/event/live-online-2013>



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**COMMUNICATING MOVEMENT**

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## ARTICLE 1

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# Full-body movement as material for interaction design

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## Abstract

This article focuses on the design potential of digital interactions where the body is seen as the interface. With computational technology and sensors infiltrating many aspects of our lives and urban surroundings, interaction designers' ability to visualise and generate designs are important in order to understand and explore such design spaces. I propose three concepts—*accessibility*, *immediacy* and *generation*—as means for analysing movement as a design material for interaction design. Drawing on a social semiotics approach, contemporary choreographic research is studied where digital tools are used to generate, explicate and communicate interactive movement. I argue that by drawing on the particularities and potentials of the moving body as interface such as those explored through choreographic practice, we may avoid imitating existing exchanges with technology and create novel interactions.

**Keywords:** interaction design, design material, communication, choreography

## 1 Positions

*Walking in the hallway, a door shuts snapping at your heels. The pre-programmed time for its opening ends, regardless of whether you have gone through or not. Your slow and considered movements go unnoticed.*

*At work, you have a complex presentation to write and you spend much time sitting still, contemplating how to clearly present your thoughts. The lights that were automatically turned on as you entered your office go out. The time spent occupying the office is not registered.*

These everyday encounters indicate a new design space for the interaction designer. The traditional screen interface between a human and a computer is usually accompanied by buttons on a keyboard, a mouse to click or a surface to touch. In the examples above, the screen is removed and the technology is activated by computer vision, and, by extension, ourselves. Here, the body is the interface.

The main question I address regarding interaction design is how may we approach full-body movement as a material. This is taken up in an heuristic approach that includes conceptualising such movements, by looking at practice-based experimental examples from choreography, as well as referring to an interdisciplinary body of related research. The focus is on the process of instigating, probing, shaping and changing



Figure 1. Still from a promotional video for Microsoft's Kinect Xbox. The interactions, albeit 'hands free', are the same as those of existing movement actions and scenarios, such as driving and ball games, dance and yoga classes.

Source: Image by kind permission © Microsoft Corporation.

possible modes of representing and generating movements. I argue that by drawing on the particularities and potentials of the body as interface, we may avoid imitating existing interactions (see Figure 1) and create novel interactions.

In presenting three core concepts, I draw on communication and design theory and cognitive psychology. The development of the concepts *accessibility*, *immediacy* and *generation* is given. These are applied as analytical resources for understanding meaning-making with movement for interaction design. The current sophistication of computer vision coupled with increased computational speed, now allows for more movement data to be captured, making it possible to further explore aspects and qualities of expressive movement. Interaction design may benefit by drawing on how choreographic practice—the shaping of full-body movement—is studied and communicated. I critically analyse current research on chor-

eographic resources in the performance field, and discuss how they may inform the design of the moving body as an interface.

The fields of interaction design and choreography are connected in order to explore how we may understand the body as the interface, where meaning is generated through bodily movement.

Currently movement is increasingly read by technology, and in interaction design, it is mostly applied in gaming scenarios such as Nintendo's Wii and more recently Sony's PlayStation Move and Microsoft's Xbox Kinect. These present exciting applications of movement in interaction. However, they currently interact existing scenarios, akin to those of dance instructors, rafting and golf. In order to explore novel applications and communications, it is argued that the interaction designer needs to further explore the communicative potential of the moving body, in order to allow and enable the material to inform possible applications.

Technologies can now go beyond fit and function (Wright *et al.* 2008), and whilst the guiding design principles of ergonomics and efficiency remain important, an understanding of the possibilities of the moving body needs to be developed together with the application of digital technology. By visualising and working with movement according to the concepts introduced here, the designer may be able to conceptualise designs at an early stage. This is important in order to avoid having technology dictate our movements and, by extension, how we live.

## 2 Movement research

Bodily movement has been studied in many fields related to communication. In anthropology, physical movement has been interpreted as non-verbal communication in relation to verbal communication. Through inter-cultural studies, the anthropologist Edward Hall (1966) found that we communicate through the use and position of the body in proximity to others. Ray Birdwhistell (1971) founded *kinesics* as a field of research and developed a deciphering system of facial expressions, posture, etc., to be interpreted in the context of other means of communication. In cognitive science, the role of our bodies is increasingly taken into account. Alva Nöe (2004) argues that our perception and consciousness depends on and is a result of, our bodily capacities and activities. Rolf Pfeifer and Josh Bongard (2007) show how thought is constrained as well as enabled by the body, by analysing the making of artificial intelligence. In an embodied communication perspective Ipke Waschmuth *et al.* (2008, p. 3) argue that human communications go beyond verbal communication and that our bodies enable ‘parallel and highly interactive couplings between communication partners’. These fields of study show that the body indeed plays a communicative role.

In ‘new media’, the focus is on the body framed by technology. Simon Penny (2004) calls for a framework for interactivity that goes beyond the theories of visual art, as interactive images are procedural, and previous theories do

not include the ‘ensuing activity’. Mark Hansen (2004) proposes a philosophy that encompasses the development of images in communicative processes, where their perception is bound to the activity of the body. And following on from Kathrine Hayles’ (1999) disconnect of information from a body or medium, Anna Munster (2006) also discusses new modes of sensory engagement, implying that digital aesthetics have reconfigured bodily experience and reconceived materiality.

In human–computer interaction (HCI), attempts to create a framework for evaluating bodily potential (Loke *et al.* 2007, Fogtmann *et al.* 2008) indicate that notions of the body increasingly are considered. As the design process is opened up for multiple interpretations (Gaver *et al.* 2003, Sengers and Gaver 2006), there is an acknowledgement of the communicative potential for expressive movement. Paul Dourish (2001, p. 126) presents an approach to embodied interaction, defining it as ‘creation, manipulation and sharing of meaning through engaged interaction with artifacts’. These approaches, based on theories of embodiment, emphasise the role that the body plays in shaping perception and action. However, ‘whilst there has been substantial advances in human motion reconstruction the visual understanding of human behavior and action remains immature despite a surge of recent interest’ (Moeslund *et al.* 2006, p. 116).

In contrast, performance studies has a long tradition of reading movement like a text, as a part of a mediating scenario, ‘a showing of a doing’ (Schechner 2002, p. 141). As traditional performance increasingly makes use of interactive technologies, the performed movements are not only expressive but functional, in that they enable other media, such as computer vision and video projection, to express and mediate. In dance, movement is studied as the main mediating material. The communication focus, however, has been on the role of tacit or bodily knowledge and whether it may, in fact, be seen as knowledge, as this kind of communication does not fit tightly within the structures of language (Sigman 2000). When movement is read by technology it is

usually interpreted together with language. In the non-verbal communication field, ‘typically, gestures are thought of as arm and hand movements, but head gestures are also well known’ (Knapp and Hall 2006, p. 225). As this article draws on the practice of choreography, the whole body is the focus, therefore ‘gesture’ becomes too limited and ‘movement’ more apt in describing full-body motion.

All the fields mentioned above study movement in relation to communication. However, the studies only partly inform interaction design in their study and shaping processes of movement, as interaction design may now draw on the communicative aspects of movement such as frequency and force, repetition and rhythm, alignment and position. Ashbrook and Starner (2010) point to the fact that motion gesture control does not yet appear outside the game console and that the reason for this might be that interaction designers are not experts in pattern recognition. It is here that choreographic research might have transferable insights to the field of interaction design as motion sensing increasingly becomes available. This presents a challenge for the interaction field, as the designer now increasingly draws on, engages with and shapes physical movement as a semantic element in interactions. Here I analyse current choreographic research in relation to the interaction design process, and formulate concepts relevant to such a design process.

### 3 Approach

In exploring the body, and specifically the moving body, as an interface, this article adopts a communications view, drawing on social semiotics (Kress and van Leeuwen 2001). Research such as Eikenes (2010) investigates movement in digital interfaces, and draws on such a framework. This article looks at the moving body as the interface through which one may control, access, influence and interact with digital technology. The spatial and temporal qualities of movement communicate multimodally, for instance through shape and change (such as frequency, repetition and scale). In fact, the body is always communi-

cating. ‘We cannot not communicate’ (Watzlawick *et al.* 1967). This is perhaps why the body as an interface becomes so complex. We each have life-long training in the sophisticated way with which we read each other. In order for technology to now do the reading of bodily movement qualities beyond touch and click, we need to analyse the moving body as a mediating artefact (Vygotsky 1978).

In semiotics a ‘text’ can be any type of object that communicates meaning, such as an image, a video, an artefact, or an interface such as the body. The concept of text enables a discussion of meaning, analysis and close engagement with the object (Bal 2002). As this approach advocates, signs and texts, as indeed movements and gestures, do not have a fixed meaning, rather are socially influenced and continuously changing (Kress and van Leeuwen 2001, 2006, Noland 2009). A communication view, treating the moving body as ‘text’, enables a discussion on the possibilities of movement as a design material, feeding knowledge back into interaction design. There is research on the moving body and technology with a phenomenological approach (e.g. Schiller 2006, Broadhurst 2007, Kozel 2007, Manning 2009). However, these studies focus on the effect of technology on the moving body and not on how designers may work with, explore and shape these interactive movements. As designers create transformative spaces (Morrison *et al.* 2009), movement is important, as we may generate our own mediated meanings and not only be the recipients of pre-set information. Designers need to work with, alter and augment movements as part of the design process. Then we may truly interact with, not only react to, the screens we encounter.

The three concepts to be presented below come out of a ‘complex field of knowledge production’ (e.g. Sevaldson 2010, p. 8). They have been developed where design is explored through both theory and practice. The focus is on working with and instigating, probing, shaping and changing possible modes of representing and generating movements. Below I focus on the specification of the three core concepts by the way of reference to

leading design and research projects together with critical readings of related research.

#### 4 Interaction design

The places, events and scenarios where technology facilitates communication, interaction and action are created by the interaction designer. Löwgren and Stolterman define interaction design as ‘the process that is arranged within existing resource constraints to create, shape and decide all use-oriented qualities (structural, functional, ethical and aesthetic) of a digital artifact for one or many clients’ (Löwgren and Stolterman 2004, p. 5). Here Löwgren and Stolterman focus on the artefact. I argue that the interaction designer today needs to address aspects that go beyond what can be communicated through an object. In this regard, the definition of interaction by Poggenpohl *et al.* is more apt:

*Interactions are a succession of actions, each responding to prior actions and each being responded to by succeeding action. By identifying and studying interaction patterns in this succession, we can design interventions that provide material support for desirable interaction patterns to emerge (Poggenpohl et al. 2004, p. 603).*

It is the material support for interaction patterns<sup>1</sup> that I take up.

The interaction designer needs to understand the possibilities and limitations that are inherent in the new making material discussed here, in order to make informed choices at a conceptual stage. This may enable the designer to look beyond imitations of already existing scenarios, and open up for new interaction possibilities. Bolter and Grusin (1999) argue that digital media achieve their cultural signification through ‘remediation’, by paying homage to earlier media in the same way as photography has refashioned (or remediated) painting. However, as our need to communicate may be media independent, the mechanism with which we communicate are media specific and when one kind of communication only imitates another, it will always be at

a disadvantage (Hollan and Stornetta 1992). By drawing on the particularities of the making material, the designer may create novel interactions, such as TV coming into its own when it no longer imitated radio but employed its unique qualities in the editing of visuals, combining image and sound, choice of *mis-en-scene*, etc. In exploring movement as communication for interaction design we need to find the particularities of movement in order to make interactions suited to its making materials.

#### 5 Design material

By exploring movement as a design material I refer to design material as the constituent elements that are formed through a design process. ‘Form is the way material builds things; to build a thing, we form materials’ (Hallnäs *et al.* 2002, p. 157). As interaction design goes from the design of objects to the design of experiences, the designers’ repertoire expands and designers now also influence aspects such as use of space and how we move. The transient and ephemeral nature of physical movement existing only in time presents a challenge. When the designer is working on an interaction at a conceptual stage, the physical part is rendered invisible, as interaction design lacks the means to visualise and, in particular, to generate and augment physical movement.

Hummels *et al.* (2007) argue for the designers of movement-based interactions to move themselves, i.e. go beyond *imagining* physical movement to themselves moving, exploring and trying out actions with their bodies, such as with juggling. Hummels *et al.* also ask how movement is unique as a design material. We have a lifelong experience of it, both in the reading of it, but also in the use of it. We all have experience of how our own body ‘works’, and in particular how it communicates.

#### 6 Choreography

I suggest that the creative practice of contemporary choreography has correlations to these new design spaces. In order to be able to explore and shape this



communicative movement material, the designer needs to become familiar with its qualities, limitations and possibilities. It is worthwhile to take a step back from the existing use of physical movement in interaction design in order to learn about the potential for expressive movement as it is communicated to and through technology. Here the practice of contemporary choreography is relevant due to its refined, abstracted, aesthetic and rehearsed field of movement, with a history of experimentation, collaboration and exploration of both new movements as well as emerging technologies (Wildschut and Butterworth 2009).

Contemporary choreography is the practice of composing new movements, working with bodily restrictions (such as every part being connected, elbows bending only one way, and so on) and possibilities (a high degree of difference from its numerous joints that may function independently of each other). Choreographers' practice may resemble an interaction designer's practice, as they shape, design and through iteration refine their material until the composition and expression of the material has the desired shape and effect. 'During this playful probing of physical and semantic potential, choreographers' and dancers' bodies create new images, relationships, concepts and reflections' (Foster 1995, p. 15). The choreographic product is usually instantiated in a performance. However, 'choreography and dancing are two distinct and very different practices' (Forsythe 2008, p. 5). The focus here is on the choreographic resources employed in the making process, rather than the performed product.

## 7 Choreographic resources

Technology now enables interaction design to draw on a wider scope of movement-based full-body communication. This extends the communicative use of movement aspects such as spatial and temporal qualities of movement: for example frequency and force, repetition and rhythm, alignment and position. The choreographic research projects described below are chosen with this focus in order to go beyond the use of gestures, e.g. arms in certain positions, and to move from

controlling, instructive movements to include expressive movement. We are able to read each other's body language; however, so far technology does not mirror this sophistication of interpretation. 'We can observe it with the human eye, but methods to extract such information are still in their infancy' (Bevilaqua 2007, p. 27).

By *resource* I refer to meaning-making materials which aid the communication of a creative process, e.g. 'resources for representation' (Kress 2010, p. 8). The choreographic research projects that will be discussed here explore how to visualise movement to aid and multimodally communicate the creation process, and do so by drawing on notation, video and motion capture as resources.

## 8 Movement concepts

The concept of *accessibility* informs how the designer may start to think about movement with regard to interaction as they select relevant aspects of the movement in the visualisations of movement. *Immediacy* allows the designer to explore whether the chosen movement aspects could serve a communicative purpose in a rapid, iterative manner. The concept of *generation* allows the designer to alter and augment parts of the visualisations in order to test, probe and explore. How these three concepts may help the designer include physical movement in the design process is further presented below.

### 8.1 Accessibility

For the designer to work with movement, that movement needs to be accessible, e.g. visualised in ways that are relevant to interaction design. Sketches or visualisations are used as thinking tools for the designer (Schön 1983, Goldschmidt 1994). With experience, the designer may get new ideas from inspecting their own sketches as new and unintended relations, patterns and functions emerge (Suwa *et al.* 2001). Such visualisations are also influenced by a working knowledge of functionality of the making material (Tseng *et al.* 2002). Goldschmidt (1994) argues that the sketch amplifies the mechanism of visual cognition

with which computational tools may be further amplified. Bill Buxton also argues that for interaction design, the sketch can extend beyond that of pen and pencil, to other forms, as ‘they need to be able to capture the essence of design concepts around transition, dynamics, feel, phrasing, and all the other unique attributes of interactive systems’ (2007, p. 136). The studies point to the important role of the visual during the design process.

The choreographer William Forsythe has explored a wide range of visualisations of interactive movement. He instigated the research project *Synchronous Objects* with the question ‘is it possible for choreography to generate autonomous expressions of its principals, a choreographic object, without the body?’ (Forsythe 2008, p. 5). In this project Forsythe and The Ohio State University Advanced Computing Center for the Arts and Design (ACCAD) explore Forsythe’s dance piece *One Flat Thing reproduced (OFTr)*. The dance is complex as it is performed to an interactive score by seventeen dancers navigating a twenty-table grid (see Figure 2).

In this work, thirty-five themes or phrases are activated, repeated and used over fifteen minutes. The underlying structural systems, or *counter-*

*points*, of movement phrases, cueing and alignments are visualised by abstracting and visualising data from a recording of a single performance. The project then analysed this footage and produced twenty choreographic objects. Norah Zuniga Shaw (2009) described the process as ‘a flow from dance to data to objects’.<sup>2</sup> Compositionally, each object arose from a trans-disciplinary process involving geographers, animators, designers and architects, as well as dancers and choreographers (e.g. Figure 3).

The project clearly demonstrates the complexity involved in communicating interactive movement, and the myriad of ways it may be approached. The visualisations took the research team three years to generate, some through computational interpretation, others were animated frame by frame. For the interaction designer, there is a need for sketches, abstractions and instructions for each stage of a design development, so the processes employed in *Synchronous Objects* would be too extensive.

Some of the visualisations are further abstracted, such as the counterpoint object. It offers a tool, where the dancers are replaced by ‘widgets’, and the viewer or user has sliding scales through which to control the shape, speed,

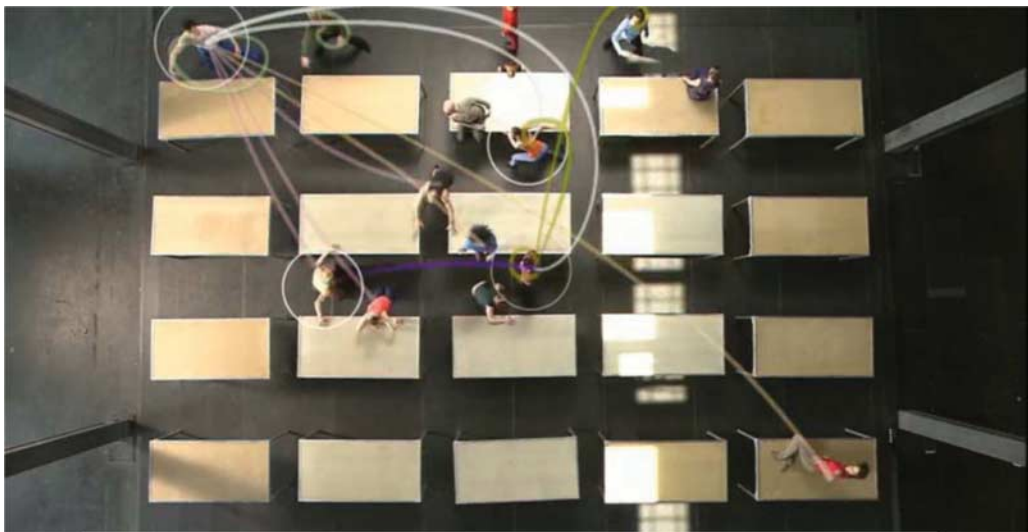


Figure 2. Still from *OFTr* with graphic annotations of alignments, e.g. where cues between the dancers are sent and received. Source: Image by kind permission © Synchronous Objects Project, The Ohio State University and The Forsythe Company.

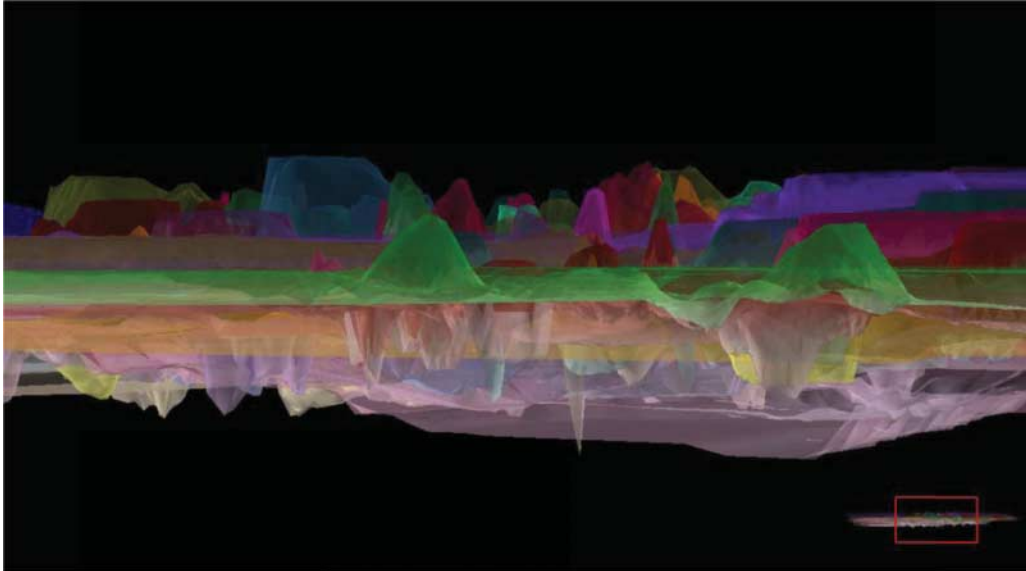


Figure 3. Still visualising spatial patterns generated by the moving bodies, with a focus on density according to where on stage the dancers spend most of their time.  
Source: Image by kind permission © Synchronous Objects Project, The Ohio State University and The Forsythe Company.

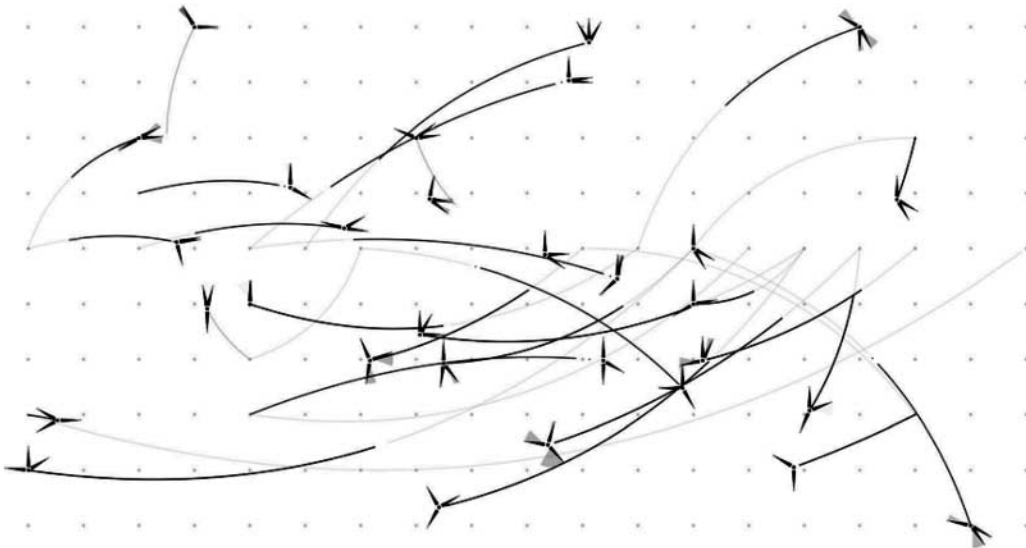


Figure 4. A still from the Counterpoint Tool where the dancers' bodies are replaced by widgets and the lines represent visual cues on which the other dancers act.  
Source: Image by kind permission © Synchronous Objects Project, The Ohio State University and The Forsythe Company.

horizontal and vertical motion, from unison to difference (see Figure 4). The designer may work with this to 'build relationships of actions'.

However, as this choreographic resource focuses on the position of the body in space, it becomes less useful for the interaction designer. This

indicates that the visualisations of movements that are of interest to interaction design need to encompass the ‘how-ness’ of the movement as well as the movement itself, e.g. the micro-analysis of temporal, communicative aspects of movement.

There are attempts to analyse bodily movement with video, such as *motiongrams*, based visually on spectrograms produced for sound (Jensenius 2007). Here movement is seen in relation to sound and music performance, so in this respect it produces data that are useful. However, for the interaction designer the *motiongrams* are too abstract to be read as communicative movement. Other real-time visualisations are being developed with a focus on expressive feature recognition, such as *eyesweb* (Camurri *et al.* 2004) and *gesture follower* (Bevilacqua *et al.* 2010). As these computational tools indicate, the development of computer vision and computation is becoming increasingly sophisticated in the reading of movement. Yet, it is the interpretation, recognition and application of these data that are challenging the further use of temporal communicative aspects when interacting with technology.

In semiotic work the first stage is to identify and name the meaning-making *modes* involved in an activity, each with a specific task and function. The design of such *modal ensembles* ‘make a specific *message* about a particular issue for a particular audience’ (Kress 2010, p. 28). The *Synchronous Objects* project shows the wealth of choices that come with communicating movement. As we include movement in interaction design, choices are made as to which aspects of movement are made meaningful for the technology. In order to make such choices, the designer needs knowledge of the extensive range of possibilities of movements and their visualization.

## 8.2 Immediacy

Drawing further on the design process, I argue that movement needs to be visualised in ways that are *immediate*.<sup>3</sup> The interaction designer usually works in a rapid, iterative process, each stage involving *reflection-in-action* and *reflection-on-action* (Schön 1983). To enable such reflection,

the visualisations of movements need to be at hand for each stage. Currently, the analysis of dance with traditional notation such as Benesh Movement System and Labanotation is a time-consuming and highly skilled process. All the same, notation has the scope to notate possible movements as well as a single instantiation. ‘The greatest value of the systems is not necessarily how precise they could be, but the possibility they have to record more than one stratum of precision’ (Bastien 2007, p. 48). This means, for instance, that as a viewer of a set of movements or a movement phrase you will only see the one version performed. The notation, however, may encompass the instruction as well as the instance as it was performed and thereby reveal the intent or purpose of the movements.

This aspect of possibility was explored in the research project *Inside Movement Knowledge* where the choreographer Emio Greco and Pieter Scholten (EC|PC) used the *Double Skin/Double Mind* installation as a ‘test case in documenting, analyzing and re-presenting essential elements of the work of EC|PC’ (deLahunta 2007, p. 20). Taking Greco’s own choreographic practice as a starting point, they developed a vocabulary of over 200 words, which together with the preparatory dance workshop formed the basis for an interactive, multimodal installation. This was in order to explore ‘systems for the documentation of live and variable media artworks and to explore how to analyse and document the dance creation process of EG|PC’.

In this project ‘the interdisciplinary research team proceeds on the assumption that the complex nature of dance cannot be adequately represented by a single technology’ (Hoogenboom 2007, pp. 86–87). As a result the installation explores multimodal mediation of movement by drawing on gesture analysis, dance notation, documentary film-making and interactive media design. Designed by Chris Ziegler, it consists of an aluminium frame construction with one projection screen, four sound speakers and a tracking camera. The participant ‘takes part’ in the virtual workshop within this set-up (see Figure 5). Instructed by a virtual Emio Greco, the

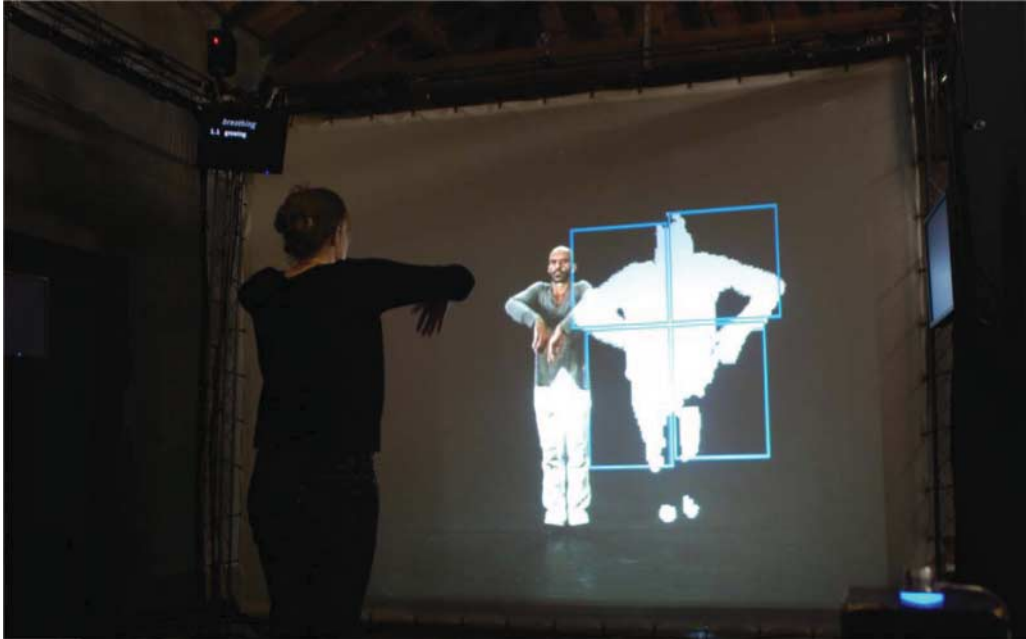


Figure 5. The author using EC|PC's Double Skin/Double Mind installation.

movements are tracked and visualised by Frédéric Bevilaqua's software *gesture follower*. The installation gives you feedback on how you move related to pre-captured data or movement algorithms, and gives you a visual representation of own movement and sonically provide feedback on how you deviate from or align with the algorithms.

This is of interest for the interaction designer as it looks at the communicability of the specificities of movement, i.e. not only that the arm is raised, but *how* the arm is raised. This multimodal mediation of movement shows how a rich bandwidth of movement qualities and intent may be communicated. The *Double Skin/Double Mind* installation is primarily a teaching tool, but as Marian Bleeker argues, one could look at it as an archiving tool for the process.

*New movement software allows for notation practices in which the focus is on the multiple potentialities of movement that the body holds ... In this context, the computer becomes an important element for choreographers, not as*

*an imaging device but as a medium in a process of emergence (Bleeker 2010, p. 3).*

The installation shows that for a system to recognise, categorise and give meaningful feedback, there is a need for pre-recorded information or algorithms set to recognise qualities of movements. This is problematic in a communication frame that is focused on more naturally occurring or unplanned interactions. This is because the complex meaning of a movement phrase is interpreted according to the aforementioned spatial and temporal qualities of movement (frequency and force, repetition and rhythm, alignment and position). These are perhaps easy to interpret in a human to human context, but as we meet technology, it lacks the reading of these communicative nuances.

As discussed, there is such a wealth of possibilities in the interpretation of movement, which makes it highly context dependent. The concept of *immediacy* allows the designer to explore in a rapid, iterative manner whether the chosen movement aspects could serve a

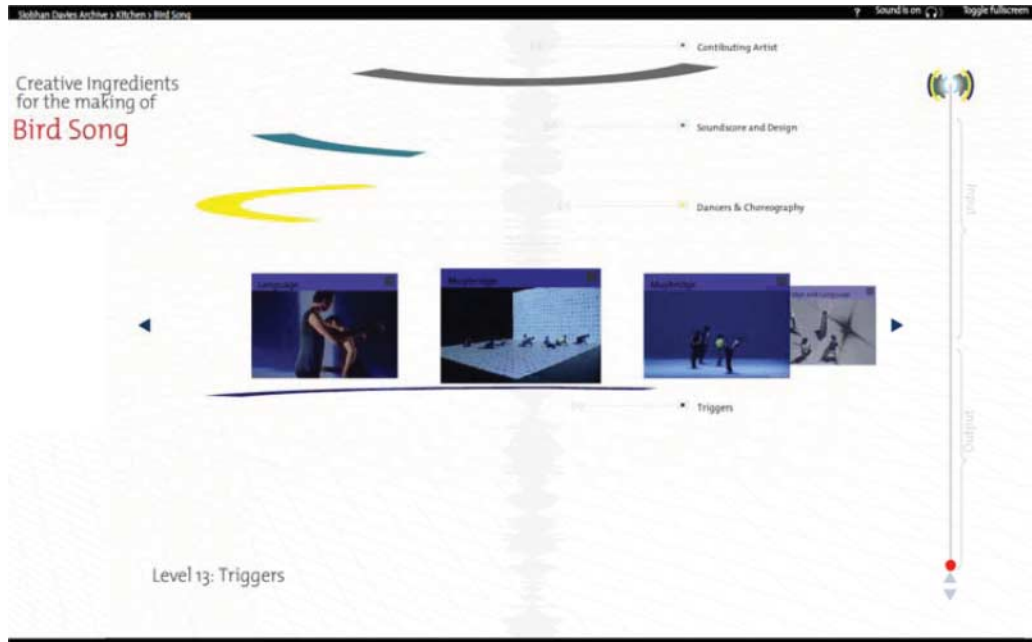


Figure 6. Screenshot of creative 'ingredients' for the making of 'Bird Song'.

Source: Image by kind permission © Siobhan Davies RePlay 2009.

communicative purpose in a specific project or installation.

### 8.3 Generation

Thirdly, the visualisations of movements need to be *generative*, e.g. an augmentable visualisation that would respond to a change to one of its instrumental parts or parameters. Working with visualisations or sketches, the designer aims to find new features, aspects or possibilities. It is argued that the designer does this through reorganising elements of the visualisation with regard to a reference frame (Cornoldi 1996). The detection of unintended features is a key element in generation of creative designs (Suwa *et al.* 1999). Stenning and Oberlander (1995) discuss specificity and abstraction in visualisation and how the focus on visualising one feature, such as proximity, for example, could reveal unintended relationship with regard to other features. So the focus of the visualisation may both limit and expand the design possibilities. The ability to discover unintended relationships and ideas from the visualisations is a skill and

draws on knowledge and practice in the field. It also depends on the visuals or sketches being flexible or generative in the sense that they can be changed, edited and re-assembled and still give new, meaningful visualisations.

Digital technology has increasingly enabled new dissemination of approaches and communications of the choreographic process due to both ease of documentation through video and new visualisation possibilities from computer vision and computation.<sup>4</sup> This development allows for a new kind of access to the making process. In part this is due to the multimodal possibilities of digital media in communicating physical movement. Despite the lack of a universal notation system, choreographers have developed their own methods, practices and strategies. These are increasingly being communicated within the choreographic field as well as to related fields (deLahunta and Shaw 2008).

The dance company Siobhan Davies Dance and Coventry University have created a digital, online archive for the collective works of the



Figure 7. Example of rehearsal tape from *Plain Clothes*, dancer Henry Montes.

Source: Image by kind permission © Siobhan Davies RePlay 2009.

company spanning thirty years.<sup>5</sup> They continue to develop tools to gain insight into Davies's choreographic process. For example, selected performances are presented on the website in an interactive manner, encompassing all parts, roles and 'ingredients' that made the piece (see Figure 6). Other key sources for understanding movement are the rehearsal tapes (see Figure 7). The dancers in the company have frequently taped each other with handheld cameras during rehearsals, and this becomes documentation, for instance, of a dancer working through a movement 'problem' or challenge. When the viewer gains access to such aspects of dance-making, the archive becomes an educational tool informing creation as well as allowing for reflection on existing performances and their visual and kinetic documentation.

The site also presents *Rotosketch*, a software program which allows drawing on live video to be saved as a record. This might become a useful tool for analysing and interpreting choreographic phrases (Whatley and Varney 2009). A further development of such a resource is a pen tool for real-time annotation on video (Cabral and Correia 2009). Such examples indicate that

digital technologies are increasingly being applied in the creative and meditational processes of choreography.

In the creation of archives, scores and educational tools such as those mentioned above, choreographers enhance the communicability of the creative practice. These appropriations of technology become interesting for interaction design as they develop from a documentation role towards a more active, generative role in the creative process. With augmentable visuals, the design of movement as a semiotic resource becomes useful as it may be altered and explored according to the context in which it is applied.

## 9 Conclusion

In interaction design a new design space is now reaching beyond the artefact or object, beyond the screen and actions of touch and click. In this design space, physical movement becomes important to understand as the designer shapes and responds to movement as a design material. I have argued that in order to make novel interactions, the designer needs to be familiar with qualities of their making material and that interaction design may benefit by drawing on contemporary choreographic research.

To conceptualise, communicate and explore possible designs, the interaction designer needs to be able to visualise, augment and try out physical movement. Visualisation of physical movement in interaction design enables a conceptual exploration of novel communications. It has been shown that *accessibility*, *immediacy* and *generation* are important concepts in evaluating this process of building knowledge of movement in interaction design. These concepts enrich the vocabulary of social semiotics and allow for further designing of interactions involving whole-body movement.

The *Synchronous Objects* project showed that physical movement may be visualised in a wealth of modes, from a singular focus to highly complex. It also showed that the bodily representation needed to retain the physical outline of the body, as the widgets showed the communicative

aspects of movement was lost. The *Inside Movement Knowledge* project showed that movement can be represented meaningfully with several modes of technology. When movement is communicated multimodally it may become a resource, as it is then able to capture and communicate potentiality. The project also showed that the naming process in identifying the modes of communication is essential in order to design a modal ensemble, e.g. to communicate something meaningful.

When movement is visualised, relevant aspects are selected and interpreted. Here the analysis of choreographic resources may give us an indication of methods for visualising movement for interaction design. As Siobhan Davies's web-based archive shows, new digital technology enables a new immediacy and multimodality where these resources go from critique to resource. In other words, they become generative tools and therefore useful to design practice as well as research.

As argued above, in exploring how we may see the particularities of physical movement as a design material for interaction design, we may enable novel interactions. By drawing on choreographic research and its related practices, interaction design may explore the communicative potential of physical movement and let it inform the design process. Movement matters in our everyday life; it may supplement, detract or contradict what we say, for instance. As these communicative aspects now may be captured and applied by technology, the interaction designer needs to be able to analyse, visualise and shape physical movements. By approaching movement as a design material for interaction design, we may allow for an understanding of how designers could work with movement at a conceptual stage, and acknowledge the choreographic aspects of the interaction designer's repertoire, as the body becomes the interface.

### Acknowledgements

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### Notes

- <sup>1</sup> The notion of patterns in design comes from Christopher Alexander's work in urban planning in the 1970s, where architectural patterns represent ways for supporting patterns of events that frequently occur in a space (Alexander 1979); it has been used in interaction design as a way to communicate best-practice to recurring problems (Löwgren and Stolterman 2004, Löwgren 2007).
- <sup>2</sup> Norah Zuniga Shaw is a choreographer and Director of Dance and Theory at ACCAD, and Co-Creative Director of *Synchronous Objects*.
- <sup>3</sup> The notion of immediacy here refers to a duration of time in an iterative design process, rather than a distinguishing notion of transparency between the virtual and real (Kickasola 2006). It is closer to Schneiderman's (1998) use of direct manipulation where an action has an immediate visual effect (such as when driving a car and turning the wheel).
- <sup>4</sup> Such as the aforementioned *eyesweb* and *gesture follower* as well as Merce Cunningham's *Lifeforms*, Troika Ranch's *Isadora*, Meso's *vvvv*, and *Siobhan Davies Replay*.

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## ARTICLE 2

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# Materializing Movement – *Designing* *for Movement-based Digital Interaction*

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Designers today have access to full-body movement data to explore the rich, interpersonal, non-verbal communication we read, interpret, enact, and perform every day. In this paper, we describe an approach to movement as a design material, where movement is seen as embodied communication. We discuss the mix of qualities in data derived from full-body movement as it encompasses the corporeal and computational, and how to present such data. The aim for this exploration is to tease out the rich communicative potential of full-body movement for digital interactions by enabling an explorative engagement with movement data. People increasingly move with, for and through technology. We argue that designers need to be aware of the nature of movement data and how such data may be applied, addressed, and influenced. Because we are concerned with the meaning-making design process of movement-based interactions, the main analytical approach taken in this study is communication and social semiotics. We suggest that for interaction design, movement may be parsed by *Velocity, Position, Repetition* and *Frequency*. We further describe the development of a tool, *Sync*, for generating dynamic movement data visualizations, and reflect on abstracting and visualizing movement data in order to inform and enable design processes of movement-based digital interactions.

**Keywords** – Communication, Design Materials, Full-body Movement, Interaction Design, Social Semiotics, Visualization.

**Relevance to Design Practice** – A *Movement Schema* allows for discussion on the conceptualization of movement dynamics as a design material. *Sync* gives interaction designers access to dynamic visuals of full-body movement data.

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## Introduction

### A Design Material View on Embodied Dynamic Movement

In everyday life we use our bodies to non-verbally navigate, negotiate and communicate. We alter our posture, the dynamics and scope with which we move our limbs and handle our weight according to the spaces in which we find ourselves, the people we are with, and what we hope to express. Goffman (1959) describes these choices of glances, gestures and positionings as a performance. If we see the way we present ourselves as a choice and an act, then we may understand that this communication can be read or sensed by technology as well as by other people.

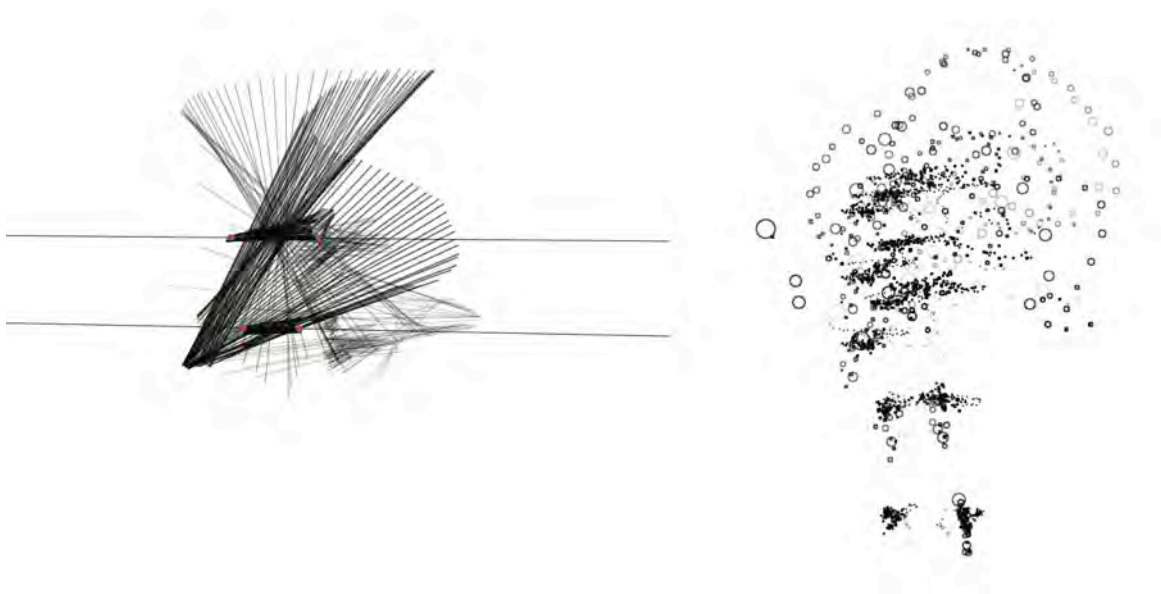
Today, people move with and through an increasing amount of technology, whether the technology is in our pockets or just pervasively available through WIFI. This influences what we do, where we move, and in particular *how* we move. This tracking and influencing of movement reveals the importance of understanding movement as it is abstracted, applied, and influenced through interaction design. An analysis of *how* we move can give us an understanding of what movement is. Because designers now increasingly facilitate, build, and extend communications with movement data, if we shift the focus to how movement *comes to be*, we may better understand *how movement might be influenced*.

Designers today have access to movement data through readily available sensors, such as the *iPhone* or the *Kinect*. In addition, the open source community makes software increasingly accessible with for instance *openFrameworks* and *Processing*. However, few resources exist in

interaction design to meaningfully engage with full-body movement data. This leaves us with the potential to draw knowledge and innovation from our everyday movement practice, including full body actions. There is also a need for technology and interaction design to envision the whole body beyond fingers swiping screens (Victor, n.d.).

This paper explores how we may approach movement for interaction design, and in particular how we may facilitate explorations of movement data for digital interactions. If we are to understand how we may build on movement data and how to design with such data, we need to know the properties and particularities of these data as a design material. As Hollan and Stornetta (1992) wrote, our needs to communicate do not depend on any media, yet how we communicate and the mechanisms with which we communicate are inextricably connected to particular media. Kirsch (2013) argued further that by exploring how we think through things, designs may draw upon our embodied, distributed, and situated cognition, our ‘physical-digital coordination’ (p. 28). In other words, communication is not only media specific, but body-media specific.

Movement data is distinctive in that it encompasses both computational and corporeal qualities. These qualities appear in the data as it is abstracted and in the visualization as movement is re-presented (i.e. both as sign and as signification). Below, we discuss concerns regarding this relational mix of the corporeal and the computational in movement data. To do this we draw on various approaches to the study of movement, such as dance and choreography, non-verbal communication, and modeling and animation of movement data. These we draw together in a schema for identifying semantic properties of movement dynamics for interaction design, informed by social semiotics. Through the schema we propose a parsing of movement according to a set of core categories of *Velocity*, *Position*, *Repetition* and *Frequency*. We further describe the design process of a digital tool called *Sync* that dynamically visualizes movement data. We then reflect on *Sync* and how it may address the concerns of movement as communication and inform interaction design.



**Figure 1: The tool *Sync* enables a visual reading, identification, and interpretation of data drawn from full-body movement. Here the two visuals refer to the same arm-waving movement, with each visual foregrounding different aspects of the movement as well as different aspects of the data handling.**

## **The Body as a Sign: Embodiment and Communication**

When we refer to everyday movement communication, we think perhaps first of gestures in conversation, typically “arm and hand movements” (Knapp & Hall, 2006, p. 225). Kendon defined gesture as “visible action as utterance” (2004, p. 7) and classified a communicative gestural phrase in three parts: preparation, nucleus, and retraction/reposition. These parts have been further expanded to include: size (distance between the beginning and end of a stroke), gesture timing (length of time between the beginning and end of a stroke), point of articulation (main joint involved in the gestural movement), locus (body space involved by the gesture), and x, y, and z axis (location of gesture within an imposed imaginary spatial plane) (Kendon, 2004).<sup>1</sup>

However, these linguistically centered classifications of gesture do not inform us how movement may come to be seen as meaningful or as gesture. “That is, the observer notes the occurrence of a gesture and then records its type. This kind of recording fails to capture the parameters of movement that makes one particular gesture appear over another, as well as what makes the gesture appear at all” (Chi, Costa, Zhao, & Badler, 2000, p. 173). Similarly, a music score does not contain information as to the mechanics of performing, beyond specifying the music to be realized (Puri & Hart-Johnson, 1995, p. 162). When we approach movement as a design material - as something that may be shaped through communicating technology and digital systems - we are interested in how movements become meaningful through their dynamic form.<sup>2</sup> This shift from an analysis of what movements are to an investigation of how they become meaningful is similar to that of going from analyzing designs to investigating designing.<sup>3</sup>

What then are the qualities of movement? For Stern (2010), “we naturally experience people in terms of their vitality. We intuitively evaluate their emotions, states of mind, what they are thinking and what they really mean, their authenticity, what they are likely to do next, as well as their health and illness on the basis of the vitality expressed in their almost constant movements” (p. 3). This vitality is a challenge to classify as Sheets-Johnstone (2011) said “There is nothing rock solid in movement [...] The observation is significant in itself and significant academically; simply put, it is easier to study objects” (p. 124). She also critiques the languaging of movement in that “the challenge derives in part from an object-tethered English language that easily misses or falls short of the temporal, spatial, and energetic qualitative dynamics of movement” (Sheets-Johnstone, 1999a, p. 268). Streeck, J., Goodwin, C., & LeBaron, & C. D. (2011) also point to the analytical orientation of picturing people “doing things *with things*” (p. 6). Design has also been described as concerned with “thing-ing” (Koskinen, 2011, p. 125). These references point to challenges in understanding the vital dynamics of movement that is central in human communication. These various dynamic dimensions of movement pose conceptual challenges for designers, and especially interaction designers, in working with movement as a material.



In addition to these aspects, the body is complex in that it communicates multi-modally, such as through glances, gestures, position, and utterances (Goffman, 1959). Distinctive as a sign, movements require a body, and movement requires physical embodiment. And from this it follows that the sign will also contain references to age, gender, race etc. (Franko, 1995). Also, “space is not an inert backdrop for movement, but is integral to it, often providing fundamental orientation and meaning” (Reed, 1998, p. 523). Lastly, in terms of interpersonal communication, we interpret actions in others informed uniquely by the knowledge of our own movements (Wachsmuth, Lenzen, & Knoblich, 2008).

In other words, the body is both a movement sign and signifier: in approaching movement as communication, we negotiate the embodied and the rhetorical, the event and representation (Foster, 1995). However, as Csordas (2002) wrote as he explored the experienced body, as opposed to the observed body, these approaches, the semiotic and the somatic, are not mutually exclusive, but exist in concert. Noland (2009) navigated these concerns when she explored an account of agency in how “gestures as learned techniques of the body are the means by which cultural conditioning is simultaneously embodied and put to the test” (p. 2). In anthropology, Farnell and Varela (2008) argued that visual studies should move from seeing the body as an object to dynamically embodied persons in action. In a similar turn, Williams (2004) proposed “semasiology” as a semiotic approach to the embodied, signifying, moving person.

This rich and complex meaning-making in human-human interaction provides us with resources to design interactive systems that draw upon, facilitate, or create such communication. Sensing technology now extends beyond the push of a key, the tap of a button, or swiping of a screen to include marker-less sensors such as infra-red sensors for automating doors to figure recognition in the *Kinect*. Designers are thereby in a position to abstract movement and to communicate it as data and digital mediation. As Kendon (1995) put it, “if signs are to be transmitted, they must be seen” (p. 116). Designers can then create structures and systems from, with, and for such communication.

This is complex, as Farnell (1999a) pointed out: “the meanings of perceivable actions involve complex intersections of personal and cultural values, beliefs, and intensions, as well as numerous features of social organisation” (p. 148). Schiller (2006) proposed that “if we accept this entanglement between human-created techniques and movement as a dynamic structural and relational event, then we replace discussions of the body and space or body and machine with the fluid surprises of relational dynamics” (p. 109). When we as designers influence this relational dynamics, we need to first untangle these actions and events to appreciate what we are working with. Specifically, this is a matter of understanding how to abstract movement for interaction design.

## **Movement Studies: Notation and Abstraction**

Notational systems for movement come primarily from dance, devised as early as the 15th Century (Guest, 1989). The most comprehensive system for notating contemporary choreographies,

independent of styles or schools of dance, is Labanotation developed by Rudolf Laban (Guest, 2005). This notation system was further developed into Laban Movement Analysis to focus on analysis of movement qualities (Newlove & Dalby, 2009).<sup>4</sup>

When movement is abstracted, selected visual qualities are translated into a system of signification. Two key movement notations (outside of dance) are that of Hall's (1996) "proxemics," which draw attention to man's use of space as a specialized elaboration of culture (p. 1). Here the body is understood as a location in space. At a more detailed level in structuralist linguistics, Birdwhistle (1971) devised "Kinetics" as a method and notational system for analyzing everyday movements in micro-social context.<sup>5</sup> However, as Farnell (1999b) wrote: "the stretch of functional-anatomical terminology explains nothing about the sociolinguistic or semantic properties of the action involved" (p. 360). In addition, Helen Thomas (2003) pointed out that not only do we *have* and *are* bodies, but they are rarely static, as most theories of the body seem to argue (p. 63). This lack of focus on movement dynamics led Sklar (2008) to call for "qualities of vitality" in descriptions of symbolic action (p. 103).

Attention to the level of structural detail of the body's movement may indeed prevent rather than enable a reading of abstracted movement. For interaction design this is important, as the computational modeling of movement is increasingly precise, without necessarily informing the practice of designing for movement in regards to the role and agency of movement in interaction.<sup>6</sup> This also extends to how movement is visualized. For "whilst there has been substantial advances in human motion reconstruction, the visual understanding of human behavior and action remains immature." (Moeslund, Hilton, Krüger, 2006, p. 116).

As these studies of movement, notation, and communication indicate, there is a wealth of possible detail and relations, and a great complexity in movement as it dynamically plays out, from which we need to make informed choices when we abstract. However, "the danger of trying to codify, generalize, and formally model the aesthetic experience for technology design is that it may miss precisely the phenomenon that was originally of interest. In abstracting from specific embodied contexts, many of the ineffable aspects of the aesthetic experience - those escaping formal articulation - may be either overlooked or designed away" (Boehner, Sengers, & Warner, 2008, p. 12:3). Addressing similar concerns, Loke and Robertson (2013) argued for designers to include the movers' perspective, to ensure the felt, lived experience is considered in the design of movement-based interactions. Here notation is interesting for design as it gives us the possibility to go from script to score, from "taking in" to "acting out" (Ingold, 2007, p. 12). In other words, we may use how something appeared to inform how future scenarios may play out and be influenced. The potential for variation here is important. "The greatest value of the systems is not necessarily how precise they could be, but the possibility they have to record more than one stratum of precision" (Bastien, 2007, p. 48).<sup>7</sup> By understanding how movement has been modeled computationally, we may be able to assess the level of detail and what kind of information is valuable for interaction design when we design movement-based interactions. This is addressed in the *Sync* tool, as we discuss later (See Figure 2).

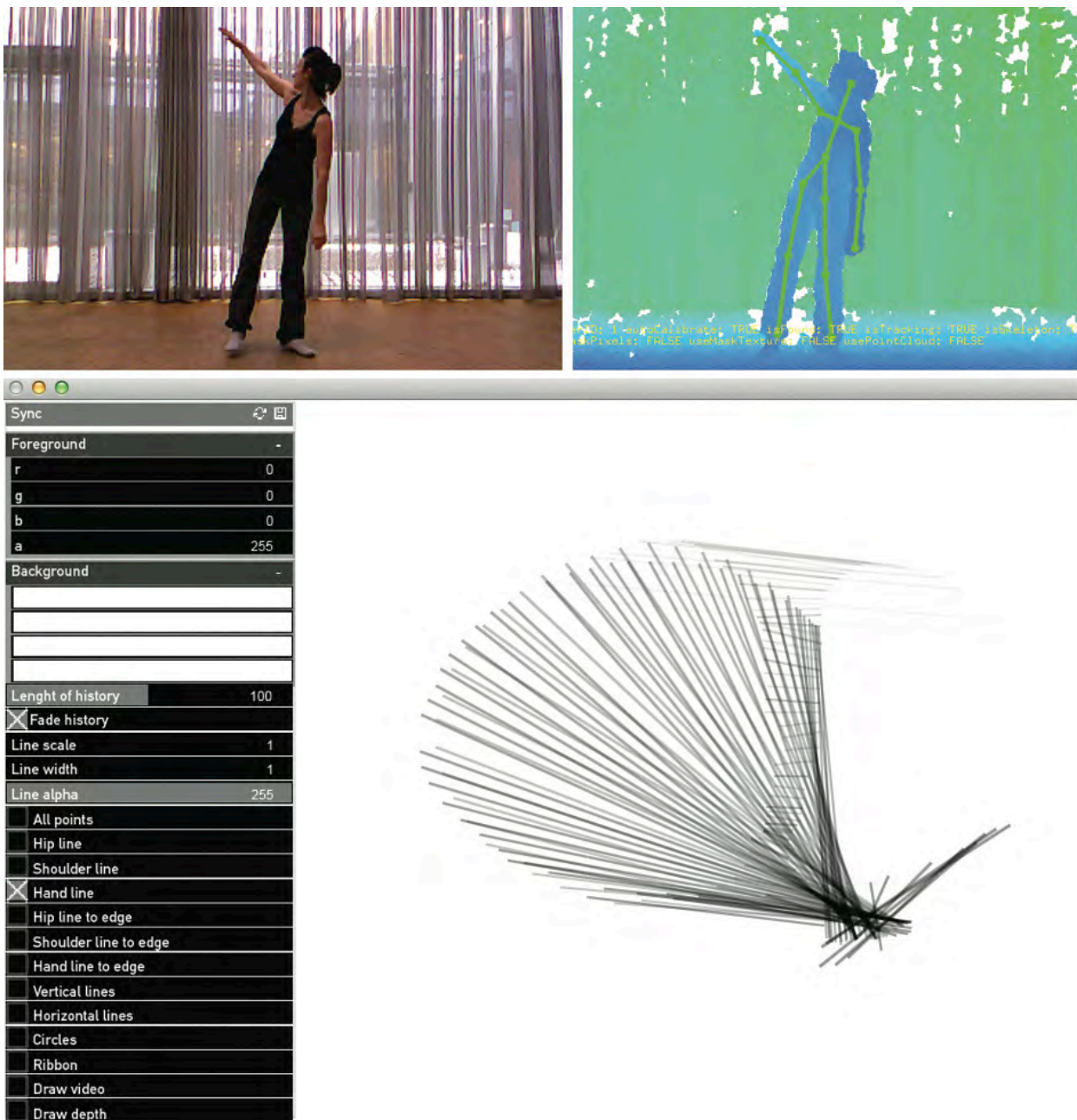


Figure 2: The video and depth data feed from the *Kinect* as well as the *Sync* GUI.

## Digital Mappings: from Script to Score

In 1979, Badler and Smoliar discussed how human movement may be represented digitally, and based “primitive movement concepts” on Labanotation to build a machine language for representing movement (1979, p. 36). This early work was developed further in the EMOTE model, an animation system drawing further on Laban’s work on effort in movement to simulate natural and expressive movement (Chi et al., 2000).<sup>8</sup> In computer science, work has also covered the identification and modeling of movement, such as classification for movement recognition (Sminchisescu, Kanaujia, & Metaxas, 2006), social signal processing (Vinciarelli, Pantic, Herv, Bourlard, & Pentland, 2008), and surface articulation (Horaud, Niskanen, Dewaele, & Boyer, 2009).

Moeslund et al. (2006) have surveyed this progress of vision-based human motion capture research, and point in particular to progress regarding initialization, tracking, human motion reconstruction, pose estimation and recognition. Niebles, Chen, and Fei-Fei (2010) proposed an algorithmic model which identifies and classifies temporal qualities, and the model developed by Kulkarni, Boyer, Horaud, and Kale (2011) identified “actemes” (akin to linguistics’ phonemes) in order to address dynamics beyond position. Lucena, Blanca, Fuertes, Marín-Jiménez (2009) addressed optical flow accumulated local histograms in order to obtain good video sequence classifiers for human action recognition. This was also explored by Pers, Sulic, Kristan, Perse, Polanec and Kovacic (2010) in regard to identification and security.

However, there has been little consensus on what the general purpose descriptors should be across the variety of computational modeling of movement. This was pointed out early by Gavrilu (1999). This remains the case, as Poppe (2007, 2010) mentioned in his overviews of vision-based motion capture research on how the evaluation of motion analysis algorithms requires a common database. Whereas attempts such as the HumanEva database aim to build a consensus of descriptors (Sigal, Balan, & Black, 2010). Although much work has been done in this area “many issues remain open such as segmentation, modeling and occlusion handling” (Wang, Hu, & Tan, 2003, p. 596).

These algorithmic analyses of movement from computer science inform the cutting edge developments of technology, such as sensors and software, that concern the precision of movement identification and prediction. The focus is on mathematically identifying or modeling movement. The evaluation is of the resulting models and mathematics, presented in graphs, statistically, or as equations often without visual reference to the origins of the data, or the movements. For the collaborative creative processes involved in much of interaction design that engages non-programmers and non-developers, these computational approaches present a challenge. Choices will have been made and parameters set regarding extraction, abstraction, and presentation, in particular of temporal dynamic relations and their representations. It is these choices that are often difficult to gauge in the descriptions of the final designs. Blaauw and Brooks (1997) wrote that “when reading the professional paper describing the architecture of a new machine, it is often difficult to discern the real design dilemmas, compromises, and struggles behind the smooth, after-the-fact description” (p. vii).

For movement in particular these choices are not yet guided by conventions (as we see by the attempts of the HumanEva project to standardize descriptors), yet they are important if we are to understand the potential of movement data as communication, and as semantic properties of their dynamics. In particular this is because “through computation, we are in a position to develop more personalized, customized, and richer technologies. By abandoning the tendency to generalize reality, digital mapping technologies undermine the role ergonomic surveys play in the measurement of organic bodies” (Silver, 2003, p. 109). It is arguably here we can see a role for design in exploring movement for digital communication.

## **A Design Perspective: from Score to Tool for Design**

In order to inform design and design practice, we decided to approach movement as a design material. Designers work informed by their materials. Sennett (2008) referred to such knowing as “engaged material consciousness” (p. 120). The designing of movement-based interactions introduces elements that until recently have not been thought of as conventional materials for designers. These include software (Blevins, Lim, Stolterman, 2006; Hallnäs, Melin, Redström, 2002; Löwgren & Stolterman, 2004), time and space (Mazé & Redström, 2005), screens (Eikenes & Morrison, 2010), and also networked objects (Nordby, 2010).

Our focus then, is on the dynamic, moving body as a material and a mode. In other words, we are interested to understand how movement data may be read, interpreted, shaped, presented, and applied in order to design from it, with it, and for it. “Computational technology gives us a very rich material to express interaction design form” (Hallnäs, 2011, p. 77). Software then is also a material that the designer may shape as it draws on movement. However, computation is a challenge as “computations need to be combined with other materials to come to expression as material” (Vallgård & Redström, 2007, p. 513). When designers explore a material, they touch and stretch and shift and shape it. With traditional materials such as clay or wood this can be direct and instant, but with computation these explorative physical acts are less available. Thus, when designers work with movement data, there is an initial design stage where the data is ordered and itself abstracted; the data is presented and visualized usually as numbers or graphs, but it is also possible to re-map the data and present it in such a way that we can *see* the data as we *see* movement.

Schön (1991) described such processes as the designer having a conversation with the material. Dearden (2006) further discussed how the process of designing with digital materials can “be sought in the material properties of digital systems” (p. 399). Ashbrook and Starner (2010) pointed to the fact that motion gesture control rarely appears outside the game console and that the reason for this might be that interaction designers are not experts in pattern recognition. Therefore, how may movement data be made available to designers in order for them to recognize patterns and structures or meaningful movement from the data?

We address this question by developing a tool that shows how the movement data *comes to be* such a computational composite. This is essential if we are to explore movement data in interaction design. For each digital abstraction of movement, we get data that we then need to present or visualize in order for us to understand what is registered and how, and then again to identify which data we need or how we may use it. What is needed is a tool that allows for various levels and types of abstractions to be drawn from the data. This enables a kind of stretching, molding, shifting, and shaping of the data, similar to what we might do to clay or fabric in order to understand its nature, the properties, and potentials for design. Hansen (2011) has previously argued that for interaction design to explore expressive movement as communication, designers may draw on choreographic practice, and in particular the digital tools and techniques that computation now make possible for choreography. From a design perspective, Hansen (2011) found that movement data needed to be accessible, visualized, and generative in order to communicate the potentials and possibilities of the movement data as a material for designing. Designers, artists, and other non-programmers are now

increasingly able to access software developments and applications through open source code, such as *Pure Data*, *Processing* and *open Frameworks*. These are described as toolkits, where you can use and build upon available code, and in turn add your own. In this way, interaction design is increasingly exploring creative computation. However, code for movement has been explored with a predominant focus on sound. Birringer (2002) pointed to the fact “that choreographers have been working with code that was by and large written by and for musicians (e.g. *BigEye*, *Image/ine*, *Max/MSP*, *VNS*). Such code may not be ideal for physically rich and complex action” (Birringer, 2002, p. 146). Also, digital tools for advanced motion tracking mainly deal with markers or site-specific annotation. Motion capture systems such as *Qualisys* and *Optitrack* are sophisticated and precise but prohibitively expensive, immobile, and with a high user threshold.<sup>9</sup>

Additionally, performance and dance-related research projects are now gradually developing their own digital tools as part of their research, such as Motionbank’s *Piecemaker*, TKB’s *Creation-tool*, Openendedgroup’s *Field* or *Whatever Dance Toolbox*.<sup>10</sup> These projects exemplify high-level handling of movement data as an expressive material, where the movements usually relate to a particular choreographer and the tools are designed for creating movement for the stage, such as TroikaRanch’s *Isadora*<sup>11</sup> or *Actionplot* (Carlson, Schiphorst, & Shaw, 2011).

As we were exploring movement and movement data, we found it particularly fitting for us to engage in “reflective practice, the framing and evaluation of a design challenge by working it through, rather than just thinking it through” (Klemmer, Hartmann, & Takayama, 2006, p. 142), and also acknowledged the connected nature of physical action and cognition (Schön, 1991). Foster (1995) argued that the conventions through which meaning of the body is conveyed needs to be accessible and “as long as every body works to renew and recalibrate these codes, power remains in many hands. Otherwise the conventions will take us ‘unawares’ and gain the upper hand” (p. 19). Foster further critiqued the ease with which other disciplines adopt concepts and concerns built up through bodily-based practices, e.g. performativity (Foster, 1998). This is why we think it is important to move our bodies as designers (Hummels, Overbeeke, & Klooster, 2007), and to explore the nature of movement data ourselves by developing an approach to movement for interaction design. Further, we see it as essential that this be extended to the development of tools for visualizing movement data. In short, we took a practice-based, bodily-present approach to research through designing in the exploration of movement as a design material.

In framing code as a way to handle data from a designer’s perspective, code becomes a tool for the designer, as well as a material. Discussing how tools are designed is important as Haigh (2009) argued, “software tools encapsulate craft knowledge, working practices, and cultural assumptions” (p. 7). Hence, such exploration of movement data can inform a professional vision as “socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group” (Goodwin, 1994, p. 606). In turn, this informs practice in the sense that just as a trained typographer will see the potential in a poster, as well as the actual poster, a trained choreographer will see movement potential as well as the actual movement. We enable such a skilled vision (of movement) by finding ways to materialize movement for designers.

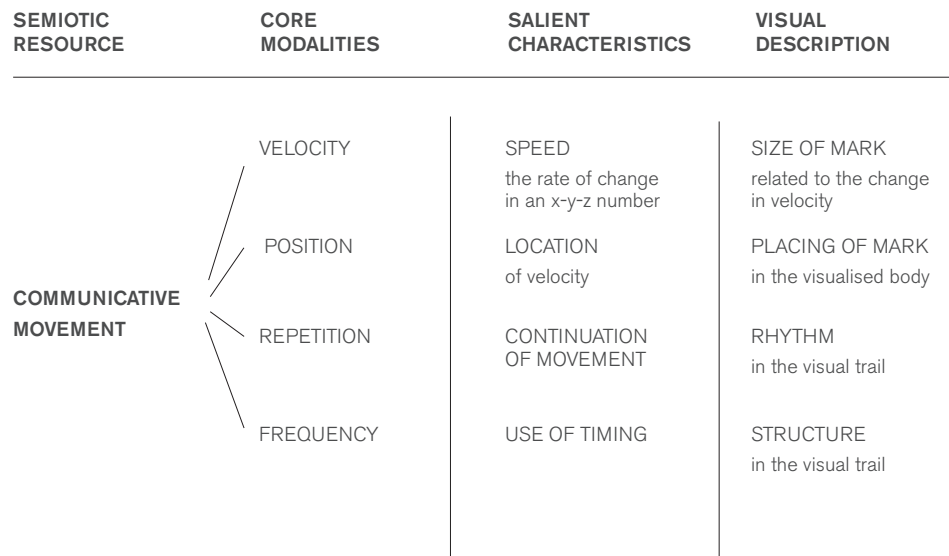
## Identifying Movement Qualities for Interaction Design

In investigating how to conceptualize movement for interaction design, with an aim of addressing the notion of vitality (Stern, 2010), we found that we needed to work out a way to identify movement qualities. Similar to most design projects, there was a need to identify and understand the constituent parts of what we were designing with. This is different from studies of the comparison of movement phrases (e.g. *Gesture Follower*) or other higher level abstractions that model emotional states (e.g. *Eyesweb*).<sup>12</sup>

In order to inform a conceptualization of movement for design, we developed a schema for parsing movement visually. To do this we drew on a variety of knowledge from training as a dancer, the professional practice of a graphic designer and an interaction design educator, as well as design and research in new media and communication design. This diverse knowledge and experience was drawn together with the body of interdisciplinary research presented above. We further drew on social semiotics, in order to devise a set of semantic properties for understanding movement dynamics.

Analyzing meaning-making processes involved in working with design materials also has close correlations to the process of meaning-making or signification in social semiotics (rather than aiming to settle on overarching rules or specific structural grammars). Social semiotics explores how meaning is made in the process of adopting, using, and modifying signs or resources in situated use (Kress & van Leeuwen, 2001). It is therefore appropriate to frame movement material as a semiotic resource, defined as “the actions and artefacts we use to communicate, whether they are produced physiologically – with our vocal apparatus; with the muscles we use to create facial expressions and gestures, etc. – or by means of technologies – with pen, ink and paper; with computer hardware and software; with fabrics, scissors and sewing machines, etc.” (van Leeuwen, 2005, p. 3). By investigating the nature of movement data in this way we explored movement as material beyond its current functions and applications. It is important to note that to date little work has been done on movement in social semiotics, despite the focus on multimodality in the past decade (Morrison, 2010).

In designing with movement as design material we drew on Kendon’s approach in classifying greetings. Kendon (1990) found that there was no “absolute” boundary for identifying a greeting, and resolved to search for “patterns of organization at the most inclusive level first” (p. 10). Similarly, we aimed to identify the visual aspects that comprised the dynamics of communicating full-body movement. We further drew on van Leeuwen’s (1999) approach to sound.<sup>13</sup> In parsing sound, van Leeuwen listed its modalities and each modality is then described by its salient or “marked” characteristics. Those could again be described and more specific characteristics named. This process creates a network of choices for mapping material. In our case it formed a system of choices on movement. This was formulated in what we have called a Movement Schema (see Figure 3).



**Figure 3: A schema for identifying semantic properties of movement dynamics for interaction design.**

This Movement Schema is designed to assist the understanding of how to communicate movement through the notions of modalities in Semiotic Resources. These are mapped to an increasing degree of detail, from left to right. First, Core Modalities are listed that cover *Velocity*, *Position*, *Repetition* and *Frequency*. These address the major modes of movement. Each then has a set of Salient Characteristics (Speed, Location, Continuation of Movement and Use of Timing). There then follows Visual Description that entails Size of Mark, Placing of Mark, Rhythm, and Structure. Further details on these aspects are described below. First, we describe the categories related to Core Modalities:

*Velocity*: As Stern (2010) discussed, vitality is central to human experience, yet it is “hidden in plain view” (p. 3). As we try to get to this quality in movement data, we address the critique by Sheets-Johnston (1999b) of the prevailing limited view of movement as an equivalent to a change in position: what changes position are objects in motion, not movement. Movement is thus not equivalent to objects in motion. This gives a focus on how a part of the body moves, not just changing from position to position, rather the main communicative element may indeed be in *how* this is achieved. This allowed us to visually emphasize the velocity of each point and find ways to visualize the rate of change in the position of a body part, rather than where it started or ended or what it produced.

*Position*: This leads to a consideration of location. This is not a matter of the overall pose or posture and its location, but the position of the velocity. This comes from an understanding that the body is multimodal as well as embodied, and indeed that when we communicate there are several semiotic systems at play at any one time (Streck, Goodwin, & LeBaron, 2011). In this sense it is important to see what part is moving and where (relative to the rest of the body). This is a shift of



focus from the position of the body to the meaning of position of moving body parts.

*Repetition and Frequency*: A shift - such as turn-taking or framings, to use Goffman's term (1986) - can be seen in the velocity and its position over time, e.g. how and when a certain change or velocity is repeated and the frequency of this repetition. For instance, meaning depends on a reading of a movement in context: are all movements repeated or only a single one? This can place greater emphasis on that particular movement. This happens in a conversation when we quickly adapt to the "language" of the other to ensure we are understood and that we understand the other (Tversky, Morrison, & Zacks, 2002). In this way a single movement is always interpreted in context of all the other movements. This led us to add *Repetition* and *Frequency* as central to understanding movement data, or, to refer to Kendon, as central patterns of the most inclusive level.

The description of these four categories or modalities indicate some of the complexity of communicating with our bodies. The choices of identifying these particular modalities was also informed by previous parsing of movement in dance, linguistics and anthropology as mentioned previously: such as dance (e.g. Guest, 2005; Schrader, 2005) and computer science (e.g. Bacigalupi, 1998; Badler & Smoliar, 1979). However, it is important to note that this is a suggestion of how to parse movement with the aim to visualize movement data for interaction design. This perspective is not an overarching nor fixed taxonomy but rather an initial step in identifying relevant qualities for interaction design as movement is increasingly read and applied in interaction design. Such a Schema also opens up areas for discussion and evaluation. The Schema therefore provides a meta-vocabulary and with it suggestions for communicative characteristics of movement. While Morrison and Tversky (2005) argued that "naming seems to activate the functional aspects of bodies" (p. 696), by providing the means for describing and explaining these resources in regards to meaning making, social semiotics in turn provides the means for describing and explaining how these resources may be understood and taken up, and then designed and applied.

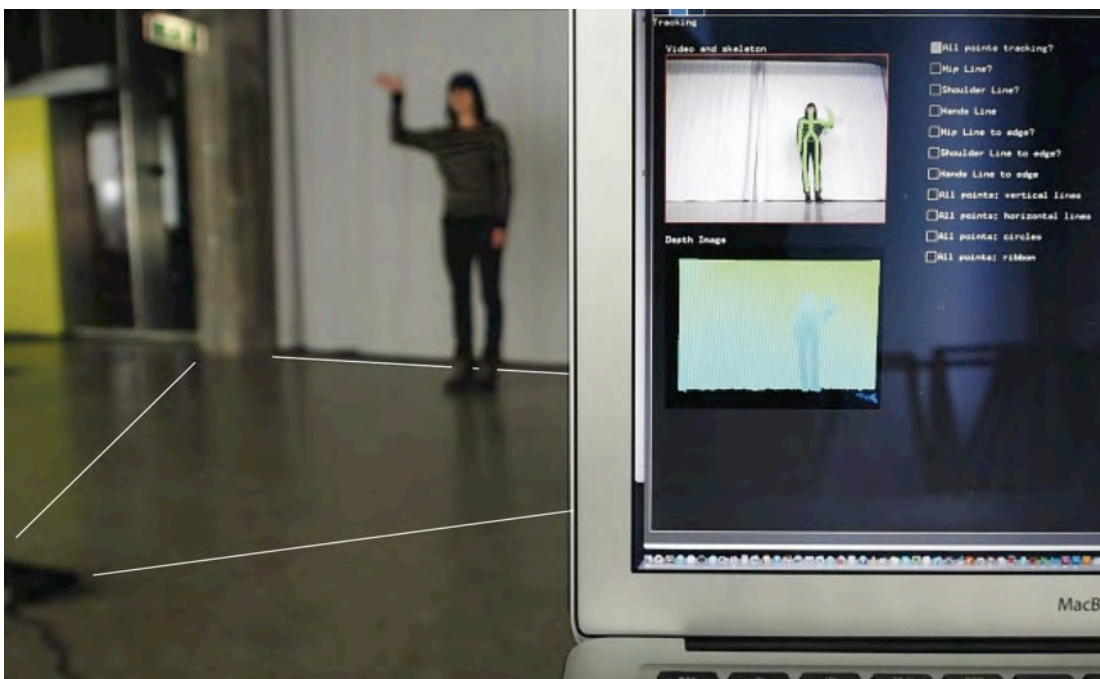
We also added the last column Visual Description to the Schema by proposing a visualizing component. This is further explored in the design of the tool *Sync* described and illustrated in detail below. The Schema formed the basis for designing a tool for visualizing such movement modalities.

## **Designing Ways to Visualize the Computational and Corporeal in Movement Data**

*Sync* was developed by the author and designer Lise Amy Hansen and *Hellicar&Lewis*, along with the interaction designers Peter Hellicar and Joel Gethin Lewis. Thus, we drew on specialist knowledge from design and dance, design and skateboarding as well as design and mathematics, covering movement, programming and visual communication. The design methods for the making of the tool were collaborative, reflecting the kinds of processes the tool aims to aid (Sanders & Stappers, 2008). Below follows a brief description of the process; the many alternate iterations and investigations are beyond the scope of this article.

An initial workshop in 2010 started with discussions around movement issues (as those outlined in this article) and the current role of movement in interactions, installations, and interactive performances. This contributed to a joint understanding of movement as communication and the kind of interactions this could inform. We also had a shared knowledge of the kinds of tools we had at our disposal and what they could do (e.g. relevant programming languages such as *openFrameworks*<sup>14</sup> and available sensors). We saw that current digital tools for marker-less movement data mainly employed body outline data (e.g. blob recognition), and we realized there was much to unravel as to how movement played out ‘within’ a single body. We were also concerned to address the whole body, in other words beyond fingers, hands, or arms typically dealt with in confined spaces such as desktop-based scenarios.

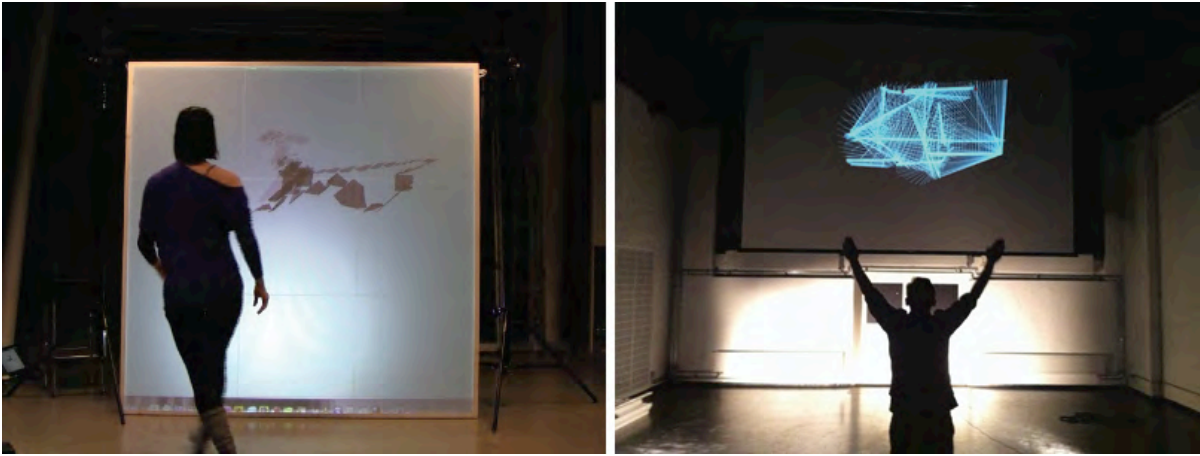
Our focus was on identifying how designers may arrive at semantic properties of the dynamics of movement in the data e.g. abstracting how the parts of the body or the body moved. The Movement Schema was our design brief, in the sense that we sought to find parameters for visualization that reflected the modalities in a variety of ways (rather than finding a separate visual for each modality). Fry (2007) described such data visualization processes in seven stages: acquire, parse, filter, mine, represent, refine, and interact. We decided to draw upon the movement data from Microsoft’s *Kinect* sensor.<sup>15</sup> It uses video and depth data from infra-red sensors to identify 14 points in an x-y-z axis representing feet, knees, hips, shoulders, elbows, hands, torso, and head (see Figure 2 and 4). However, the tool we developed may equally well take its feed, e.g. the x-y-z points from other sensors.



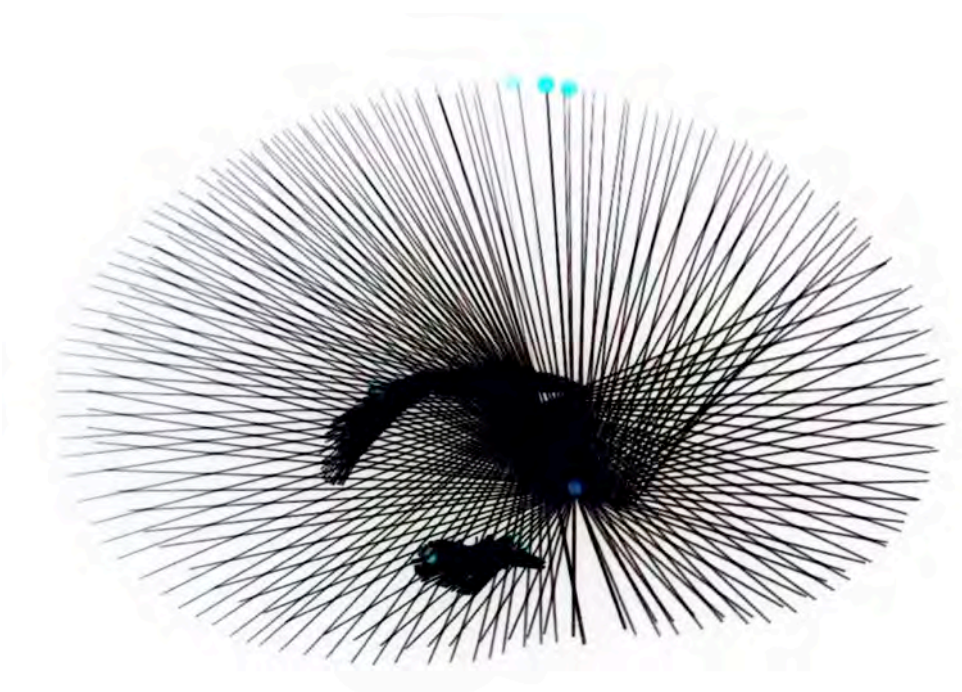
**Figure 4:** An indication of the scope of the *Kinect* sensor and an example of the set-up with a laptop running *Sync*, with the GUI menu. For exact measurements of *Kinect*'s scope see Dutta (2012).

We collaborated remotely, as well as in workshops in 2011 and 2012. We continuously tried out the visualizations by exploring our own movements through them, as well as allowing

colleagues from choreography and interaction to explore the various visualizations. On these occasions we projected the generated movement data visuals on large screens so people could see their own data as it played out (See Figure 5 and 6).



**Figure 5:** Moving their own data around in real time in the design workshops 2011 and 2012.



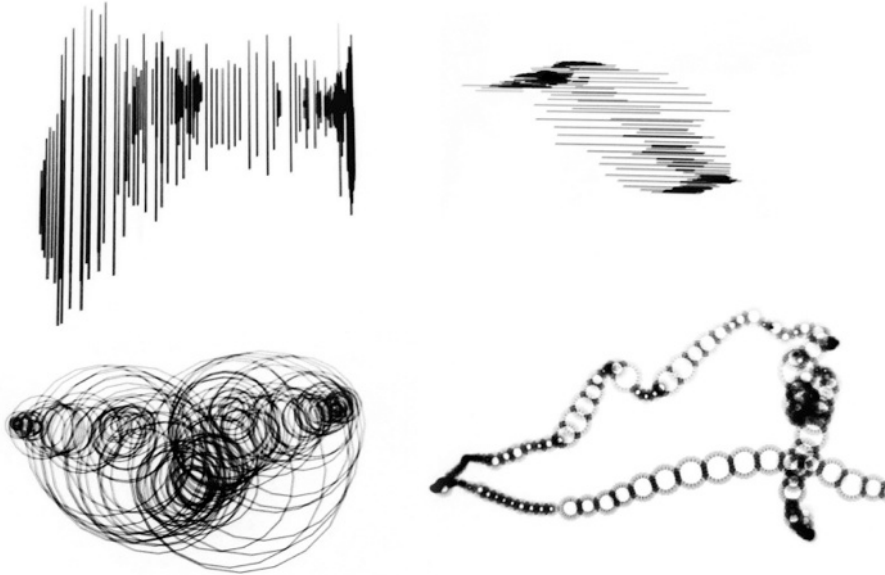
**Figure 6:** Here *Sync* visualizes hands, hips and shoulders by connecting each pair with a line, and shows the data from a martial art sequence.

## ***Sync*: A Tool for Visualizing Movement Data**

The outcome of these design workshops was the tool *Sync*. It is a script, or lines of code, that call upon the movement data and in so doing it “organizes the data and presents patterns and relations, structures and dynamics that may otherwise be near invisible to us” (Hansen, 2013).

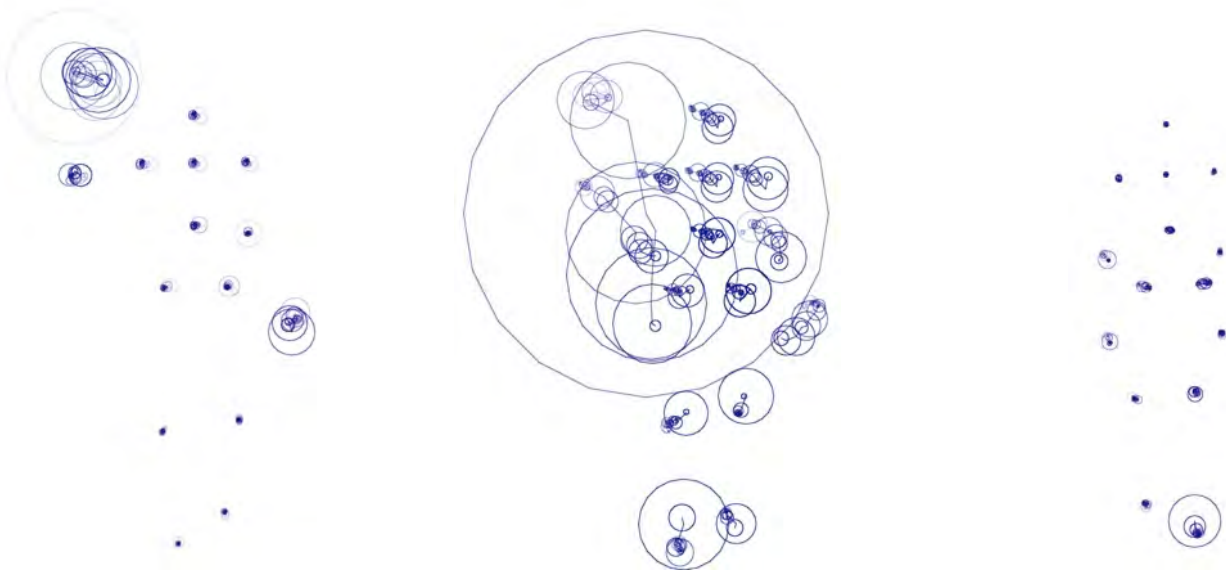
## Parameters and Options

The tool has a graphical user interface (GUI) with a range of options as to how the movement data is presented dynamically. The data draws on the *Kinect* in its tracking and identification of the body through 14 points in an x-y-z axis. With *Sync*, these x-y-z points may be visualized in different ways: vertical and horizontal lines, circle and ribbon (see Figure 7). Each visualization choice will foreground different qualities of the movement data.



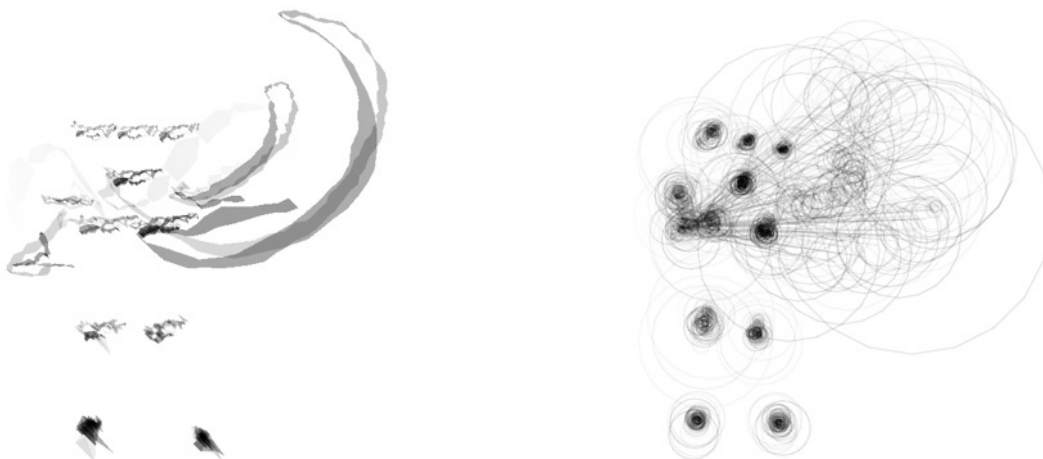
**Figure 7:** Each x-y-z point can be visualized by *Sync* as one or several or all marks; circle, vertical line, horizontal line, and ribbon.

The rate of change in an x, y or z number (e.g. the position of a point relative to the *Kinect* sensor) was indicated by change in the size of the visual mark representing that point. That is, movement is registered as a change in any of the x, y, or z planes, measured by the rate of change in its position. This in turn is visualized, so that an increase of speed will extend the marks, extend the size of the circle or extend the length of the lines or the width of the ribbon (see Figure 8).



**Figure 8:** This composite image show three stills of visualized data from a simple raised (right-hand) waving action ending with a small (left) foot shuffle. The size or scope of the movement is available in the line trailing the x-y-z- points, whilst the size of the circles reflect the rate of change of each point.

The marks are continuously drawn, which allows for a visual trail where repetitions may build up visually and relationally e.g. the frequency may become apparent through comparison in the visual trail (See Figure 9).



**Figure 9:** In these comparative visualizations of a wave, the x-y-z points are visualized by the ribbon mark (left) and by the circle mark (right). The velocity or rate of change in a point, here the elbow and hand in particular, is visualized by a wider ribbon or bigger circle.

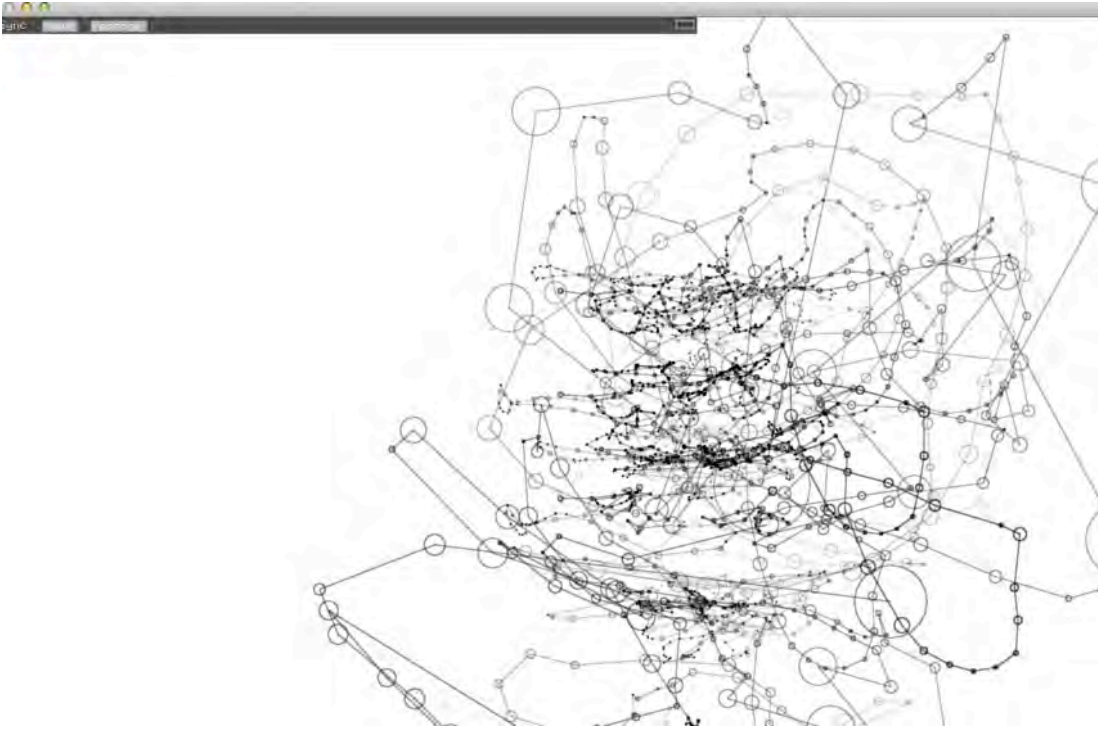
The interface further allows for the mark visuals to be shaped according to size, line width, and density through sliding controllers (see Figure 2). This allows for decisions on how the movement data appears in regards to sensitivity (a large sized mark can obscure a reading of small movement

for instance) detail (the thin line width of the mark allows for precise positionings of a movement) and history (the denser the mark, the harder it is to see the history as it builds up visually and overlaps). In addition, there is a history or visual trail for each mark and a slider controlling the length of the history.

We also created an option to track pairings of points: shoulders, hips and hands. These may be visualized by a line connecting each pairing of points or by a line extending to the edges of the screen, amplifying their alignment (See Figure 1).

*Sync* has screens showing the video and depth data feed as well as a screen where the data is visualized according to the parameters set in the GUI.





**Figure 10:** The graph becomes visually complicated if too many parameters are visualized. *Sync* video and depth data feed as well as a close-up of the data visualization (available here <http://kinetically.wordpress.com/sync-download/>)

## **Record, Repeat and Reveal**

We also chose to include a recorder function in the tool. This allows the movement data from the *Kinect* along with video and depth information to be stored, accessed, and replayed. This enables an exploration of alternative representations of the same movement as the data may “run” over and over again. For each run, the designer may choose a different visualization, and by playing with the options available in *Sync*, the designer may then become familiar with both the tracking parameters (e.g. what the *Kinect* registers and how) as well as the movement repertoire (e.g. the kind of movements performed in that specific context and location). This is important with the wealth of possible data for visualization (see Figure 10).

This enables the designer to fine-tune exactly which aspects of a movement are to be tracked, again giving a more sophisticated reading of movement. *Sync* can be set to only show fast movement, or it can be set to show a long history of movement and dense marked areas, which would identify points where there is little movement, and so on (See Figure 1).

## **Reflections on *Sync* and Movement Data**

### **Materializing Movement Data**

*Sync* allows designers to decide the ways in which movement data is presented. It opens up the options for designers to set the parameters of algorithms that call upon movement data, namely the x-y-z- points. In this way, *Sync* generates dynamic visuals that digitally re-present full-body

movement. By having the possibility to compare these visualizations to a video and the depth data, the designer in a way gains a particular access to the algorithms, in the sense that they can explore the movement data through play, by twisting, shifting and shaping the parameters, and thus the visuals. This elasticity is itself a key difference to the tools mentioned previously. Such flexibility also opens up for a material understanding of the possibilities of movement data that emerges in and through use. This is similar to squeezing and pulling clay to gain insights into aspects such as density and resistance as material properties. Exploring the various parameters and algorithms with movement data is a similar materializing process through which a designer can appreciate how movement and movement data can be worked with, selected and read.<sup>16</sup>

Observing a finished object may help communicate material possibilities beyond those employed. However, in order to make informed choices such as scope and fit as well as effect and ethics, we need to know the material properties and potentials. Through computation, designers now have novel access to abstracted movement or movement data. With *Sync*, designers are in a position to explore the notion of communicating digitally with our movements and “as we create new interfaces between our bodies and our symbolic systems we are in a unusual position to rethink and re-embody this relationship” (Utterback, 2004, p. 226).

### **Viewing the Corporeal**

By re-presenting movement and abstracting it to a level where we may still appreciate a body in the dynamic presentation of the data, we can still draw on our “everyday” yet sophisticated reading of movement as we identify and familiarize ourselves with the data and thereby the movement. We have aimed to keep an alignment of the data that can be traced back to the actual body. In this way, we can link the data to physical movement and may re-embody the relational dynamics as we, as designers, became familiar with how the corporeal is stretched into the computational and how the computational abstracts the movements.

However, the same ability to interpret movement data visuals extends beyond what is “there.” As we materialize movement by visualizing the data, we can also notice missing data. Bleeker (2008) addresses this aspect of skillful viewing in her writing about visibility in the theatre: “we always see less than is there” and further points to the fact that we also see more than what is there (p. 18). With computer vision the same can be said to be true; a tool that represents data visually is set to register only a certain selection of available information, from which we then read more into than what is “there.” It is important then that we engage in altering, twisting, and shaping the data to find the grain, plasticity or malleability, and material restraints. First though, movement itself needs to be understood as a dynamic and accessible material for interaction design.

### **Accessing the Particulars**

In *Sync*, the data from the environment, such as proximity or the nature of the surroundings, is not registered. However, the *Sync* set-up is portable and relatively un-intrusive. Consequently, *Sync* enables a design process to take place in specific settings, and in this way addresses the “orientation



and meaning” that a backdrop may give (Reed, 1998, p. 523).

*Sync* is a bottom-up tool; it does not place the movement data in a system of immediate signification nor does it currently analyze movement in relation to other sets of information, such as location data, time of day, or work tasks for instance. It allows for analysis of specific particular movement, and thus, to a certain extent, situated movement, and avoids the need to read movement according to a particular vocabulary. *Sync* then enables designers to address Franko’s concern regarding embodied elements, such as race, culture, and gender, in the sense that it opens for designing according to specific settings and for specific movements, specific needs and specific expressions. Digital depth cameras, such as the *Kinect*, have existed for a while in a variety of forms. However, “when they become cheap and distributed throughout the culture [...] suddenly people have a new way of expressing themselves” (Levin, n.d.), to which we add, so do designers.

### **What Does this Mean for Design?**

For designers these temporary visual representations may function like a sketchbook that “encourage exploration of rich and non-obvious spaces of opportunity” (Gaver, 2011, p. 1560). The visuals may be seen as mappings that can inform design briefs for future designs. *Sync* allows designers to visualize a dynamic that otherwise would normally be buried in numbers in the lines of data that are generated by the change in each x-y-z point. This may be accessible for a computer programmer reading lines of numbers, but it is hard to interpret for others. Staying close to the actual movement, and visualizing the movement data with comparison to video and depth data, as well as providing dynamic, generative visualizations enable the designer to “see” the data and to make informed decisions in linking movement data to communication, function and aesthetic. This kind of seeing is the skill Goodwin (1994) calls “professional vision,” and we suggest it is what is needed for interaction design to appreciate movement as material.

Accordingly, such mapping or exploration of materials may inform use of movement beyond current functions. And because the arguments and designs laid out in this paper are propositional and explorative, thus they align with such outcomes. Hansen has further written about the importance of teasing out and making available the creative decisions for design in handling movement data. These decisions are crucial in the materializing process as the data is selected, read, and called upon in order for it be visualized and the creative potential communicated (Hansen, 2013). In this sense, By making *Sync* available, the tool also invites skill and virtuosity in handling this material. The tool is published as open source, and as such is designed to prompt, inspire and motivate interaction designers and others to creatively engage with movement data, and by extension, movement as material.

### **Conclusion**

Movement data, and by extension movement, remain largely inaccessible for designers. Few resources exist that allow designers to creatively explore the potential in various ways to conceptualize and apply movement qualities in a design process. In our enquiry we framed

movement data as a material that can be shaped, which in turn shapes the design process. We were motivated by the notion that every material will have properties that give particular possibilities of expression and communication.

Above, we outlined notions of the moving, expressive body in interpersonal communication, as an embodied sign and signifier, socially situated, culturally performed, and read. In order to approach such complex movement for digital interactions we looked at how movement has been studied and notated in dance and choreography. We also examined how it has been taken up in non-verbal communication, new media, and communication design. We further looked at how computer science has abstracted and modeled movement, and discussed how computation allows for an increasingly detailed mapping and dynamic re-presentation of movement. Overall, we argued that it is important for interaction designers to be able to appreciate the ways in which movement may be abstracted and re-presented. Materializing movement may then benefit interaction designers in designing for and building upon the nature of movement data.

We presented a *Movement Schema* that identifies movement qualities according to *Velocity, Position and Repetition* and *Frequency*. This schema addresses the dynamics of movement, rather than more static readings such as of posture and location. We then presented an open source, digital application *Sync*, which is publicly available, that allows designers to generate dynamic visuals from movement data with comparison to actual movement. Access to such tools opens up spaces for design in the shaping of movement-based interactions, and enables these spaces to become semiotic and communication design resources. The tool *Sync* enables designers to explore ways in which movement may become a design material. It does this by allowing a variety of choices regarding the parameters of how the movement data is visualized. It reveals aspects of both the corporeal and computational qualities in the data. By materializing movement in this way designers may creatively engage in shaping the complex communication potential of digital interactions and our expressive, relational, lived bodies.

## Endnotes

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1 Further, McNeill classified gesture in relation to language into four groups: iconic, metaphoric and deictic and beat-like gestures (1992). Cadoz and Wanderley categorizes gesture in regards to their perceived function: semiotic (communicating meaningful information), ergotic (manipulating the physical world and creating artefacts), and epistemic (learning from the environment through tactile or haptic exploration) (2000).

2 Sheets-Johnstone describes this form as “by the very nature of its spatio-temporal-energetic dynamic bodily movement is a formal happening [...] Form is the result of the qualities of movement and of the way in which they modulate and play out dynamically” (1999: 268).

3 Similarly, just as “choreography and dancing are two distinct and very different practises” (Forsythe 2008: 5) we can say that designing interaction and experiencing an interaction are two distinct and very different practices: “expression is what makes experience possible, which is why concepts and theories of experience can never provide a logical foundation for design aesthetics” (Hallnäs 2011: 75).

4 Related to interaction design Labanotation has been applied in HCI from Badler & Smoliar (1979) to Loke et al (2007), Loke & Robertson (2010), as well as studies of dance and anthology (Farnell 1995) and Williams (2004).

5 However, Williams critiques Birdwhistle’s notation in a description of hitch-hiking: “When we are told by Birdwhistell that a ‘macro-kinesic’

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explanation of this state of affairs is something like this: ‘two members of the species homo sapiens, standing with an intra-femoral index of approximately 45 degrees, right humeral appendages raised to an 80 degree angle to their torsos, in an antero-posterior sweep, using a double pivot at the scapular clavicular joint, accomplish a communicative signal’ we are justified in saying ‘no.’ That is not what we see. We see persons thumbing a ride” (2004, p. 184).

6 Similarly, Labanotation is considered to be the most comprehensive of notation systems, but it is also necessarily complex so whilst it is precise, designers would be mostly unable to identify potential in seeing what could be changed and altered and the effect this would have on the rest of the body.

7 This differs from analysing movement through photography (such as Muybridge and Marey) or through video in the studies from Hall (1966) and Birdwhistle (1971) to Kendon (2004) and Streek et al. (2011).

8 Related work drawing on Labanotation is Eyesweb, a software for video analysis of movement aiming to recognise the expressive qualities of movement (Camurri et al., 2007; Camurri et al., 2004).

9 “These days I think very few people remember or recall that software is made by people, and that software is something that they could make themselves. [...] I think it is essential for artists to have a seat at the table in determining the future trajectories of technologies” (Levin, n.d.).

10 See <http://motionbank.org/en/piecemaker-2/>, <http://tkb.fsh.unl.pt/ctkb-introduction>, <http://openendedgroup.com/field/> and <http://badco.hr/works/whatever-toolbox/>

11 See <http://troikatronix.com/>

12 See [http://ftm.ircam.fr/index.php/Gesture\\_Follower](http://ftm.ircam.fr/index.php/Gesture_Follower) and [http://www.infomus.org/eyesweb\\_ita.php](http://www.infomus.org/eyesweb_ita.php).

13 This work is based on the work by linguist Halliday’s systemic-functional approach (2004).

14 *openFrameworks* is a cross platform open source toolkit for creative coding in C++ ( see [www.openframeworks.cc](http://www.openframeworks.cc)). This choice gave us access to the libraries of C++ as well as a speed of computation which a visual approach would need in processing the complexities of tracking physical movement. The open source software also aligns itself with an important goal of this research project of maintaining relevance to practice (we were able to draw upon cutting edge developments) and dissemination (we also publish the application: <http://kinetically.wordpress.com/sync-download/>).

15 The sensor constitutes a simple portable set-up with the small-sized sensor connected to a laptop. This set-up is easily portable thus highly adaptable for observing and working with movement not just in a controlled lab setting, but a variety of settings or contexts, however transient, from street corners, to bus stops and café entrances.

16 The lines of code used in Sync and the actual movement data remain “out of view” and is accessed through the GUI. However, the code that comprises Sync is published, see <https://github.com/HellicarAndLewis/Sync>.

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## ARTICLE 3

Hansen, Lise Amy. (2013). Making do & Making new: performative moves into interaction design. *International Journal of Performance Arts and Digital Media*, 9 (1): 135-151.

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# Making do and making new: Performative moves into interaction design

## ABSTRACT

*It is now possible to creatively explore movement data and this article queries how we may engage with movement data in order to explore the inherent dynamics in computational data when sourced from the expressive body. It discusses how design-intermediary digital tools may reveal the potentials and particularities of movement data. It proposes Malleability, Visuality and Ambiguity as central to the design of digital tools as these may be put to work to tease out the performative potential of movement data.*

## KEYWORDS

movement-based  
interaction  
movement data  
design material  
design process  
visualization  
communication  
performativity

## INTRODUCTION

We communicate and interact with each other with sophistication, seamlessly changing our movements according to the setting, be it a cafe, shop or office. Through our movements we provide a rich performative, communicative visual expression onstage and in other unscripted scenarios. Movement is unique in the sense that we have a particular insight into other people's bodies through the projection of our own (Wachsmuth et al. 2008) as well as having training from birth in navigating the complex situations that inter-personal communication create (Stern 1998). When we abstract movement, we need only six dots in an animation to visually identify 'posture, gait and other activities'

1. Frédéric Bevilacqua points out that we observe movement qualities 'with the human eye, but methods to extract such information from the digital data stream are still in their infancy' (2007: 27).
2. See [www.eyesweb.org/](http://www.eyesweb.org/) and [http://ftm.ircam.fr/index.php/Gesture\\_Follower](http://ftm.ircam.fr/index.php/Gesture_Follower).
3. Digital depth cameras (such as the Kinect) have existed for a while in a variety of forms. However, 'when they become cheap and distributed throughout the culture [...] people have a new way of expressing themselves' (Levin 2012).

(Bruce 2003: 378). However, when movement is 'read' by technology or 'seen' through computer vision little use is made of our own intricate system for making sense of full-body movement.<sup>1</sup> The title 'Making do and making new' refers to research that creatively explores designing tools for the study and understanding of movement data, with the view that digital abstraction may give new possibilities.

Today, full-body movement is increasingly available as data. Sensors, such as the Kinect, are readily accessible in addition to open source video-analysis softwares such as EyesWeb and Gesture Follower.<sup>2</sup> This means that we now have access to movement data as a compositional material, as a material with its own properties and particularities (Hansen 2011).<sup>3</sup>

In order to explore the nature of such a material we need to investigate the digital embodiment embedded in data drawn from our movements whilst recognizing the structures and rhetorics of the computational. To be able to create and design with such a complex material, there is an initial design stage where the data is ordered and itself abstracted; it is visualized and becomes a computational composite (Vallgård and Redström 2007). This early treatment of data can be seen as the beginnings of designing a digital tool that in turn enables an exploration of the potential of movement data. The tool is a script, lines of code, that call upon the original data and in so doing organizes the data and presents patterns and relations, structures and dynamics that are otherwise near invisible to us. In this way digital tools may unfold and communicate the nature of movement data and reveal the potential for novel digital interactions. The tools do this by transitional and explorative representations of the data as visualizations; simply put, they are sketches. Most designers and artists use visuals as part of their creative process; architects draw, writers make notes, choreographers film and tailors tack. They use preparatory and intermediary tools that are not necessarily part of the final outcome such as pen and paper, photo camera, video camera, etc. The tools themselves may convey information about the making materials, the unique properties (scale, flexibility, texture, etc.) and possibilities (size of a handle could show the amount of force needed to bend, etc.). Approaching digital tools in this way frames tool-making as part of an explorative and artistic design process, here specifically in the field of movement-based interaction and performance.

## ON MOVEMENT DATA

Digital tools have been designed to explore and visualize large databases, such as global flight traffic (see Figure 1) and many others. On a different scale, but no less complex, full-body movement data can be analysed as a database in itself. Similarly to how visualizing flight patterns reveal the nature of air traffic, we can now write scripts and design tools that explore the particularities and potential of movement as data.

Movement-based digital interaction is often a collaborative endeavour as it draws on the computational fields (such as programming or maths, engineering, etc.) and the corporeal fields (such as choreography or physiotherapy, sports, etc.). These fields come out of different practices that build and transmit knowledge in different ways. This emphasizes the need for tools that enable creative collaboration informed by knowledge of the making material i.e. the movement data.

The design of computational tools for movement-based interactivity also has a role in contributing to the interactive performance field, be it for the



Figure 1: Images show different levels of data, from a single flight to a list of flights (image by Ian Mitchinson) to Kobling's *Flight Patterns* that use flight traffic data to visualize patterns and densities (2009). Image by kind permission Aaron Koblin.

stage or our everyday lives. Each new interaction or installation, artwork or performance all add to the conventions and readings of movement in interaction. In addition, research projects in the performance field are increasingly developing computational tools as part of the research.<sup>4</sup> These tools, original and customized, are frequently shared through open source and digital communities of practice. In this way one can see that despite computational requirement of categorization and logic, these tools may facilitate the processes of artists, designers and performers by visualizing and communicating movement data in novel ways. This allows designers and artists to be informed beyond that of felt experience of existing work or technology and to be able to conceptually position and explore the future potential of movement data in interaction.

Discussing how these tools are designed is important as Thomas Haigh argues. He writes that 'software tools encapsulate craft knowledge, working practices, and cultural assumptions. [...] these encapsulated qualities are reproduced with each new software revision, often enduring for decades' (Haigh 2009: 7). Exploring movement as data then becomes a question of 'how to find out how to find out?'. Below, the novel possibilities brought by computation in dynamic mapping, embodied information and movement data dynamics are discussed.

## DYNAMIC MAPPINGS

Technology now facilitates interaction beyond the click of a mouse or the touch of a screen, through marker-less sensors that let us include information drawn from movement and gestures, in space and over time. In this way we may design movement-based interaction with and for the expressive body in new ways. Maxine Sheets-Johnstone writes that

by the very nature of its spatio-temporal-energetic dynamic bodily movement is a formal happening. Even a sneeze has a certain formal dynamic in which certain suddenesses and suspensions of movement are felt aspects of the experience. Form is the result of the qualities of movement and of the way in which they modulate and play out dynamically.

(1999: 268)

4. See for instance 'Synchronous Objects', <http://synchronousobjects.osu.edu/>, A Transmedia Knowledge Base (TKB) for contemporary dance, <http://www.clunl.edu.pt/PT/projecto.asp?id=1555&mid=and> and Siobhan Davies' Rotosketch, <http://www.siobhandaviesreplay.com/record.php?id=2615> and McGregor's Choreographic Language Agent, <http://openendedgroup.com/index.php/in-progress/choreographic-language-agent/>.

5. Choreographer Steve Paxton argues

you can improvise within forms, games are that kind of thing. The word improvisation has the freedom [...] but as a practice it very quickly takes on characteristics and then loses that freedom that we keep saying exists. I'm not sure there is that kind of freedom for us. In language we can get there, in language we can say these things. Whether we can behaviourally play that game, I'm not sure.

(2007)

It is this 'form' that we work with; this is a form that is possible to register and read by computer vision.

By drawing upon these forms digital interaction may also reflect the complex interactive structures that we build in our every day life, such as within a conversation; we adjust and correct our messages from the perceived feedback, we quickly build references and conventions that help us communicate, we imitate each other, we pretend, we exaggerate and we perform. We do this adhering to conventions and forms that we may identify.<sup>5</sup>

These visible communications are in some ways invisible to us, as Peggy Phelan points out:

to apprehend and recognise the visible is to eliminate as well as absorb visual data. Just as surely as representational technologies – the camera, the canvas, the theatrical frame, language itself – order visual apprehension to accord with a (constructed) notion of the real so too do the human eyes.

(1993: 13)

Uncovering movement qualities invisible to the human eye is not new. It can be seen in movement studies from Jules-Etienne Marey's photographic gun in the 1880s that took twelve consecutive frames per second captured on one negative, to the Gilberts' cyclegraphs where long camera exposures captured workers' movements by way of lights attached to the workers' hands in the 1910s.

However, compared to capturing unseen properties of movement on film or celluloid, computation now gives us a unique flexibility in having a script call upon the movement data and in each new call generate unique representations or visuals. In this way, when we map movement data it is not to fix nor resolve meaning, but to reveal the multiple potentialities of movement, and in this way such notational computational data can become 'a medium in a process of emergence' (Bleeker 2010: 3). This shift in approach enables representation to go from 'replacing reality to shaping reality' (Boehner 2009: 31).

One example of this is the recent RGBDToolkit (see Figure 2). It uses a digital video camera for colour data and the Kinect's infrared sensor for depth data. It then renders a three dimensional video, that allows us to dynamically shift and scale a virtual point-of-view, compared to that of our eye or that of a camera lens. In this way the tool animates the data. It shows us that 'systems need to be designed to be experienced, and not necessarily designed to be experienced as "the world" is experienced' (Matthews 2006: 408). In other words, digital visuals may be configured in novel ways. As Mark B. N. Hansen writes, 'the new technical environments afford nothing less than an

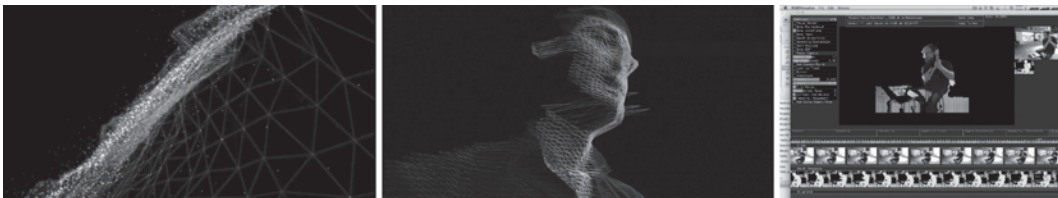


Figure 2: The RGBDToolkit uses a Kinect camera and a SLRD set-up to render 3D visualization, images from <http://www.rgbdtoolkit.com/>.

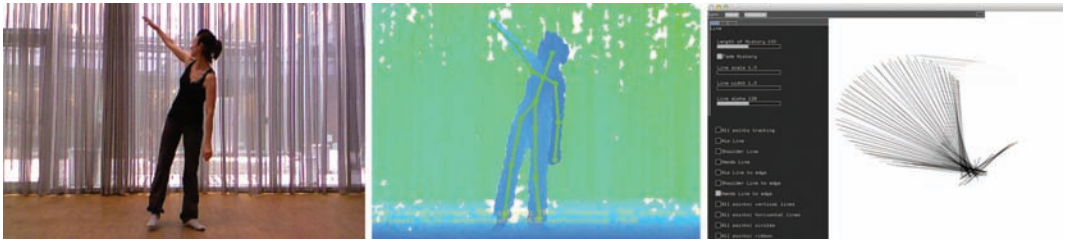


Figure 3: The graphic user interface of the Sync application, showing a moving body re-presented as the movement data is visualized.

opportunity to suspend habitual causal patterns and, subsequently, to forge new patterns through the medium of embodiment – that is, by tapping into the flexibility (or potentiality) that characterizes humans as fundamentally embodied creatures’ (2006: 29).

### PERFORMING INFORMATION

However, alongside developments of technology, we need to explore the complex relationships and dynamics already inherent in the data. As the artist Paul Kaiser puts it regarding animation, ‘lost in such special effects is not only the subtlety of movement but also the crucial identification and alignment of viewer and dancer’ (2003: 86). On a similar note N. K. Hayles points to how we as a society have dissociated information from the body (1999). Camille Utterback further points to the current elevation of abstraction over embodiment and how this ‘is mirrored by a corresponding lack of computer interfaces that meaningfully engages our body with the information and codes represented in our machines’ (2004: 218). In contrast, Anna Munster, critiques Hayles in her investigation of digital embodiment and points to how ‘the spaces and times of digital life are themselves particular’ (2006: 62). These discussions on digital embodiment emphasize the particularity of data derived from body movement. By tracing and translating the moving body into data, we are removing the body and our lived time and space from movement data. Yet bodily qualities reside in the dynamics in the data itself, though in a different, digital time and space, as Munster points out. In addition, if we use Kaiser’s ‘identification and alignment’ to again interpret such data, the data can become a source for expressive, meaningful communication.

How are we to explore the nature of a ‘digital life’ in such abstracted movement data? Gretchen Schiller proposes that ‘if we accept this entanglement between human-created techniques and movement as a dynamic structural and relational event, then we replace discussions of the body and space or body and machine with the fluid surprises of relational dynamics’ (2006: 109). In order to creatively work with this ‘relational dynamics’, we need to untangle the constituent parts, the elements that make us understand the dynamics. In this case, how we may read and make meaning with movement data. This matters as we can then make informed choices concerning our digital embodiment. Here intermediary digital tools play a part as they visualize movement data and in that way enable us to investigate digital embodiment informed by the movement data themselves. Moreover, it enables discussions also on what this entails for interaction, informing performance in and with digital systems.

6. The interaction designers Hellicar and Lewis, [www.hellicarandlewis.com](http://www.hellicarandlewis.com).
7. Computational tools such as the ones discussed here, are temporary building blocks in an explorative process. Potentially they may become more permanent tools such as openFrameworks (www.openframeworks.cc), initially developed as a teaching tool by Zachary Lieberman for teaching fine art students the potential of C++ in artistic practice at Parsons School of Art.

## Sync

As part of researching movement as a design material, the tool *Sync* was designed to visualize and give access to the 'relational dynamic' that Schiller describes. *Sync* was developed as a digital application with the author/designer and interaction designers Joel Gethin Lewis and Peter Hellicar.<sup>6</sup> It was designed in openFramework<sup>7</sup> drawing upon the Kinect sensor. *Sync* visualizes movement data with a graphic user interface that enables the data to be visualized depending on what one might be looking for e.g. it can be tuned to pick up small movement or it can trace a long movement phrase and so on. The application allows for movement data, the x-y-x points, to be visualized according to several parameters such as the mark (circle, vertical line, horizontal line or banner) and as well as setting the marks' density, history, etc. (see Figure 4). The focus was not on finding specific bodily representations nor positions, rather it focuses on visualizing dynamics, e.g. *how* parts of the body moves. The x-y-x values represent body parts or joints (here fifteen points that make up a 'skeleton') and each mark changes according to a change in location and speed, the circle and banner widens, the lines are lengthened (see Figure 5). It also gives the option to links shoulders, hips and hands (shown later in Figure 7). A simultaneous video feed enable comparison to the actual movement. It also has a recording function that allows for repeated viewings with alternative visualizations.

*Sync* is a tool that communicates what data we have, that is, it lets us see what movements may be registered. It is designed as an application that can run on multiple platforms and is able to draw on a variety of data and it is

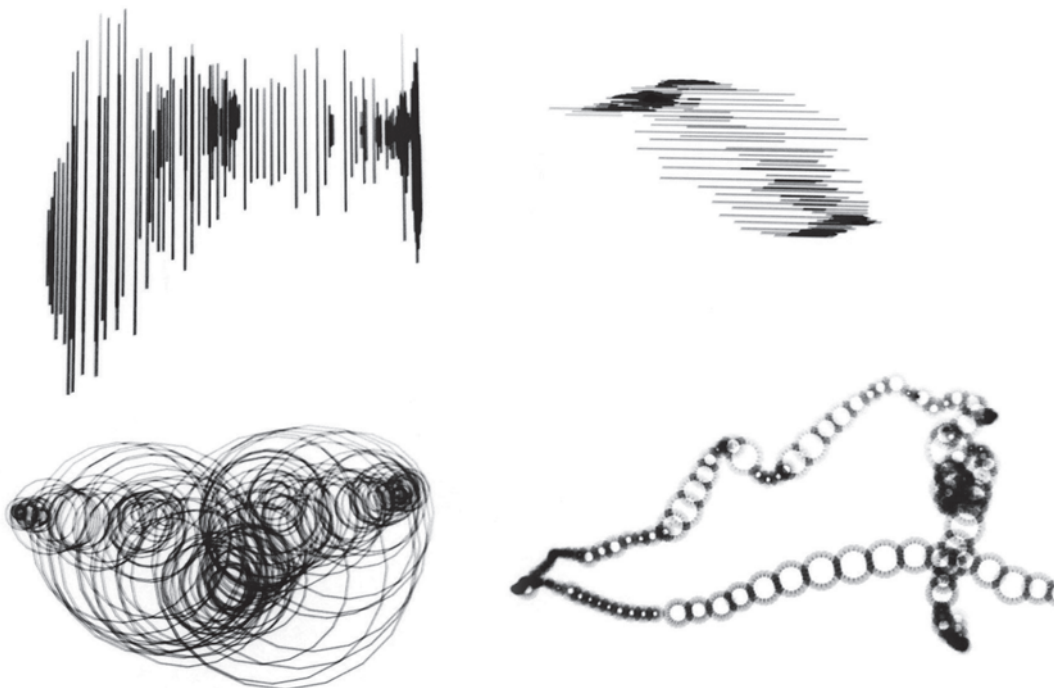


Figure 4: The *Sync* application gives the option of four marks for each point: circle, vertical line, horizontal line and banner as shown here.





Figure 5: Each mark foregrounds different qualities, such as location of the most or least movement or the trajectory of the movement. Images from the *Sync* application.

freely published.<sup>8</sup> *Sync* also allows designers and artists to work with movement data and build interactions informed by the possible data readings, revealing the nature of the data. The visual representation of the data enable us to identify interesting movement or relevant movement i.e. it allows us to visualize a dynamic that otherwise would be buried in numbers in the lines of data that the change in each x-y-z point generates. This may be accessible for a computer programmer reading the lines of numbers, but would be hard to perceive for anyone else. In addition, the visuals may simply be used as they are, amplifying or abstracting movement qualities in real time for example with a performer onstage. However, the main goal of *Sync* is to enable artistic investigations of movement data and digital interaction. The tool is designed to prompt, inspire and motivate interaction designers and others to creatively engage with movement data, and by extension, movement, as material (Hansen in press).

8. See kinetically.  
wordpress.com.

## TOOLING UP

This design of *Sync* was a part of a research project in which much attention was on the options and decisions taken during the design process. As this was an interdisciplinary collaboration between designers and creative programmers many concerns and questions were expressed. The aim was to arrive at several key concepts to enable further analysis of interaction design as meaning-making. The concerns and questions were developed into three concepts *Malleability*, *Visuality* and *Ambiguity* (see Figure 6). These were arrived at through the practical design work and related research in Human-Computer Interaction, Design and New Media studies as well as Performance studies.

The process of developing the concepts was informed by social semiotics, as it offers an approach to the process of meaning-making. B. Hodge and G. Kress write that 'we see communication essentially as a process, not as a

9. However, social semiotics is rarely applied to movement, with the notable exception of Radan Martinec (2000).

disembodied set of meanings in texts. Meaning is produced and reproduced under specific social conditions, through specific material forms and agencies' (1988: viii). Materials are seen as a resource and include 'the actions or artefacts we use to communicate' (van Leeuwen 2005: 3). Social semiotics sees resources as created over time and in use,<sup>9</sup> dependent on the social context (Kress and van Leeuwen 2001). T. van Leeuwen points to how we may identify and describe the characteristics of a resource and thereby also describe possibilities of how the resources could be used, i.e. it may inform design. This is because the focus is not on finding a fixed or definite meaning, rather on the meaning potential that can be 'narrowed down and coloured in the given context' (van Leeuwen 1999: 10). This communicatively oriented approach is useful in that it has moved from 'language' to encompass other modes.

As Sheets-Johnstone points out 'linguaging the dynamic of movement is a challenging task [...] The challenge derives in part from an object-tethered English language that easily misses or falls short of the temporal, spatial, and energetic qualitative dynamics of movement' (1999: 268). The goal in designing and conceptualizing with *Sync* has not been to find a definite 'language' of movement as it is translated into data, but rather to enable ways for movement data to become a creative resource in the design of movement-based interaction that draws on the performative potential of movement. By finding what is unique or particular to movement data, we may also go back to movement itself, informed by the digital possibilities of abstracted movement. In this way, we may see that the semiotics and the somatic perspective are not mutually exclusive, rather complementary standpoints (Csordas 2002: 243).

The concepts are identified and positioned in a model outlining the design of digital tools (see Figure 6). This model was developed on the basis of a trans-disciplinary design process and engagement with digital materials. The

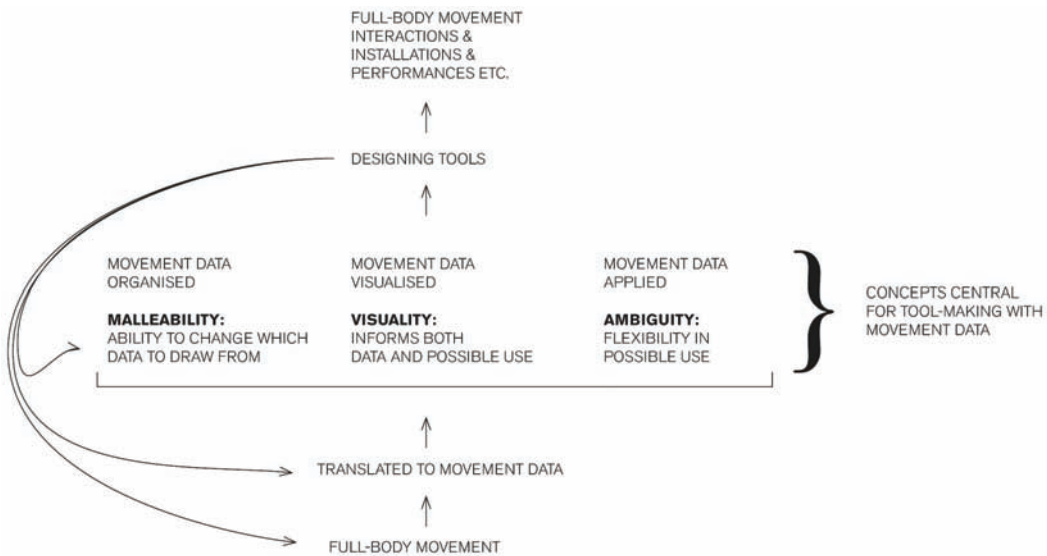


Figure 6: Model of the design of computational tools for movement-based digital interaction. The three key concepts are included: Malleability, Visuality and Ambiguity. Knowledge from this process further informs movement itself (as the round arrows show), knowledge of the nature of movement data as well as the design process, since with new material knowledge comes new making processes.

model starts with movement, which is then abstracted into movement data. Such data are then evaluated with regards to selection, visualization and application informed by the concepts of Malleability, Visuality and Ambiguity as they reflect the development of the design process. These concepts were formed during the design process of *Sync*, through discussions on and with the material (Schön 1991) and with reference to meta-categories employed by social semiotics such as ‘modality’ and ‘sound time’ (van Leeuwen 1999) or ‘componential relation’ (Martinec 1998).

Malleability refers to a flexibility in the decision of what movement data is of interest or is useable. Visuality addresses the communication of potential of the movement data in a collaborative, explorative process. Ambiguity refers to the openness of application or appropriation, or possible function of the movement data, thus allowing for the creative process to adapt according to the available data or the nature of the data. In the next section, these three core concepts are described in more detail along with how they relate to the exploration of movement data and the design of digital tools for movement data.

## **MALLEABILITY**

As we move through the world we do not take in the majority of information available to us. In writing about visuality in regards to the theatre, Maaïke Bleeker argues that ‘we always see less than is there’ and further points to the fact that we also see *more* than what is there (2008: 18). With computer vision the same can be said to be true; it will be set to register only a certain selection of available information, which we then read more into than what is ‘there’.

Making a tool malleable helps to keep it flexible so as to be able to perceive and decide which data might be of interest, as this may change. For movement the first consideration is one regarding the availability of data. How easy is the movement data to get hold of and in what form is it generated? Is it formatted in a particular way? Of the many possible readings of movement, what is prioritized and may that change according to context or over time? By designing a malleable tool, it remains flexible as to what data is registered.

## **HONING IN ON MOVEMENT DATA**

Another consideration is the content of each data set, in the sense that it relates to other data sets, such as a point tracking an elbow will also be referring to the position of a shoulder, etc. Here a malleable tool is useful to inform a decision that balances precision with expression. For instance, the decision whether one needs to track individual fingers or if a hand is enough to capture a certain expression. By being able to evaluate the data according to scale, sequence and scope – in other words the granulation of data – one can tease out the right level of precision of data to go with that of a desired expression or communication.

By gauging the granulation of the data and through changing the data set that the tool draws upon, the tool can also inform future decisions of what data is relevant. Scale and scope also give insights into future application, in the sense that a vast, detailed dataset will entail a certain server or running capacity in a future application and so on.

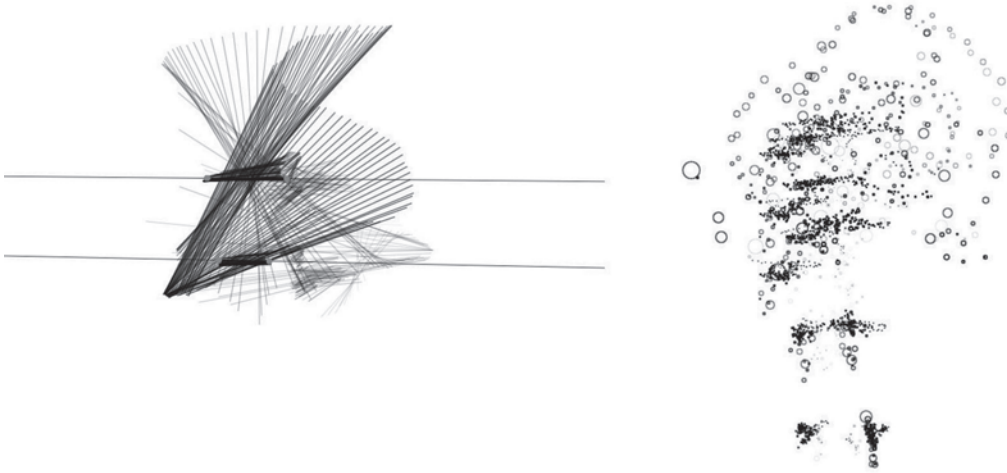


Figure 7: Two visuals from Sync, drawing on the same data capturing a waving phrase. As these examples show, Sync enables a visual identification of the data i.e. one can visually decide that the data that maps the velocity of the right hand is the most dynamic in this movement phrase. Images from the Sync application.

## FROM MAPPING TO CONCEPTUALIZATION

In exploring the nature of movement data, rather than trying to find a fit to a specific function, it is important to be able to draw on different data or be able to shift what and how we map, as the creative process develops. The visuals are different from models or prototypes in that their aim is to formulate potential, rather than to test a specific use or function. A material exploration of movement data differs from extrapolating data with a specific function or product or problem in mind. Rather, exploring how visuals may suit or reveal the data or the various visualizing scripts that could be generated by the data, tells us about the nature of the data, its particular qualities and potentials. This can help us tease out what is significant and how it may be represented. These data visualizations can inform future functions or future datasets or become part of the final work itself. In other words, by uncovering what is feasible to track, such digital tools enable a process of conceptualization of the meaning of movement.

## VISUALITY

Movement data are invisible as the code itself (outside of a programmer's screen) is invisible (Löwgren and Stolterman 2004). Despite our bodies being ever present and highly visible, our own movements are ephemeral, and in a material sense, invisible. By creating digital tools that visualize movement data, we enable an artistic connection to the material and allow for ideas to surface and to be worked with. These are then ideas that come from the uniqueness of the material itself. This is important, as these ideas may not otherwise come about. We think in order to make, but we also make in order to think (Suri 2011). A visualizing digital tool allows for alternating between these states of thinking and doing. In order to unfold the potential we need to identify the material properties and particularities. Each time data is selected, it may be called upon in different ways and thereby visualized in a different

way. How one does that communicates in itself and the selections and omissions alike may pinpoint new relationships (Eppler and Stoyko 2009).

## CREATING ENGAGEMENT

The creative developer Bret Victor argues that you need to connect visually to material: 'You can't discover if you can't see what you're doing' (2012). Richard Sennett refers to such a connection as 'engaged material consciousness: we become particularly engaged in what we can change' (2008: 120). One way to create such engagement, is to design tools that allow us to visualize, alter, adjust, repeat and rehearse aspects of the materials. When you can touch materials such as clay or paint, the value of a material exploration is immediate. For movement data, digital visualizations become a way to explore material properties and particularities, such as velocity, repetition and so on.

## ENABLING COLLABORATION

In projects based on body and code, the exploration is rarely solitary rather relying on several people, with diverse backgrounds and competencies. The visualizing tools can then construct boundary objects, described by G. C. Bowker and S. L. Star as 'those objects that both inhabit several communities of practice and satisfy the information requirements of each of them' (1999: 297).<sup>10</sup> As such they enable everyone involved to contribute creatively, based on information of the actual data available. These temporary visualizations are important in a creative, shifting and growing process, particularly so for the design of digital interactions, where the visuals need to be temporal and procedural to encompass the unique attributes of interactivity such as 'transitions, dynamics, feel and phrasing' (Buxton 2007: 136). Temporary visuals give access to and 'encourage exploration of rich and non-obvious spaces of opportunity' (Gaver 2011: 1560). Tools that are flexible and adjustable allow participants to draw on a 'shared enthusiasm' in the creative process (deLahunta and Bevilacqua 2007). Harnessing excitement and curiosity enriches a creative process as it focuses on possibility and multiplicity.

Such flexibility also opens up for the possibility of comparing or adding relevant or related data. For example, movement data coupled with GPS coordinates might yield new insights into movement variation; movement data coupled with time codes might give insights into frequencies and repetitions and so on. Also by generating visual representations of the movement data, one enables an understanding that do not necessarily rely only on words. It allows us to collaboratively gauge what may be meaningful, as Ben Matthews addresses regarding movement-based interaction; we can say anything we want, 'but we cannot mean anything we like' (2006: 408).

## AMBIGUITY

When the movement data has been selected and visualized, we can start to evaluate its potential. Here it is important to be aware of new possibilities for the data, to see what kind of communication, expressions or functions may be designed with, around or for them. Ambiguous tools foster creativity, as 'ambiguity gives designers the ability to suggest issues and perspectives for consideration without imposing solutions' (Gaver et al. 2003: 240). They also enable engagement that not only focuses on 'making it work' or details or correctness. Despite using high-tech equipment to capture movement, by

10. An example is Wayne McGregor's sketchbook in the Choreography and Cognition project, named a 'transactable', allowing cognitive scientist an understanding of the choreographic process (deLahunta et al. 2004).

11. Harold G. Nelson and Erik Stolterman contrast design with science and art, as science has a focus on process with a given outcome; it is the truth (though sometimes the truth of the process is the outcome). Art has a focus on outcome, the artwork, whichever way you get there (though sometimes the process is the artwork). Design, they argue, needs to focus on both process and outcome (2003).

framing the visualized data or explorations as sketching, we can allow the visuals or the ideas to be rough and incomplete so we can try out ideas quickly and creatively, and identify patterns or new relations that were previously unimaginable or invisible. Tools also invite virtuosity or expert handling of materials, as well as facilitating expression and simply making.

## TEASING OUT THE POTENTIAL

The irregular or the unexpected become an opportunity: 'It's not a bug, it's a feature (Lewis personal communication)'. As expectations are challenged by the data not 'behaving' the way we expected it to, new uses or expressions are found beyond what we expected to find. Sheets-Johnstone proposes that we need to first 'make the familiar strange' to think anew when we draw on the dynamic body (2009: 379). By reframing the data we may discover new potential as indeed the limitations of technology may inform new kinds of communication (Hollan and Stornetta 1992). Here there is a balance between what already exists on the one hand and exploring what is possible to make on the other.<sup>11</sup> 'Creativity depends partly on recognising what is considered impossible because of real laws of nature and what is thought impossible because of an arbitrary system or assumption. Here again, is the importance of, not just knowing, but knowing about what we know' (Evans 1998: 206).

Creating digital tools that are deliberately ambiguous, allows us to explore the potential of future uses or applications. A designer of movement-based interaction balances across the approaches of the computational and the corporeal, and needs to be familiar with the potential and particularities of both. This kind of composition may be referred to as 'finding a fit between artistic and communicative expression and the functionalities and stability of information system design' (Morrison et al. 2010: 186).

Allowing for tools to remain ambiguous enables a process of evaluation and innovation. Through selecting and visualizing movement data, these tools give an understanding of what is available, how it is available and how it may be visualized. From this, some central descriptions and concepts may have crystallized. Knowledge of the nature of that data, such as how the data compound and scale for instance, may be foregrounded by the tools. This may also bring up associations and relations to related data, related functions, related expressions that further position and inform the potential of the data. By using the data to build visuals, non-programmers or non-developers gain access to the creative possibilities of the data (Armitage 2009). Such tools enable an exploration of designing through performance (Bayliss et al. 2007) as well as research through the performative (Haseman 2006). We may, therefore, begin to build for digitally extended performativity of bodies and of systems around bodies, informed not by speculation, but by the data itself.

## CONVENTIONS AND IMPROVISATIONS

In this article performative moves in interaction design have been discussed through artistic investigations of the expressive on the one hand and through software and hardware developments increasing technological precision and capacities on the other. However, it is the balance between the functional and the expressive, the computational and the corporeal that together uniquely inform the potential and future use of movement data. It provides a complex challenge in that within movement data sit conventions of movement patterns

and expressivity that are corporeal, complex, dynamic and interactional. In performance these conventions and structures have been taken apart and examined most notably in the Judson theatre work (Banes 1993, 2001). In contrast, computation is a relatively new medium with few conventions and quickly taken down to ones and zeros (Murray 2011). With movement data, then, we have few conventions and high expectations.

As we are creating new expressions and functions, exploring new interactions, it is important to uncover the processes behind these descriptions to inform future designs. In this respect social semiotics provides a useful approach for naming and identifying resources in a design process. This is important as G. A. Blaauw and F. P. Brooks point to in their study of computer architecture, 'when reading the professional paper describing the architecture of a new machine, it is often difficult to discern the real design dilemmas, compromises, and struggles behind the smooth, after-the-fact description' (1997: vii).

Susan Leigh Foster writes about the difficulty of translating physical endeavours in navigating the embodied and rhetoric, the event and representation. She argues that the conventions through which meaning is conveyed needs to be accessible and how 'as long as every body works to renew and recalibrate these codes, power remains in many hands. Otherwise the conventions will take us 'unawares' and gain the upper hand' (Foster 1995: 19). In this view it is important to be able to further discuss the process of designing with movement data.

## REFLECTIONS

By discussing these concepts central to designing digital tools, as well as presenting a model of such processes, we enable an evaluation of the direction of the field. With tools such as those described here as well as making specific installations, performances and interactive work, we are able to expand the field of movement-based practices and add to the conventions of the field. 'Through digital abstraction, we can get a better understanding what people are doing in spaces, and this will make a massive differences for how we can make new kinds of interactions and new kinds of artwork and new improvements to life through design' (Levin 2012).

Tools such as *Sync* enable an artistic, visual exploration of data in the entanglement that is movement and code and communication.<sup>12</sup> Their visuals serve as boundary objects in the development of performativity in interaction design. They enable material to be explored on its own terms as it builds on actual data, rather than approximations or speculation. By exploring movement data, we explore the expressive, communicative, visual qualities of movement and we can enrich and extend interaction design.<sup>13</sup> Interaction design can both find new ways to draw on the performative body as well as inform new ways to facilitate the performative (of bodies as well as systems) in interaction design. 'As we create new interfaces between our bodies and our symbolic systems we are in an unusual position to rethink and re-embody this relationship' (Utterback 2004: 226).

## 'DOING NEW'

By framing movement data as an instrumental design material in a creative process with the aim to enrich movement-based interactions, we open up for novel use of these: code and movement. The concepts Malleability, Visuality

12. Such as the aforementioned EyesWeb [www.eyesweb.org/](http://www.eyesweb.org/), Gesture Follower [http://ftm.ircam.fr/index.php/Gesture\\_Follower](http://ftm.ircam.fr/index.php/Gesture_Follower) and RGBDToolkit, <http://www.rgbdtoolkit.com/> as well as OpenendedGroup's Field, <http://openendedgroup.com/field/> and BADco's Whatever Dance Toolbox, <http://badco.hr/works/whatever-toolbox/>.
13. Digital tools are increasingly shared through online communities. Microsoft has released developers software for their Kinect, <http://www.microsoft.com/en-us/kinectforwindows/develop/>, Apple welcome new apps, <https://developer.apple.com/programs/ios/> and recently Leap Motion invited developers to explore future applications of their new sensing technology, <http://leapmotion.com/>. These developments indicate possibilities of novel explorations with technology for movement-based interaction.

and Ambiguity have been discussed as central in designing digital tools that explore movement data for interaction, and together with the model for designing explorative computational tools they add to a social semiotic reach and vocabulary.

When we explore movement data we are simultaneously finding out how new visuals or representations may be generated (such as with the flight traffic patterns or RGBDToolkit) as well as uncovering the nature of the data (such as with *Sync*). With the body we are familiar with such patterns, qualities and conventions; we know the difference between a friendly wave and a warning wave. How does this appear in the new visuals that movement data may generate and how may we use that knowledge to build code and communication around that again? What processes or functions in the code have potential with the respective ones we know, see, feel and use with our bodies?

Carrie Noland writes that ‘testing our powers of articulation against the limits of articulation is the way we contribute to history, not just the history of our singular bodies as expressive and operational but also the history of what is given to humans to make into marks’ (2009: 215). The questions above provide a rich area of exploration and digital tools are instrumental in investigating movement data to this end. They enable us to see what we have to work with as we need to understand the nature of our materials in order to inform the ‘make do’. To innovate and ‘make new’, however, we need to further explore the potential of our digital movement material to find its particularities and possibilities. In this sense, digital tools give us access to movement data and the possibility to create increasingly complex and sophisticated interactions.

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