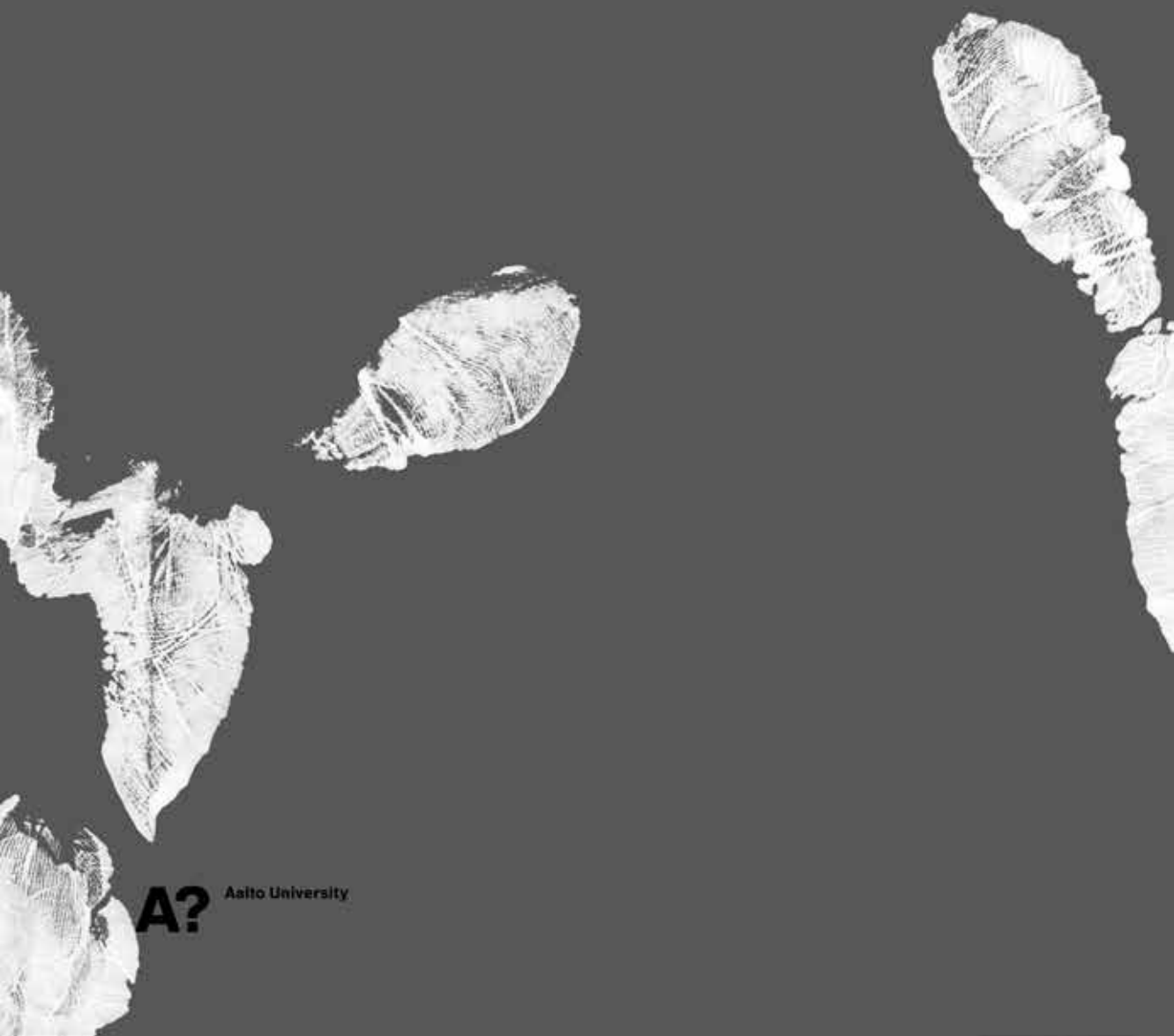


Making Sense Through Hands

Design and Craft Practice
Analysed as Embodied Cognition

Camilla Groth



Making Sense Through Hands

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Camilla Groth

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Abstract

Design and craft practitioners' thinking has been researched in design cognition studies; however, lately research on the embodied mind has also begun to influence the field of design and craft. While this theoretical frame situates knowing in actions and thus ties design practice to cognition, few empirical studies on embodied cognition have been made in relation to design and craft practices. This doctoral thesis opens up empirically-based aspects of what embodied cognition theory could mean for design and craft practice. The general research question is: How do design and craft practitioners think through their hands? Through three case studies, notions of body-based knowing, especially related to haptic experiences were studied. The first case involved ceramic workshops with deafblind makers, conducted at the IIRIS Service and Activity Centre for the visually impaired in Helsinki and the Tampere Resource Centre for the Deafblind. The second case involved a practice-led self-study on tactile augmentation in ceramic craft practice. The third case examined Masters' students' use of their embodied knowing during a design and material exploration process. A multimethod for studying experiential knowledge was developed during the research process. Since much of knowing is situated in action and in relation to previous experiences and material skills, embodied cognition theory was considered to lend itself well to informing research on design and craft practice. Because ideation and concepting also rely upon these embodied experiences, a conceptual separation between making and thinking in design is not feasible. The practice-led research setting was found to be an efficient way of studying experiential knowledge as it includes the practitioner's perspective, thus allowing for sensory experiences and emotions to be studied in action. The use of video documentation was found to be especially useful in both the effective study and dissemination of experiential data and research results due to its multimodal potential. Emotions were at the fore in all three cases, in different contexts and on several levels and especially in the different decision-making processes that the practitioner was confronted with. The research thus puts forward four theoretical and practical implications: 1) Embodied cognition theory lends itself well to informing design and craft related practice. 2) Design processes include embodied knowledge even in the cognitive and immaterial stage of creating mental images of the intended physical designs. 3) Making may be seen as a way of negotiating meaning through interaction between the embodied mind and the material environment, thus it may affect intrapersonal growth and provide a useful platform in educational settings. 4) Design and craft research benefit from a combination of research approaches that aid in investigating both representational and non-representational aspects of the practice.

Key words: Experiential knowledge, haptic experiences, embodied cognition, design and craft research, design and craft practice, ceramic practice.

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The research at hand is conducted as part of, and makes a contribution towards, the Handling Mind (2013-2016) project. Handling Mind is one of 12 projects that are part of the Human Mind research programme of the Academy of Finland, opened in 2012. The project is led by Pirita Seitamaa-Hakkarainen and Maarit Mäkelä, and is conducted by a multidisciplinary research consortium, consisting of Aalto University, the University of Helsinki, the University of Turku and the Finnish Institute of Occupational Health. During this project, research topics have become more closely linked through a better understanding across disciplines. Thank you for having the courage to engage in multidisciplinary research, making it enjoyable to collaborate across the sciences: Kai Hakkarainen, Minna Huotilainen, Tellervo Härkki, Kaiju Kangas, Tarja-Kaarina Laamanen, Marianne Leinikka, Mimmu Rankanen and Eija Syrjäläinen.

In connection to the first case study, I wish to thank social-haptic communication specialist Riitta Lahtinen from the deafblind association for taking time from her busy schedule to make sure that I understood the special world and culture of the dually-impaired, deafblind, participants of this research. Riitta also kindly helped me in finding participants for my research by arranging the workshops and the discussion seminar. Ceramists Saana Murti and Soile Paasonen, who are experienced in conducting ceramic workshops for deafblind people gave me good advice regarding how to approach the participants in the workshops. I would especially like to thank all the participants in this study, without whom this research would not have been possible: 16 deafblind participants from the IIRIS Centre and the Tampere Resource Centre for the Deafblind, especially the two participants of the Tampere workshop who patiently answered my nosy questions, and the 19 design students from Aalto University, especially the two participants in the interviews who kindly gave me the opportunity to look deeper into their material exploration and sense-making processes.

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meaningful discussions during Mikkel Tin's course Body-based practices. The peer-support relationship with textile designer Kirstine Riis and ceramist Astrid Heimer who both conducted a practice-led doctoral study simultaneously in Norway, provided a valuable long-distance anchor. Thank you also Professor Emerita Riitta Hari for reading and commenting on my manuscript from your point of view. During my studies, I have been a member of the Empirica research group, led by Maarit Mäkelä, in which one main strategy is to utilise practice, including craft and art, in methods for design research. A fundamental factor for this research to have taken the course it did is the general openness towards artistic research in design that this group facilitates. So thank you Anna, Hanna-Kaisa, JP, Krista, Priska, Pia, Svetlana, Sandra, Shi Di, Tuulia and Tjhien. Professor Emeritus Tapio Yli-Viikari has been a father figure for ceramics both in the ceramic department at Aalto Arts and in Finnish ceramic culture for as long as I can remember, thank you Tapio for all that you have done for the ceramic community during your career.

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Helsinki, January 2017
Camilla Groth

List of original publications

This thesis is based on the following original publications that are referred to in the text by their Roman numeral I-IV:

- I Groth, C., Mäkelä, M. & Seitamaa-Hakkarainen, P. (2012) Making Sense - what can we learn from experts of tactile knowledge? *FORMakademisk Journal*, 6, (2), 1-12
- II Groth, C., Mäkelä, M. & Seitamaa-Hakkarainen, P. (2015) Tactile Augmentation: A multimethod for capturing experiential knowledge. *Craft Research*, Intellect, UK 6, (1), 57-81
- III Groth, C. (2015) Emotions in risk-assessment and decision-making processes during craft practice. *Journal of Research Practice*, AU Press, Canada. 11, (2) article M5
- IV Groth, C. & Mäkelä, M. (2016) The knowing body in material exploration. *Studies in Material Thinking*, AUT University, Australia. 14, article 02

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Personal contribution

In the co-written publications I and II, my personal contribution has been the main research design, the data collection and analysis of data together with the writing of the main content of the articles. In Publication IV, already existing data were supplemented with additional interviews. In addition to writing the papers together, Maarit Mäkelä and Pirita Seitamaa-Hakkarainen have supported the process by supervision of the research.

Foreword

- Do you enjoy baking the ginger biscuits?

- Mum, my hands are making the biscuits and my eyes are just following what my hands are doing.

Conversation with Aino, 4 years old.

The act of making something with one's hands in a material is a way of participating in the world. It is a conversation, interaction and negotiation between the person and her environment. By manipulating material, we affect the world and are simultaneously affected. What we make either stays or vanishes, but the experience has changed us, maybe in little ways, maybe in great ways. Our hands are the ultimate contact point between our self and the world, the physical and material. Through our sense of touch, we feel the material and its properties, its potential and its agency.

When we have become familiar with a material, we have grown in understanding it and its possibilities in relation to our skills and our intentions. We may recall the tactual feel of a material even when not in contact with it, through our tactile memory and imagination. We have embodied the material and the way it behaves or the tools used to handle it.

For practitioners working with their hands, there might be a feeling of the hands taking over and doing the work as if by themselves. When my daughter described her feeling of her hands being the makers of the biscuits, I knew so well what she meant. However, I had no concepts for describing or understanding this phenomenon. That was the moment I decided to apply for doctoral studies. I wanted to discover what lay behind this notion of making sense through hands.

1 Introduction

1.1 Touch and the Body in Sense-Making

The act of *making* is at the core of art, design and craft practice. Making is, however, not limited to these practices but occurs in multiple forms, on many levels in different contexts. By transforming matter, we transform society and make an imprint of our culture and of ourselves. The act of making is powerful, as through making we also make meaning, communicate meaning and share meaning: the act of making has a corporeal cognitive dimension. In sense-making through handling, shaping and interacting with various materials, our hands form the connection between mind and material.

Touch is thus integral in many, if not all aspects of designing and making artefacts. We also evaluate many material features in products through the tactual experience we have of them (Gallace, 2012). The way something feels also affects emotion and, as such, we may even direct our designs towards particular emotional effects (Karana, Pedgley, & Rognoli, 2015a, 2015b; Rompay, & Ludden, 2013). Still, we tend to take information related to and gathered by our tactile sense for granted, forgetting the significance of active touch in the processes of learning, making, feeling and communicating.

In this research, the study of haptic and tactile experiences is used as a means for studying experiential knowledge in design and craft practice. I am asking how design and craft practitioners think or make sense through their hands. In the field of crafts, *thinking through making* (Mäkelä, 2007) and *thinking through material* (Nimkulrat, 2009, 2012) have already been acknowledged in research. Researcher and ceramic artist Maarit Mäkelä (2007) has contributed to the concept of thinking through making and argues for viewing artefacts as bearers of knowledge created in this process. Researcher and textile artist Nithikul Nimkulrat (2009) has in her doctoral research studied the expressiveness of paper string and her own thinking through material processes, developing the concept in her later research contribution (2012). There is now also a Journal (Studies in Material Thinking) dedicated to this research orientation, and publication IV in this thesis is contributing to this Journal.

I am thus not questioning whether there is also a notion of *thinking through hands* within the practice of design and craft. Rather, I seek to investigate *how* embodied knowing is enacted in the design and craft practices. While specifically investigating the interaction of mind and material through the hands and the tactile sense, it is still acknowledged

that design and craft activities are fundamentally multimodal and complex, that they equally include socially and materially mediated meanings and that sense-making is not an isolated activity but depends on many background factors.

Art, design and craft practices may be seen as a part of the making disciplines (Nilsson, 2013). Architects and design researchers Halina Dunin-Woyseth and Jan Michl (2001) apply the term *making* professions for the fields of “art production, object design, industrial design, architecture, landscape architecture, urban design and spatial planning” (p. 1). In the present research, no further separation is made between these disciplines: instead it is acknowledged that the art, design and craft practices fundamentally originate from the same sources.

When a designer or craftsperson manipulates material, more than merely the sense of touch on the skin of the hand comes into question. Active touch is described as haptics – and constitutes a part of the haptic system (Gibson, 1966/1983, p. 97). The psychologist James Gibson (1966/1983) describes the haptic system as follows: “The sensibility of the individual to the world adjacent to his body by the use of his body” (p. 97). The concept includes the person’s deliberate and active movements, balance and orientation as well as proprioception. ‘Proprioception’ refers to the awareness of one’s body parts in relation to each other, the kinetic movement and position of the limbs (Gibson, 1966/1983, p. 36–37; see also Paterson, 2009). The word ‘haptic’, although it describes wider dimensions of touch, is less common in ordinary speech. Even researchers on the haptic modality use the word tactile in cases where the word haptic would be more appropriate. In my publications, I have sometimes used the word ‘tactile’ or ‘tactility’ for this reason.

‘Making with hands’ is fundamentally a haptic activity. However, there are also many instances when the designer or craftsperson manipulates material through tools, even without touching the material itself, as in the act of blowing hot glass. The sense of touch or the haptic modality is thus extended through the tools just as the blind man’s cane allows feeling of the structure of the floor or pavement.

Through the digitalisation of many craft processes there is a vast discussion around the issue of the hand made in relation to the digital within craft research (Bamford, 2015; Harris, 2012; Ionascu, 2015; Piper & Townsend, 2015; Taylor & Townsend 2014, Townsend, 2016, see also Bailey & Townsend, 2015; and Frazer, 2010). Issues raised in this discussion deal with new possibilities enabled through new digital tools and the interplay between hand and the digitally produced artefacts in the developing fields of ‘digital craft’ and notions of ‘digital handmade’.

Although the importance of tacit skills and direct physical manipulation or sensorial aspects either before or after the digital process is highlighted in the above research contributions and presented as hybrid processes combining these dimensions, the purpose of this present doctoral research has not been to research or compare these aspects. Although many issues

raised in my research relate to the above discussion, my focus has been to study and describe mainly physical haptic experiences. This is not to say that embodied cognition and experiential knowledge is exclusively physical; on the contrary the introduction and theory section of this thesis shows how embodied cognition is increasingly researched in, for example, the field of human computer interaction (HCI) and interaction design.

However, ‘making with hands’ is in this present research defined as any material manipulation that transforms matter in a physical manner directly or through hand-held tools, but does not include for example 3D drawing and modelling or 3D printing where the designer comes in contact with the finished physical piece only after its computational conception. Even in hot glass blowing, which is mainly conducted without physical contact with the actual material, the maker feels the different temperatures of the glass on his skin, the weight and the orientation of the piece is felt in the muscles, the viscosity of the glass and the overall material agency is felt in the hands through the tools used. Similarly, in jewellery-making the maker also feels the density of the material through the hammer or other tools.

Instead of using the word *thinking* in connection to embodied knowing, I have in this thesis preferred the word *sense-making*. *Sense-making* is a key concept in the enactive approach in cognitive science. It is described by philosophers in the field of cognitive science, Evan Thompson and Mog Stapleton (2008), as the organism’s (animal or human) activity of transforming the world into an environment that has salience, meaning and value for it: “Sense-making is behaviour or conduct in relation to environmental significance and valence, which the organism itself enacts or brings forth on the basis of its autonomy” (p. 25).

Also in ordinary language, the meaning of making sense of things has a stronger connection to utilising the senses (the body) in the act of meaning making. Philosopher Mikkel Tin (2013) connects sense-making to the activity of *making* and speaks for the making activity as a sense-making activity that yields knowledge of another kind than ordinary discursive knowledge (p. 1). Cognitive scientist and design researcher Henrik Gedenryd (1998) writes about designers’ sense-making processes and claims that their outwardly simple but authentic means of sense-making activities have often proven superior to existing cognitive theories, if only understood on their own proper terms (p. 4-5). In short, sense-making in this thesis refers to the way we *make meaning* of our *experiences*.

As the purpose of this study has been to specifically study haptic and tactile experiences and the sense-making connected to the act of making, the word *cognition* comes into play. I have included cognition studies in a more philosophical form by mostly relating to writings in the field of design cognition or embodied cognition. Design cognition studies ground our current understanding of the designerly way of knowing (Cross, 1982) and are based on earlier theories of human cognition (for a review, see Goldschmidt, 2001). This strand of research often leans on representations and simulations of the

world in the form of mental images that facilitate an abstract and conceptual disposition towards human cognition.

In recent years, design cognition studies have been met with some criticism as only a few of these studies touch on the experiential knowledge and real world experience of the designer. Gedenryd (1998) proposed a reason for the exclusion of body and environment in the study of both design methods and the traditional design cognition research by claiming that the scientific research tradition is focused on *intramental* activities and are thus far apart from the physical and embodied activities that designers are actually involved in (p. 7-8). In his argumentation, he goes as far as saying that: “designers go to some length to even avoid having to work intramentally, as the usual theories claim they should do” (Gedenryd, 1998, p. 17).

In Gedenryd’s opinion, those concepts developed within design cognition theory reflect a view of the human mind as an isolated spectator of phenomena happening outside the mind. Materials are discussed as external constraints, and visual and sensory experiences and images of the environment are described as extensions of long-term memory (Gedenryd, 1998, p. 8). In his opinion, this scientific lens does not provide a comprehensive view of design practice as it has difficulty in explaining the authentic sense-making of the designer and presents an idealised view of the rational mind (Gedenryd, 1998, p. 2).

While there might be many reasons for cognitive science to develop into a science that revolves around the mind rather than including the body, environment and social interaction in knowledge making, most often the philosophical tradition of dualism, famously initiated by Rene’ Descartes, has been blamed for this development (Dourish, 2001; Gedenryd, 1998; Johnson, 2007, Lakoff & Johnson, 1999), discussed also in the theory section. This division of mind and body also divides theory and practice into two hierarchically posed dichotomies. Practice has the disadvantage of being silent knowledge, less explicable and thus also not easily distributable in a format suitable for the academic world. Our body-based and practical knowledge hides from our conscious thought (Tin, 2013).

Philosopher Mark Johnson writes in his book *The Meaning of the Body* as follows: “We are born into the world as creatures of the flesh, and it is through our bodily perceptions, movements, emotions, and feelings that meaning becomes possible and takes the forms it does” (2007, p. x). He challenges the mainstream and dominant view of meaning making that he calls the conceptual-propositional theory of meaning and that he finds over-intellectualise human ways of making meaning (Johnson, 2007, p. 7). Johnson is thus, like Gedenryd, promoting an epistemology that is in stark contrast to the conceptual and propositional meaning-making that constitutes design cognition studies.

I submit that if you want to understand human meaning-making, you should probably not start with theories of meaning put forth in contemporary analytic philosophy of mind and language. You will find their treatments of concepts, propositions, and various language-like structures, but you will not find any awareness of deep, embodied, vital meaning. For this immanent or embodied meaning, you must look more deeply into aspects of experience that lie beneath words and sentences. You must look at the felt qualities, images, feelings and emotions that ground our more abstract structures of meaning.

Mark Johnson, 2007, p. 17

It has taken time for the body to be recognised as a relevant contributor of knowledge. Although for several decades scholars and researchers have generated evidence for the embodied mind, the implications of this research have still not properly entered public consciousness (Johnson, 2007, p. 1). The tradition of phenomenology, American pragmatism, enactivism in neuroscience and embodied cognition theory has spoken for a knowing body for almost a century.

Theory on embodied cognition describes how we think or make sense through our physical interaction with our environment. It suggests that knowing is created in and through action and it has potential to describe knowing in design and making actions. However, it is a tacit knowledge (Polanyi, 1958, 1966) that is perceivable in enactments of the body, and as such it is still silent unless we find ways of explicating the knowledge. The amount of research in embodied cognition has grown rapidly in the last ten years and the areas of research are various, ranging from artificial intelligence to cognitive neuroscience. Empirical research within these fields is both specific and general; however, very little is directly applicable to design and craft practice.

While unconnected to embodied cognition theory as such, the idea of making sense or reflecting in action through the hands has been touched upon by many thinkers and writers who have tried to come to terms with this tacit notion within the field of design and crafts (Anttila, 2006; Dormer 1994; Schön 1983, Sennett, 2008). However, the general research paradigm has not been ready for including the body, sensory experiences or emotions as these more subjective aspects have not been seen as contributing to rigorous research (Biggs, 2004; Niedderer & Townsend, 2014). Instead, concepts that describe the same attitude to sense-making but from other domains are referred to, such as the theory of affordance, knowing in action, reflection in and on action, reflective conversation with materials, experiential, tacit or personal knowledge, emphatic or emotional design. These concepts are further explained in the following theory section.

As the Finnish word for tacit knowledge, *hiljainen tieto* (silent knowledge), indicates, the knowledge that is handled in the act of making is implicit. Design and craft research has found other ways to describe the situated and embodied notions of the practice, and *experiential knowledge* has been one key term in this field. This *a priori* knowledge is only truly known through the lens of the practitioner; however, through the inclusion of designers and craftsmen in the academic arena it has lately been possible for educated practitioners to study their own practice through organised enquiry.

The number of researcher-practitioners describing their own experiential knowledge through a practice-led research setting is now growing. This strand of research is playing a visible role in the general discussion on design and craft research (Almevik, Jarefjäll, Samuelsson, 2013; Bang, 2010; Berg, 2014; Ings, 2014; Mäkelä, 2003, 2016; Niedderer, 2009a, 2009b, 2012, 2013; Niedderer & Reilly 2010; Medbo, 2016; Niedderer & Townsend 2014;

Nimkulrat, 2009, 2012, O'Connor, 2005, 2007; Pedgley, 2007; Riis, 2016). In this context, researchers are confronted with the task of making tacit and silent knowledge somehow researchable and explicable in an academic context – through text. This is a real challenge, and one that the researcher-practitioner in particular faces (Niedderer, 2007).

Silversmith and design researcher Kristina Niedderer has studied aspects of experiential knowledge in design and craft practice rigorously (Niedderer, 2007, 2009a, 2009b, 2012, 2013; Niedderer & Reilly, 2010; Niedderer & Roworth-Stokes, 2007; Niedderer & Townsend, 2014). She suggests that although experiential knowledge is tacit, it is possible and important to include aspects of the tacit dimension in the dissemination of research by including elements of the practice itself, such as video, demonstrations and coaching situations (Niedderer, 2007, p. 12). For example, designer and researcher Nicola Wood has successfully implemented new media in her practice-led research on how the tacit knowledge of master craftsmen may be communicated to novices, even via online studies, by using audiovisual material (Wood, Rust & Horne, 2009).

Previous design and craft related research on tactile knowing or tacit and embodied aspects of a material manipulation activity have often employed an autoethnographic stance (Ellis & Bochner, 2000). There are many terms prevailing internationally around the kind of research conducted in the creative fields where the researcher is conducting research on and through her own practice, and where the course of the practice is leading the research (for overviews of these, see Candy 2006; Mäkelä, Nimkulrat, Dash & Nsenga, 2011; Niedderer, & Roworth-Stokes 2007; Nimkulrat, 2012; Rust, Mottram & Till, 2007). The terms that are used for describing the research in these fields are varied, including, for example the following: artistic research or arts-based research mostly used in the context of art (see, for example, Borgdorff, 2006); design-based research, research through project, PhD through design or research through design are linked to design processes (see, for example, Pedgley, 2007); and research through practice, practice-based and practice-led research are more general and inclusive of different practices (see Niedderer, & Roworth-Stokes 2007; Mäkelä, Nimkulrat, Dash & Nsenga, 2011).

Mäkelä leads the research group *Empirica* in the Aalto University School of Arts, Design and Architecture, encouraging design research that includes artistic research methods. Together with Nimkulrat, she has contributed to the emergence of a notion of practice-led research in the field of studio-based practice, in which documentation and reflective practices are key to knowledge formation (Mäkelä & Nimkulrat, 2011). Discussions on the focus being either the process of the practice in itself, or the process of creating the artefact have been met by Linda Candy (2006, p. 1), who defined the practice-led direction as follows:

Practice-led research is concerned with the nature of practice and leads to new knowledge that has operational significance for that practice. In a doctoral thesis, the results of practice-led research may be fully described in text form without the inclusion of a creative work. The primary focus of the research is to advance knowledge about practice, or to advance knowledge within practice. Such research includes practice as an integral part of its method and often falls within the general area of action research.

Although the discussion in this area is vivid, the research described in Case 2 of this thesis is conducted using a practice-led research orientation focusing on the process rather than the artefact created. Thus, the above description by Candy fits this particular research endeavour. However, my general research approach has been influenced by the legacy of Mäkelä and Nimkulrat.

Finding ways of researching the experiential knowledge of the practitioner is important for design and craft practices. The time for including the bodily and sensory aspects of knowing is in many ways mature; however, there are still few empirical descriptions or studies regarding what the theory of embodied cognition could mean in the field of design and craft practice (Seitamaa-Hakkarainen, Huotilainen, Mäkelä, Groth & Hakkarainen, 2014, 2016). The objective of this study has been to meet this challenge.

1.2 Objectives and Scope

The research at hand aims to contribute to the above discussion by opening up issues in relation to the sense-making that occurs in the act of material manipulation from the perspective of the practitioner, with a focus on the haptic and tactile sensory experiences. This thesis thus focuses on the embodied sense-making in the making disciplines and is informed by theories from design cognition and embodied cognition (image 1).

The research presented in this summary is based on the original publications I-IV, as listed on page x. A preliminary analysis of the three cases is published in an earlier article: (Groth, 2016). The present summary is a more profound and nuanced analysis that also provides the proper context for the entire study.

The guiding research question of this thesis is: *How do design and craft practitioners think through their hands?* This general question evolved into four sub-questions aiming at revealing experiential and embodied knowing in the design and craft practices: *How do experts in tactile knowing use their enhanced tactile sense in a making situation? What methods may be used in the study of embodied and experiential knowledge in crafts? What is the role of emotions in connection to tactile experiences in a craft practice? How do design students use embodied knowing in material exploration?*

Image 1. Framework of the research.

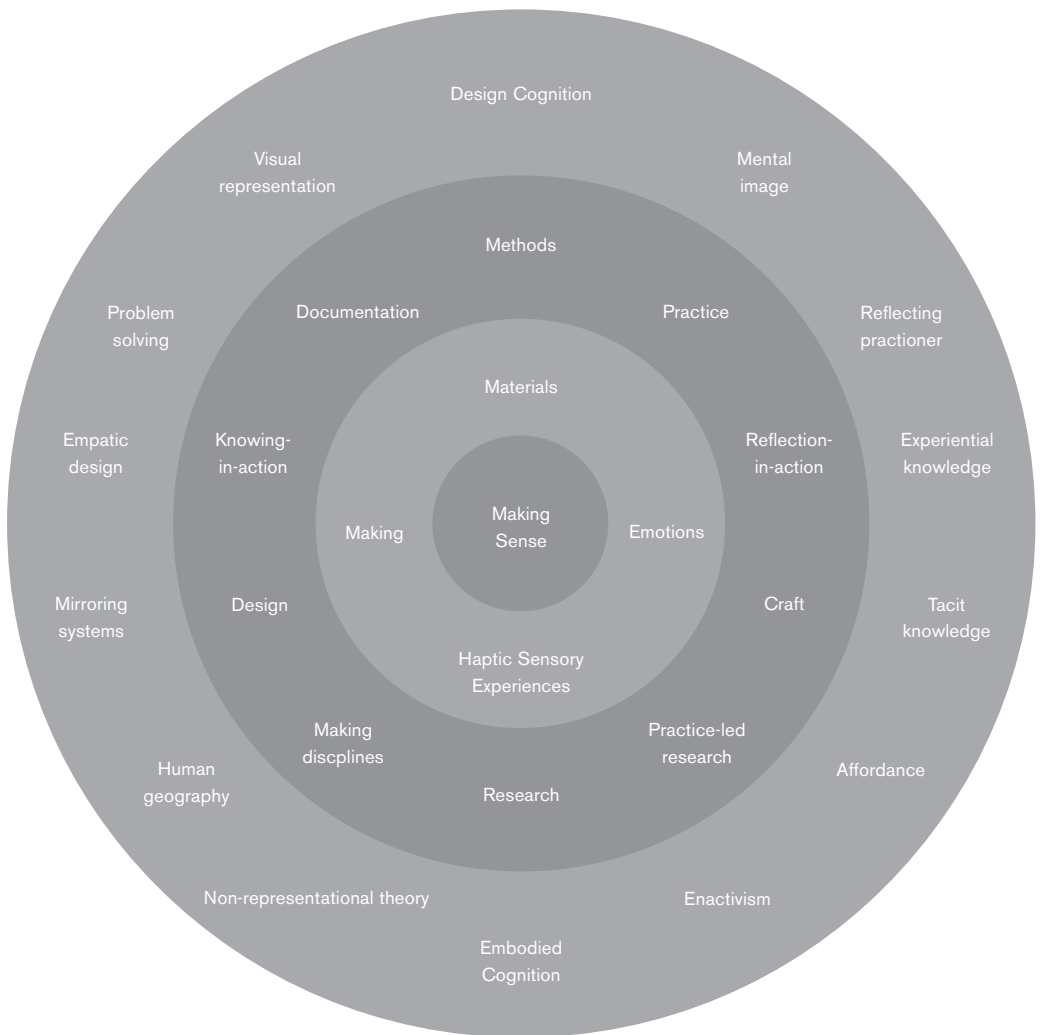
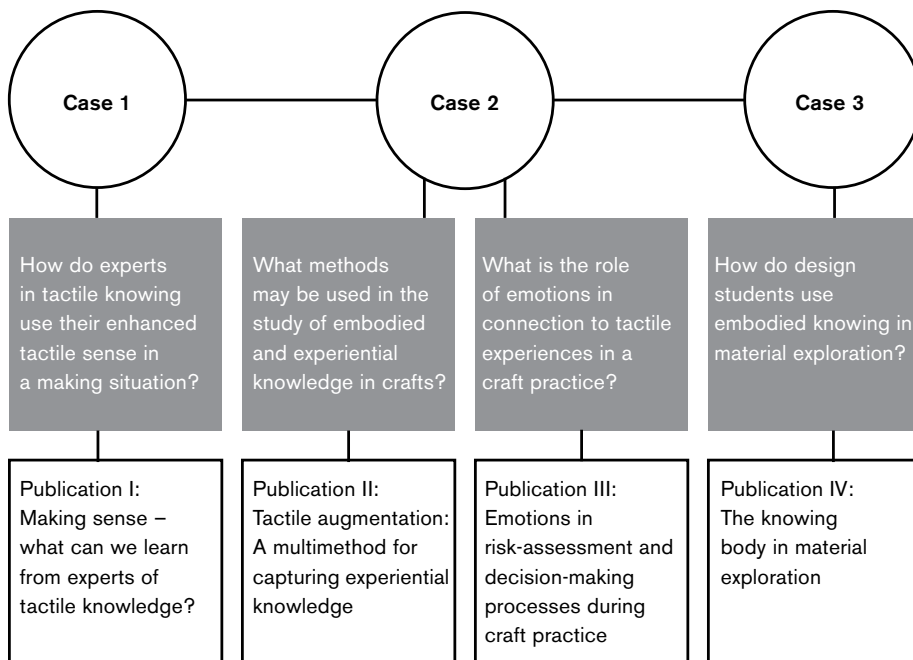


Table 1. Relationship of cases to the questions answered in each publication.



These questions, (further explained in section 3) are answered in their related publications as shown in Table 1.

Through the use of a multiple case study research design (Yin, 2009), the general research question was studied from three different perspectives in three cases.

Methodologically, I have used the haptic and tactile experience as the platform for investigation. The research may be seen as a sensory ethnography as outlined by visual anthropologist Sarah Pink (2009), focusing here, however, on the tactile rather than a fully multisensory point of view.

Sensory ethnography is: “a way of thinking about and doing ethnography that takes as its starting point the multi-sensoriality of experience, perception, knowing and practice” (Pink, 2009, 1). While the senses never operate on their own but always in relation to each other, the 5-sense system, consisting of vision, touch, smell, taste and sound, is useful in the way that it helps us to communicate linguistically about our experiences (Pink, 2011, p. 266). According to Pink (2011), it is of interest to analyse and divide the experiences into the categories of each sense in order to be able to assign culturally constructed meaning to the activities being researched (p. 267).

In order to study such knowledge it was necessary to use multiple methods, consisting of participatory workshops and ethnographic and autoethnographic methods (Ellis & Bochner, 2000) as well as thematic and qualitative content analysis (Fereday & Muir-Cochrane, 2006) of interviews and video material.

I began my research by making an exploratory dive into the world of haptics by contacting one of the keynote speakers at the EuroHaptics conference in 2012, Riitta Lahtinen, social-haptic communication specialist at the deafblind association in Finland. I was interested in how tactile experiences are contributing to experiential knowing in crafts and design, and my assumption was that deafblind people might be very knowledgeable in this area. With the help of Lahtinen, I arranged three ceramic workshops with deafblind makers in Helsinki and Tampere during the spring of 2012. The aim was to study the context of making in an enhanced haptic setting, learning from participants who would be true experts in their use of their haptic sense. This research is presented in Publication I.

Having gained experience and inspiration from these informants, I considered researching the same question but in relation to a more experienced craft practitioner. However, as I also found that researching another person's sensory experiences was challenging, I considered it more useful to make a self-study. As I have experience as a craft practitioner in a more professional way than the deafblind participants, I complemented the previous case with an autoethnographic study in which I spent five days blindfolded in my studio, throwing clay cylinders using a potter's wheel. This was done in order to reflect on my own tactile experiences, rendered more easily available due to the blindfolding.



Image 2. Throwing clay blindfolded on the potter's wheel. Screenshot from the video recording of the event.

The challenges met in relation to data collection evolved into the development of a multimethod useful for research on experiential knowledge. This research is presented in Publication II. The multimethod developed generated ample amounts of rich data, enough to have conducted a separate doctoral thesis only on this case. Therefore, there was an opportunity to deepen the analysis in order to explore an additional sub-question that

developed due to the initial analysis, namely the role of emotions in connection with haptic and tactile experiences in a craft practice. This research is presented in Publication III.

For the third case, I was curious to examine yet one more perspective of my general research question. As the design department where this research is situated offers the opportunity to study students' making processes, and the research project *Handling mind*, that I was part of during my research, used these students as research participants, it was natural to involve the students in my third case. Therefore, the third case involved a study on design students' use of their tactile sense and how haptic experiences are contributing to experiential knowing in crafts and design.

From two groups of 19 design students in total, two students who were found to be more advanced practitioners due to their previous artisanal education and professional background were studied more closely and interviewed for this research. Their own documentation, diaries and artefacts were analysed through a thematic content analysis. This research is presented in Publication IV. These three cases are presented in section 4, which also presents the general research design and in greater detail in the original publications in section 9.

Essentially, this research concerns the relationship between maker and material and related sense-making. Social aspects or even the professional practice of the contemporary designer or craftsperson are therefore not the main subject of this exploration. The study specifically concerns the contact point of the embodied mind and material; thus, the haptic and tactile sensory experiences have been chosen as the main focus of analysis.

As the ceramic practice is very rich in haptic experiences, I used this practice as an example; thus, I was also situating most of the research in this specific domain and in making with hands. I have a personal background in the field, having spent three years as a potter's apprentice at the age of 19–21 years, and having studied or worked in this context, both as an artist and designer for more than 20 years. These experiences formed a basis from which I was able to interpret the data from a situated perspective, utilising my insider's knowledge throughout the study and thus hopefully giving a certain depth to the analysis.

To be able to obtain a glimpse into the world of the deafblind subjects involved in this research, I participated in a course on social-haptic communication led by Riitta Lahtinen. Through discussion with her and through reading her doctoral thesis on social-haptic communication as well as books written by deafblind authors, the world of the deafblind was opened to me to some extent before conducting the workshops. It is, however, not possible to understand the deafblinds' experience fully until one experiences a similar dual modal impairment personally.

Despite having taken courses in cognitive neuroscience (at the University of Helsinki) for this research and having included references from the field of cognitive science, even cognitive neuroscience, I have here

incorporated the cognition studies in a more philosophical form. Basically, I have looked at these theories from a craft practitioners' perspective. The contribution of this research serves rather as a perspective on the act of making from an embodied point of view. The research is intended to create a building block for further investigations by examining very basic aspects of making and the related sensory experiences and associated sense-making.

The understanding of the word *practitioner* is here seen as *a person who regularly does an activity that requires skill or practice*, rather than a professional designer or a professional craftsman. The reason for making this definition is the understanding that the act of making is ubiquitous and therefore also relevant in situations outside a professional context (Cross, 2011; Lawson, 1980/2005; Tin, 2013; Nilsson, 2013). The participants of this research are representative of three different contexts where making constitutes an important aspect. The practising community is much larger than the community of design professionals or craft professionals; therefore, research on only professionals would give a very narrow picture of making activities.

Although the research for the larger part (2 cases out of 3) is based within the context of making in clay material, I hope that the results are general enough to make a contribution in other material contexts and possibly beyond these areas of creative practice to include other areas of making with hands. This is the reason that the title of this doctoral thesis points towards a more general context rather than the specific ceramic craft context. In the following, I will elaborate on the theoretical foundation briefly touched upon in the introduction.

2 Theoretical Foundation

Theory and practice have a difficult past in terms of trying to negotiate their relationship with each other (Lakoff & Johnson, 1999; Tin, 2013; Molander, 1993). Practice may be understood as knowledge in action, and theory as knowledge disseminated through words. This division is generally described as knowing *how* and knowing *that* (Ryle, 1949). In order to investigate how we make sense through our hands, a theory is needed that allows for the body to be part of knowledge making and that allows thinking through acting.

Although there are different strands, the general theory on the embodied mind may be summed up with the following four Es: Our mind is *Embodied*, thus we are situated and our understandings are *Embedded*. Our mind is *Enacted* through the body. We offload meaning onto external objects, thus our mind is *Extended* (Robbins & Aydede, 2009, p. 3). In addition, our emotions give meaning to our experience (Johnson, 2007). Hence, embodied cognition theory suggests that all knowledge is situated and emerges in our embodied interaction with our environment, thus also opening up issues of practice for theoretical ponderings.

However, in the field of design and craft, a comprehensive theoretical framework has already been developed, describing the cognitive processes of the design-specific problem-solving and framing of design tasks. Concepts developed in this research orientation have been used when describing the processes of both industrial designers and craft practitioners.

2.1 Design Cognition

Traditional research in design cognition has used rigorous methods to study the behaviour and cognitive activities of designers at work in a multitude of disciplines. Design researcher and theoretician Nigel Cross has documented and reported on the progress and results of these studies over the years (1982, 1984, 2001a, 2011). Cross also provides an overview of the developments over time on the relationship between design and science (2001b), and he identifies a recurring movement for making design scientific which then is rejected, occurring over cycles of 40 years (2001b, p. 1). He separates the notions of *design as a scientific act* as proposed by cognitive psychologist, and computer scientist Herbert Simon (1969/1996 and the *scientific study of design practice* (Cross, 2001b, p. 4).

Design cognition is the study of the *designerly way of knowing* (Cross, 1982). The development of the study of design cognition, or *design thinking*,

was mainly situated in the period 1970-1990, in connection to and as an extension of the design methods movement (Goldschmidt 2001, p. 199). According to architect and design theoretician Gabriela Goldschmidt (2001, p. 199), the design research community struggled to develop a *design science* that would forward the design discipline and aid in gaining an academic status similar to that enjoyed by the sciences.

Research into how the designer works was investigated in the “design methods movement” that was inspired by the “hard” and analytic research paradigm as opposed to the age-old “soft” design strategies that hampered the profession (Goldschmidt, 2001, p. 200). However, the “design methods movement” failed in finding a recipe for rigorous design methods based on well-defined algorithms that could be consequently used by designers in their practice (Goldschmidt, 2001, p. 199).

The soft design strategies referred to here are connected to the craft tradition. There is a notion of the designer as a thinker, while the craftsman is a maker, separating making and thinking into two professions. Craft and design critic Peter Dormer (1993) writes about this and says that the hierarchial differentiation between designing and making in the professionalisation of design is not new and that as far back as the 14th century the weavers, for example, were paid less than the designers of the same product (p. 9). Dormer (1993, p. 9; see also Lawson, 1980/2005, p. 25-26) writes: “Designers do not manufacture things. They think, they analyse, they may model or draw, and they specify.” Dormer (1997, p. 18-19) describes this phenomena as a separation of making from meaning, leaving craft perceived as lower in status.

The research on design “reasoning” was initiated as a response to the criticism that the design methods movement received (Goldschmidt, 2001, p. 200). However, the agenda was still to make the gap between the practice-based design profession and the sciences narrower, aiming at academic recognition for the design science. Therefore, the example of human cognition studies was taken as a model for research on design reasoning (Goldschmidt, 2001, p. 200).

However, this approach seemed to some researchers too distant from the pragmatic and context sensitive practice of the design profession (Mareis, 2012, p. 63). Design theoretician and philosopher Donald Schön opposed the positivist way of thinking of his time (Cross, 2001b, p. 4) and developed the concepts of reflective practice and knowing-in-action (Schön, 1983). Schön’s constructivist and human approach is now portrayed as the Schönian phenomenological (or pragmatist) approach as opposed to the Simonian positivist approach (Dorst & Dijkhuis, 1995, p. 262). According to Dorst and Dijkhuis (1995, p. 262), these are “fundamentally different paradigms”; however, they seem to form the space in between where design cognition researchers position themselves (see also Cross, 2001b; Mareis, 2012, p. 63).

One of the first contributions to the study of specific ‘designerly knowing’, or design thinking, in architecture was made by Peter Rowe

(1987). Much of the theory has evolved around problem-solving (Simon, 1969/1996) and strategies for framing the ‘wicked’ (Buchanan 1992; Rittel & Weber 1984) or ill-defined (Goel & Pirolli, 1992) design problems into smaller entities for analysis.

Goel & Pirolli (1992) have, for example, presented ideas on the structure of the design problem spaces. In their article, they compare the different task environments and show that non-design problem-solving tasks vastly differ from design-related problem-solving tasks (Goel & Priolli, 1992). Design thinking is described as a distinct form of knowing, and the act of designing “is a quintessential cognitive task” (Goel & Priolli, 1992, p. 395). Cognitive neuroscientist Vinod Goel has also studied the process of drawing in connection to designing and found that, through drawing, designers deal with representations of artefacts rather than with actual artefacts in the design process (Goel, 1995).

Internal and external representations are important in the study of design cognition as designers create and manipulate these in their search for solutions to design problems on an abstract level before implementation. Gabriela Goldschmidt has contributed greatly to our understanding on analogical thinking, especially concerning the ideation processes (Goldschmidt, 1995, 1997, 2001). Designers use external visual stimuli as sources for inspiration while creating inner representations that are then in turn developed through analogy. The internal and external representations are thus translations. Cognitive psychologist and design researcher Willemien Visser further develops the idea that design is essentially about generating, transforming and evaluating representations (Visser, 2011).

In addition to facilitating the iterative thinking process on an individual level, in industrial design visual representations are commonly also produced for communicating the design to stakeholders at different stages of the process. Industrial designer Eujin Pei (2009), under the supervision of design researcher Mark Evans, studied and categorised the different kinds of representations that industrial design students and professional designers use and created a card system called ‘iD cards’ (Evans, Campbell & Pei, 2013). These explored the many different nuances of representations that the designer uses during the design process. Evans and his research colleagues developed a taxonomy of representations and identified when in the design process these were used and for what type of communication, mainly between the industrial designer and the engineer.

However, the role of design representations is larger than only a communication tool. The designer uses visual representations as a way of externalising ideas in order to make them more understandable to him/herself, as well as to store and compress information (Larkin & Simon 1987). External (visual) representations are also used as support for thinking (Goel, 1995; Seitamaa-Hakkarainen & Hakkarainen 2001; Suwa et al. 1999) and in developing ideas (Suwa, & Tversky, 1997). Design representations are even described as “cognitive artefacts” (Purcell & Gero, 1998). In short,

visual, symbolic and tangible representations are considered essential parts of the design practitioner's thinking process.

Designers rely on visual mental images created in their mind during the design process (Ferguson, 1994; Suwa & Tversky 1997; Kosslyn, 2005). The ability to imagine the idea from different angles in a three-dimensional manner requires mental rotation (Purcel & Gero, 1998). The difference between the internal mental image or representation and the external representation of the intended design may sometimes need adjustments as the designer moves between the idea world and the concrete world.

Design researcher John Zeisel (1981/2006) recognises the designers' dilemma, and he has described how the designer adjusts and modifies predictions about the final artefact as she tests her design through external representations in the form of sketches and material prototypes. The design process is thus visualised as a series of iterations in the shape of a spiral movement round the base of experiential knowledge (see Zeisel, 1981/2006, p. 26). This process includes conceptual shifts or creative leaps as the designer's visions of the final product shift. Previous experiences and the skill base of the designer are utilised in the evaluation of acceptable solutions.

Models for how designers think have been presented throughout the history of design cognition studies (for an overview, see Rowe, 1987; Lawson, 1980/2005). Protocol analysis has a special place in design cognition studies as a tool for investigating the thinking processes of the design practitioner. During the Delft Protocols Workshop in 1994, an international group of renowned design researchers gathered to investigate the potential use of protocol analysis in combination with cognitive psychology (Cross, Christiaans & Dorst 1996; Cross, 2011). The use of protocols for actions and *think aloud* verbal accounts (Ericsson & Simon 1984/1993) gave insight into the thought processes of the designers in experimental settings while working on given design tasks.

Industrial design researcher Kees Dorst, the host of the Delft Protocols, has developed the understanding of design activity in a number of publications in relation to the workshops (Dorst 1995; Dorst & Dijkhuis, 1995). According to Dorst & Dijkhuis (1995) the problem-solving approach means: "looking at design as a search process, in which the scope of the steps taken towards a solution is limited by the information processing capacity of the acting subject. The problem definition is supposed to be stable, and defines the "solution space" that has to be surveyed".

Architect and design researcher Ömer Akin has conducted several studies on the psychology of architecture in which some protocols were also used as a method for categorising design activities. He discovered the dual-mode process of the designer, which is the way that designers seek novel ideas interchangeably in the verbal-conceptual and the visual-graphic modes (Akin, 1986; Akin & Lin 1995; Akin, 1997).

Design cognition studies, including the problem-solving approach, have been informing not only architecture and product design but also research

in the field of craft-design processes. In her research on novice and expert textile designers, craft-teacher educator and design researcher Pirita Seitamaa-Hakkarainen also found that the process of weaving design was best considered as a dual-space search between the composition space and the construction space. Additionally, this search is subject to internal and externally generated constraints (Seitamaa-Hakkarainen & Hakkarainen, 2001).

Study on expertise in design is providing clues concerning how designerly thinking develops and thus also what it constitutes. Architect and design researcher Bryan Lawson, (2004) has criticised design cognition studies for concentrating on students (novices) in their research settings. He specifies how novices and experts differ, in the way experts are able to utilise their matured schemata and gambits for solving problems that the novice has not yet developed.

Many of the concepts and research methods developed through the combination of cognitive and psychological studies aided the design research community in advancing the design field into a design science that explains phenomena recurrently present in the practice of the designer. However, few studies are conducted from the practitioner's point of view and few mention the physical aspects of sense-making. While based on thorough observations, video-recordings, protocols and interviews, the *embodied, emotional, and experiential* knowledge of the designer remains largely concealed in the traditional design cognition research strand.

This deficiency was accepted since practitioners' subjective experiences were thought difficult to systemise in such a way that design-related knowledge could accumulate (Lawson, 1980/2005, p. 288; Seitamaa-Hakkarainen et al., 2016). Dorst & Dijkhuis (1995) however, were taking a step in this direction by comparing the two, in their view opposing but mutually complementary, paradigms of design research (the positivist and the phenomenological). As a conclusion, they propose a combined paradigm to more comprehensively describe design processes, taking *action* as the unit for studying design, to get closer to the activity as experienced by designers (Dorst & Dijkhuis, 1995).

Embodied cognition theory proposes that cognition is situated in and enabled by actions and thus seems to solve the problem. However, the fundamental difference between design cognition and embodied cognition lies in the way in which design cognition relies on dealing with *representations* of the world while embodied cognition deals with the *actual* world. Therefore, according to a non-representational view, in order to get close to the real life experience of making, we must look beyond, (or rather *closer* than) the representational mode in our descriptions of designer's material exploration, even if designers themselves use representations of the world as tools in their sense-making process during the planning phase (see also the figure in section 6 on page 64).

2.2 Embodied Cognition

Embodied cognition theory is grounded partly in phenomenology and partly in pragmatism. Phenomenology is a philosophical strand initialised by Edmund Husserl (1859–1938), who was devoted to studying the *lived experience* and the human mind, taking perception as the starting point for situated knowing (Dourish, 2001, p. 105). At the time, his ideas were still developments of Descartes' dualism (Dourish, 2001, p. 106), which holds the opinion that sensory experiences are deceptive and logical thinking based on deduction is to be preferred over sensory impressions (Lakoff & Johnson, 1999, p. 400–402). This mind-body division still affects directions in research and our general hierarchies of the mind over body and theory over practice in connection to knowledge (Damasio, 1994, p. 247–252; Dourish, 2001, p. 107; Gedenryd, 1998; Johnson, 2007; Kozel, 2011, 2013; Lakoff & Johnson, 1999, p. 75 & p. 400; Molander, 1996, p. 25; Pallasmaa, 2005, p. 15, 2009, p. 13; Pink, 2009, p. 24).

More recent developments of phenomenology which are useful in a designerly context include Heidegger (1889–1976) and Merleau-Ponty (1908–1961). Heidegger responded to Descartes famous “I think, therefore I am” that there cannot be any thinking unless we exist, therefore *Being* comes first and *Thinking* after that. With this statement, he took the next step in developing a phenomenology that entirely considers the body and its involvement with the world as the fundamental aspect of being, being in the world or *Dasein* as he called this concept (Dourish, 2001, p. 108).

Merleau-Ponty (1945/2010) developed his phenomenology of perception on these previously presented ideas, emphasising the role of the physical body in our direct contact with the world and our way of creating meaning through our sense perceptions. As the research at hand is geared towards sensory experiences, Merleau-Ponty's way of understanding the body and the senses as informants in sense-making and the immediacy of the embodied sense reflection is interesting.

American pragmatism (Dewey, 1934/2005; Shusterman, 2005) also discusses knowledge as being situated in actions. This strand has been seen as distinct from the philosophical phenomenological path; instead, it is linked to psychology. However, much of the content speaks the same language as phenomenology, and lately theoreticians have begun to merge these different strands. For design research, the influence of pragmatism has been very strong through Donald Schön (1983). Schön (1983) draws heavily on the pragmatist Dewey, as he emphasises the reflection in and on action made by the practitioner.

Although philosophers have discussed the subject of knowledge being dependent on the situated body for quite some time, the concept of embodied cognition is relatively new. As it evolved from phenomenology, this scientific direction also understands human cognition as being fundamentally

dependent on the body and sensory experiences, and developing through interaction with our environment. It is thus fundamentally different from previous scientific traditions, and challenges much of the earlier work in general research on the human mind. The question is, does this demand a total revision of previous research on cognition at all levels and in all fields of knowledge, or is an addition of the embodied aspect enough? Regardless, it is clear that the theory of the embodied mind has begun to influence general research concerning the human mind (Hari & Kujala, 2009, p. 1). While a new orientation, it has nonetheless developed quickly and made its way into several different disciplines, not only those such as philosophy and cognitive neuroscience, but also psychology, linguistics, robotics and artificial intelligence, and recently also human-computer interaction, interaction design and industrial design.

Many studies on embodied cognition in neuroscience touch on the direction of attention and action depending upon ‘external stimuli’ in the form of language or sensory cues. The research in this field is often very specific and direct application to design theory, and design practice in particular, is scarce. However, there are many similarities in the approach to understanding human sense-making in relation to the environment.

The general theory on embodied cognition proposes that the mind is embodied and that our understandings are embedded as they depend upon our direct bodily interaction with our environment. Thus, our mind is also enacted through the body. Essentially, this strand of cognitive science opposes traditional cognitivism in the sense that it rejects the manipulation of representations as the basis for cognition (Menary, 2010, p. 459). Instead, the boundary between the mind and the environment is diffused. This is visualised in Gedenryds’ (1998, p. 12) images of, on the one hand, the traditional intramental view of cognition affected by external inputs and responding with outputs (Image 3a) and, on the other, a wider and less

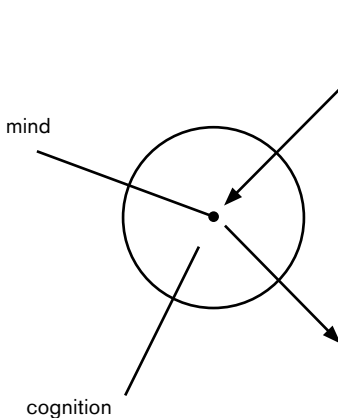


Image 3a. Simplified presentation of the traditional view on cognition as intramental. (Adopted from Gedenryd, 1998, p. 12)

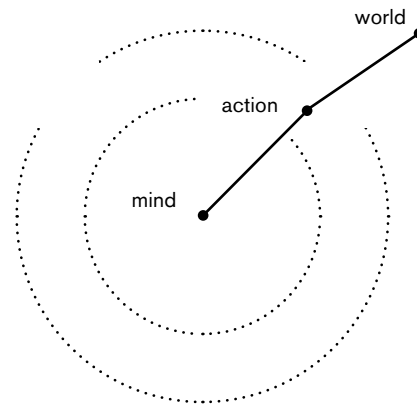


Image 3b. A view on cognition as wider and less circumscribed. (Adopted from Gedenryd, 1998, p. 12)

circumscribed view acknowledging the concrete interaction with the environment (Image 3b).

Embodied cognition theory has developed in two directions: One is more connected to environmental biology and enactivism, thus highlighting the role played by bodily states and their constraints. The other direction seeks to ground the *extended mind* in multiple ways, in language and *simulation*, which makes it similar to situated cognition (Borghi & Cimatti, 2009, see also Robbins & Aydede, 2009). Although there are disputes over particular issues within these strands (see Thompson & Stapleton, 2008), these strands may also be considered mutually compatible depending on the context (Borghi & Cimatti, 2009). As the general idea of knowing through action is the same, both directions are interesting for research in design and craft practice.

The philosophical strand of neuroscience that has embraced the idea of embodiment is called the ‘enactive’ approach. Enactivism suggests that a person learns in action and accumulates knowledge through her embodied experiences with her environment; thus, the body is integral in all knowing (Noë, 2004, 2009; Thompson, 2010; Varela, Thompson, & Rosch, 1991). This means that we build our minds through our experiences, and the more experiences we have of a certain action or interaction, the better we are able to anticipate and predict possible outcomes from future similar actions and interactions.

Enactivist philosopher and neuroscientist Alva Noë (2004) develops the idea of *knowing in action*, which is well-suited for studying practice. We learn to make sense of the world through interacting with it and manipulating it. In this way, we learn skills and understandings of the *affordances* (Gibson, 1986) of the world and material agencies in relation to our capacities. For example, *vision* is one such embodied skill that we have enquired through interacting with our environment, as vision does not make sense to us without our experiential knowledge in relation to what we see (Noë, 2004). In design and craft practice, we may agree that knowledge is made through actions and that acting with and through a material is a form of sense-making. Enactivist theory confirms this notion.

The other strand of philosophy of mind and developmental science highlights simulation, which also refers to our mind-reading capabilities; for example, we may simulate in order to understand the mental states of others (Borghi & Cimatti, 2009, p. 763). This ability is generally thought to be facilitated by mirroring systems of the human brain (Gallese, 2001; Rizzolatti & Craighero, 2004). Mirror neurons, originally found in monkeys, fire in a qualitatively (although not quantitatively) similar way when a person is looking at someone performing an action, to when the person is performing that action herself (Gallese, 2001). That means we empathise with other people’s bodily actions: for example, when watching someone run or lift something heavy our respiration becomes faster even if we are sitting down motionlessly (for a review, see Hari & Kujala, 2009). Mirroring systems that support mental simulation and imitation are thought

to help us not only to connect socially with our friends but also learn, for example, tacit manual skills (Hari & Kujala, 2009).

Cognitive scientists Anna Borghi and Felice Cimatti (2009) argue for an extended view of embodied cognition that is grounded in and enabled by language. They consider language a form of action that extends the boundaries of the body, which may be seen in, for example, how we position our self and our sense of body in relation to hand-held tools and objects, also in passive body states (Borghi, & Cimatti 2009). For the context of design and craft, the use of activating words and the positioning of tools and hands in relation to possible actions or emotions is interesting and relates to the theory of *affordances* (Gibson, 1986) explained on the next page.

As seen in the above discussion, the embodied mind also manifests itself in and through language. The contribution of cognitive linguist Georg Lakoff and philosopher Mark Johnson (1980) highlights the metaphors that our language are built on and that are closely linked to the way we use and inhabit our bodies – through *image schemas*. A *body schema* is a conceptual representation of our body's interaction and movement in space, not to be confused with the more self-conscious *body image* (Gallagher, 1986; Johnson, 2007, p. 5). A body schema is the un-conscious and automatic bodily knowing that allows us to operate our body while attending to other things (Gallagher, 1986). The concept is not new, and has also been used by, for example, Merleau-Ponty, (1945/2010, p. 163).

Building on the concept of body schema, Johnson and Lakoff (1980) have developed and refined the concept of image schemas. Johnson (2007) explains the concept of image schema as the recurring structures and patterns we create through learning by action; “We learn what we *can do* in the same motions by which we learn how things *can be* for us” (p. 21). According to Johnson and Lakoff (1980), the image schema is directly responsible for structuring concepts. We may notice this in the way we construct language based on our bodily experience in relation to space, time and direction (Johnson & Lakoff, 1980; Johnson, 1987).

Different image schemas are exemplified as metaphors in our language as in for example the Up-Down, Front-Back and Container schemas (Lakoff & Johnson, 1980; Lakoff & Johnson, 1999; Johnson, 2007). As humans have a standing position we understand things to be organised in an Up-down pattern. Example: “*She was down yesterday, but now she has cheered up*”. As we have our eyes in the front we also have a backside, so we understand things to be align along a Front-back axis. Example: “*That was back then, this is ahead of us in the future*”. We experience having an inner and outer space, thus our bodies are our Container. Example: “*I need to get out of this situation*”. There are more than 100 identified metaphors and image schemas; Johnson lists the 27 “more important” ones (Johnson, 1987, p. 126) and gives us an example of how we include the notion of our bodies being containers that allow for inner and exterior space which we move between, in our conceptual language (Johnson, 1987, p. 31):

You look *in* the mirror and see your face staring *out* at you. You reach *into* the medicine cabinet, take *out* the toothpaste, squeeze *out* some toothpaste, put the toothbrush *into* your mouth, brush your teeth *in* a hurry, and rinse *out* your mouth.

Johnson (2007) further elaborates on the importance of emotions and feelings in the meaning making of our experiences and says that: “There is no cognition without emotion” (p. 9). However, he emphasises that this meaning making is not always conscious. Antonio Damasio is yet another cognitive scientist who ties the body and the mind together in his research, which is primarily on the relation between body and emotions. In his book *Descartes’ Error: Emotion, Reason, and The Human Mind*, Damasio (1994 p. 169 & 173) claims that bodily experiences, or “gut feelings”, generate emotions that guide us in intuitive decision making, and he calls this the somatic-marker hypothesis (*Soma* means *body* in Greek). While the role of emotion in reasoning and making decisions is recognised in studies of the embodied mind, the role of emotions has been precarious in general scientific research practices (Damasio, 1999, p. 39).

Both theoretical strands of embodied cognition, the “enactivist” and the “extended mind” version, presented above consider patterns of information in the environment that informs action. As such, they are very similar to the psychologist James Gibson’s environmental psychology (1986). Gibson’s work developed from defining the senses as perceptual systems (1983) that involve the haptic system (mentioned in the introduction of this thesis, page 2) to an environmental psychology mainly focusing on the visual perception (1986). In this work, Gibson describes organisms’ (human and animal) information pickup processes. Gibson (1986, p. 127) describes his concept of affordance as follows: “The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill” (Italics in the original).

Gibson’s theory of affordances is directly linked to the idea that meaning is made by the sensory experience of the environment in a direct and un-reflected manner that invites us to act upon situations accordingly. This understanding has also been drawn upon in design research, especially in interaction research (Dourish, 2001), but perhaps most fundamentally in product-design, by Donald Norman (1988) (to be discussed in the next section on page 26–27).

As mentioned in the introduction, Gibson (1966/1983, 1986) also contributes to the field of sensory cognition. In the sensory cognition strand, vision and related cognitive aspects are well researched, while touch has been studied relatively little (Gallace, 2012; Nicholas, 2010). Gallace and Nicholas are looking into the sense of touch and how we make sense through our tactile understanding. Nicholas (2010) has studied deafblind subjects and found that deafblind people are generally more experienced in recognising stimuli by active touch (p. 17), their tactile memory is enhanced and they have a superior tactile performance (p. 18). Blind touch

has also been researched in relation to architectural studies, especially by design researcher and architect Ann Heylighen and her research group (Vermeersch, Nijs & Heylighen, 2011). Blind informants give another view on the sensory experience of a space that is concretely felt and embodied.

Human geography is a research field mainly concerned with the interaction between human and environment, thus, research involving perception is also developing in this strand. Human geographer Paul Rodaway wrote about 'Sensuous geographies' in 1994. Mark Paterson (2009) further develops the concept of 'Haptic geographies' and calls for research methods that take the haptic modality into consideration. Human geographer Hanna Mcpherson (2009) also studied the aspect of blind touch as she interviewed visually-impaired walking-group members, and paid particular attention to their way of articulating the felt experience. As blind touch is primarily associated with the hand, the notion of the participants describing their *thinking through their feet* was a new discovery (Mcpherson, 2009, p. 186; see also Tim Ingold, 2004). Some strands of ethnography likewise expand towards the sensuous realm and human geography through sensory ethnography (Pink, 2009, 2011; Ingold, 2004; see also Paterson, 2009).

These strands of research draw on embodied cognition theory and links to the non-representational theories initiated by human geographer Sir Nigel Thrift (for an overview, see Anderson & Harrison, 2010). Non-representational theories deal with the un-procedural meaning-making that transcends language and other symbol systems, such as visual representations, and that form the personal and embodied knowledge in, for example, practice-based domains. It is described as thinking-in-action, or as the unreflective background knowledge that we are not conscious of but that enables all representing to take place (Anderson & Harrison, 2010, p. 7, see also Harrison, 2000).

The direct and unmediated sensory dimension of sense-making is thus concerned with reducing the distance between subject and object – as opposed to being distanced by representation as mediation (Gregory et al. 2009, p. 646). The representational model is in this view seen as inhibiting or restricting access to the “perceptual practices of our sensory and somatic lives” (Gregory et al. 2009, p. 646) while the non-representational theory “attends to how certain spaces, experiences and states act directly on the body, addressing the manifold affects, sensations and, indeed, visibilities of the world in the subject’s felt engagement with it” (p. 646).

In the field of craft education, craft researcher Milla Ojala (2013), links sensory experiences and perceptual processes to the construction of knowledge during craft making. She identifies seven concepts that describe the perceptual processes during a making activity in crafts: imitative, anticipative, evaluative, experimental, emotional, temporal and bodily perceptions (Ojala, 2013, p. 67). Thus, a direct role is attributed to sensory experiences in the sense-making process in the field of craft. Similarly, glass artist and researcher David Prytherch (2002), has focused on the

haptic system in relation to creative processes in arts based craft. Prytherch describes the sensorial sense-making related to art and artistic process in very similar terms to those in which Johnson describes his theory on the aesthetics of human understanding (2007). Prytherch (2002, p. 7) writes:

Art, like the senses, operates simultaneously on many different levels. It is this very multi-layered interaction that challenges scientific attempts to quantify and separate out its elements whilst retaining a realistic understanding of the whole. Haptic sensibilities, by their very nature defy reductionist methods of investigation, yet are demonstrably significant in the perception of our reality.

Prytherch is a glass artist and links the word *art* to his own practice. However, craft theoretician Glenn Adamson in his book *Thinking through craft* (2007) makes the differentiation between art and craft in the way that art is concerned with the distant visual and craft with the tactual material, as craft is grounded in and always “entails an encounter with the specific properties of a material” (p. 39).

Within craft research, as elsewhere, there are theories on different types of intelligences or cognitions, describing the body as having one way of processing information and the rational mind another (see, for example, Abrahams-son & Lindgren, 2014, p. 2; Storkersson, 2010). Johnson (2007) highlights the importance of not understanding this as the body knowing something that the mind does not and vice versa. Instead, we may benefit from understanding the bodymind as a psychophysical entity that is embodied and not as two completely separate types of cognitions, as this will again drive us into a dual system that is not integrated (Johnson, 2007, p. 12–13). How we are able to articulate knowledge that is specific, concrete and body-based through a conceptual and general language is a different issue (See also Tin, 2013).

Although embodied cognition theory was not initially developed in the field of art, crafts or design, it seems a very natural theory for understanding knowing-in-action, involving sense-making in and through making with a material, as well as emphatic and emotional aspects of sense-making. Having said that, it is clear that embodied knowing is implicit and tacit. The notion of tacit knowledge is, however, not a new idea in the field of design and craft.

2.3 Embodied Cognition in Design: Knowing-in-Action and the Reflecting Practitioner

As the concept of embodied cognition has developed in philosophy and cognitive neuroscience, there is no direct link to design and craft practice. However, the fields of design and craft research have a long history of studying situated learning and body-based knowing through other concepts.

The term ‘tacit knowledge’ was coined by physical chemist and philosopher Michael Polanyi (1958, 1966) and is generally understood as un-declarative practically-oriented knowledge. As such, it is very closely connected to experiential knowledge. Polanyi speaks of the subjective and personal knowledge that guides the researcher in his work (Polanyi, 1958). Polanyi (1966) also elaborates on the role of the body in sense-making and says, “Our body is the ultimate instrument of all our external knowledge, whether intellectual or practical” (p. 15). Polanyi (1966) recognises the extended aspect of knowing and the embodiment of objects and goes further: “We can say that when we make a thing function as the proximal term of tacit knowing, we incorporate it in our body – or extend our body to include it – so that we come to dwell in it” (p. 16).

Along with tacit knowledge (Polanyi, 1958, 1966), experiential knowledge has been preferred when describing the reflective conversation with materials (Schön, 1991) so essential in any making with hands. In the field of design and craft, the study of practice has opened issues to do with knowledge being situated in actions. American pragmatism (Dewey, 1934/2005; Shusterman, 2005) has long reconnected aesthetics to sensory experiences (aisthētikos) and discussed knowledge as being situated in actions. As discussed earlier, Donald Schön (1983) draws on Dewey and emphasises the reflection in and on action made by the practitioner and thus links to sense-making through actions.

Designers in both product-design and interaction-design have additionally relied on the theory of affordances, coined by Gibson (1986). However, by agreeing with this theory, it is necessary to adopt a worldview that accepts the embodied mind. Design thinker and computer-science researcher Donald Norman (1988), after conversations with Gibson himself, relates the idea of affordances to design practice in his book *The Psychology of Everyday Things*. The theory of affordances was quickly taken up in design practice due to this book and has influenced the field of human-computer interaction in particular (Dourish, 2001.)

Recently Norman (1999) has warned that the concept has been slightly misunderstood, as he says that he did not at the time properly grasp the idea of Gibson’s theory, Norman writes: “I came to appreciate the concept of affordances, even if I never understood his other concepts, such as “information pickup.” He and I disagreed fundamentally about how the mind actually processes perceptual information (that phrase alone would infuriate him)” (p. 39).

Gibson (1986, p. 225) clearly promotes the idea of the embodied mind through his work, and takes a firm position against the hierarchical dichotomy of mind over body and the computational model of the mind in the following:

Neuropsychologists, most of them, are still under the influence of dualism, however much they deny philosophizing. They still assume that the brain is the seat of the

mind. To say, in modern parlance, that it is a computer with a program, either inherited or acquired, that plans a voluntary action and then commands the muscles to move is only a little better than Descartes's theory, for to say this is still to remain confined within the doctrine of responses.

Norman (1999) has since tried to clear up the misunderstanding of his use of the concept, linking the word affordances more tightly to Gibson's original environmental psychology and developing a new understanding of the phenomena, presenting design-related visible affordances as "signifiers" (Norman, 2008). It seems from this discussion that Norman would not accept the concept of the embodied mind and related ideas of organism-environment interaction. However, other researchers have re-connected the original theory of affordances to design, saying that Donald Norman was on the right track after all (Hartson, 2003).

Philosopher Bengt Molander (1996) draws on Schön in his book *The Practice of Knowing and Knowing in Practices* (Kunskap i Handling). He says that knowledge that is situated in practice is *alive* and cannot be separated from the practitioner and the tradition that it is anchored in (Molander, 1996, p. 68, see also Adamson, 2007, p. 4). Similarly, the anthropologist Tim Ingold in his book *Making* (2013) draws on learning through action, suggesting an approach to research in which he challenges the researcher to "learn by himself" by acting and making in order to earn an intrinsic understanding of the phenomena under study (p. 1). Ingold (2013, p.1) writes; "To know things you have to grow into them, and let them grow in you, so that they become part of who you are".

From this discussion, it seems that both design researchers and designers have for some time been looking outside the scientific model for theories and methods more adaptive to the practice, but only recently have researchers in product-oriented design and craft relied on the concept of embodied cognition as such, as will be discussed in the following passages.

While design is relatively new to the field of embodied cognition, the field of dance and performance have come a long way. Through being concretely depending on the action of the body, the field of dance is ahead of design and craft studies when it comes to investigating the embodied mind. For example, dancer and philosopher Susan Kozel (2011, 2013) has built her phenomenological research on the body's movement and expression, and the whole field is advanced in this sense. Similarly, performance and cinema have studied their phenomenological (Loukola, 2014) and enactive (Tikka, 2008) aspects. Kozel advocates the use of phenomenology as it removes unhelpful divides such as theory and practice. Mirroring in particular, studied as part of embodied cognition, has been linked to the concept of affect as well as skill learning in dance practice (Calvo-Merino, Glaser, Gre'zes, Passingham & Haggard, 2005; Kozel, 2013).

As already mentioned, embodied cognition has recently become much more elaborated upon in the field of interaction-design, especially in

relation to tangible interfaces. Computer scientist Paul Dourish (2001) has influenced the field through his book *Where The Action Is: The Foundations of Embodied Interaction*. Similarly, human-computer interaction researcher Eva Hornecker has integrated the embodied view in a long history of research on interaction-design (Hornecker & Buur, 2006; Hornecker, 2011). Interaction-design researcher Kristina Höök is transferring embodied horse-riding skills to interaction (2010). Design researcher Danielle Wilde and her fellow researchers (Wilde, Tomico, Lucero, Höök & Buur 2015) are looking for ways to research embodied experience in wearable textile interactions. Several new research contributions that link embodied cognition theory to interaction-related design methods are being made by interaction-design researchers Ambra Trotto and Caroline Hummels, (2013) and Hummels and Jelle Van Dijk (2015).

The general theoretical framework of Embodied Cognition (mentioned in the above passages) has recently been touched on within product-design (McNerney, 2013; Poulsen & Thorgensen, 2010; Ramduny-Ellis, Dix, Evans, Hare & Gill, 2010). In a recent study in product-design, design researchers Thomas van Rompay and Geke D. S. Ludden investigate embodied cognition in relation to designing objects' expressions as a way of communicating certain features to the customer (Rompay & Ludden, 2013). Design researchers Thomas van Rompay, Paul Hekkert and Wim Muller (2005) have written on the embodied aspects of products' expression, tying viewers' experiences of them to image schemas, as developed by Lakoff & Johnson (1999). For example, a large chair that is stable and shields the user from the outside by creating an inner space ties to both the container schema and the balance schema, thus giving an expression of stability and security (Rompay et al., 2005).

The aspect of empathy in connection to design was touched upon as early as 1897 by psychologist and philosopher Theodore Lipps (see Rompay et al., 2005), whose theory included projecting oneself onto the object of perception, exemplified by the embodied understanding of the heavy weight that the pillars have to carry in holding up ancient Greek architectural structures (Rompay et al., 2005, p. 1). This notion of empathy may be connected to mirror systems theory as the viewer of the pillars might imagine how heavy the weight must be.

Empathic design (Battarbee, Fulton & Gibbs, 2014), human experience and behaviour may act as a starting points for design (Fulton Suri & Hendriks, 2010). In the design office of IDEO, the utilisation of "experiential sketching" and "body storming" are means of enacting the experience of, for example, patients in a hospital environment (Fulton Suri, 2003).

An unreflective aspect of behaviour and embodied cognition is especially vivid through the work of human-centred designer Jane Fulton Suri in her book *Thoughtless Acts?* (Fulton Suri, 2005). Product designer Naoto Fukasawa (Fukasawa, 2007) also utilised the unthinking aspect of human behaviour in his designs. Fukasawa has facilitated several workshops with

young designers and exhibited their works under the exhibition name Without Thinking (Shoji, 2002). Both Fulton Suri and Fukasawa display subliminal human interaction with objects and spaces that are shared but unpronounced. The way we read Fulton Suri's images (Images 4a, 4b, 4c) strikes a chord with Johnson's (2007) claim for the embodied, immanent, pre-conceptual and non-propositional meaning-making that he considers the basis for all forms of meaning and grounds our more abstract concepts (p. 34; also Johnson, 1987).



4a



4b



4c

Images 4a, 4b, 4c. Images from Fulton-Suris' book *Thoughtless Acts?* (Copyright IDEO with permission.)

In an interview, IDEO Designer Michael Hendrix says that the design team first leaned on intuitions of embodied cognition without knowing about the underlying theories (McNerney, 2013). However, now the design team is aware of where their insights are grounded, as Fulton Suri says in the same interview:

Evidence from studies of embodied cognition can... provide science-based rationale for design decisions. They can increase our confidence about the importance and validity of design details we're proposing. Not only is specific evidence from their empirical studies useful to design, even the evidence of embodied cognition itself lends weight and credibility to the patterns that many designers recognize intuitively. For audiences who prize objectivity over intuition, the psychology of embodied cognition provides us with a rational basis to explain why particular design concepts and design details are relevant.

As mentioned before, issues of embodied cognition have recently attracted considerable interest, and more and more designers have begun to refer to the concept as such. Instead of referring just to making with hands or the embodiment of an idea in physical form, this theoretical framework calls for a fundamentally different attitude towards sense-making, one that shifts from observing to acting, from objective to subjective, from the verbal to the performed. Instead of thinking of us *having a body*, this attitude rather requires us to think that *we are our body* or simply that the mind and body are one.

However, embodied cognition theory suggests that we offload meaning onto objects, thus extending our mind. This aspect is also familiar in general product-design as the role of object relationships and extensions of the self is acknowledged (Jarrett, 2013). In this context, tactile qualities are highlighted as they are also transferred to the user or consumer through the produced object. These felt qualities make a difference in the lived experience of a product (see also Karana, Pedgley, & Rognoli, 2015a, 2015b).

Some theory building in the field of sensory cognition has used tactile aspects to exemplify this embodied notion. Gallace (2012) for example, refers to research by psychologists and researchers on haptic and tactile experiences Joshua Ackerman, Christopher Nocera, and John Bargh, (2010) on the psychological qualities that *weight* is associated with. In one of these research events, a person's Curriculum Vitae (CV) presented on a heavier clipboard was evaluated as portraying a more serious and capable job applicant than a CV presented on a lighter clip board, although the content of the CV was exactly the same on both clipboards (Ackerman et al. 2010). Similarly, the perception of food can be affected by the weight of the plate that it is presented upon (Gallace, 2012). Gallace (2012) sums this up as follows (p. 899):

(...) certain tactile qualities of objects, such as their weight, texture and hardness have a strong effect on the neural processes that immediately follow the contact. In

particular, the neural activity generated by these tactile attributes might trigger in the participant's brain the associated concepts (e.g. strength or weight) and therefore affect their behaviour and choices.

These psychological aspects of weight in relation to how we perceive objects are important in the field of product design and may affect the success or failure of a product. However, as embodied sense-making in relation to tactile experiences may go unnoticed and stay unpronounced, only sales figures will tell the story.

2.4 Experiential Knowledge Articulated through Practice-led Research

As elaborated above, design and craft research have studied issues of embodied knowing using other terms developed within its own practice. Most of the recent research involving the body and the sensory experiences of the practitioner are naturally situated within the practice itself.

Clearly there are challenges when reaching for knowledge that is situated, immersed in the body and enacted through the body in action, and known rather as an implicit reflection by the embodied mind on its interaction with the environment. However, the practice-led research setting allows us to study practice *through* practice, enabling the explicable part of this experiential knowledge to emerge and facilitating reflection *in* and *on* action. Now that practical fields such as arts and crafts and also nursing and teacher education have been accepted into academia, this self-study approach has developed naturally, especially in the area of arts (Candy 2006; Mäkelä, Nimkulrat, Dash, & Nsenga, 2011; Nimkulrat, 2009, 2012) but also in other practice fields (Hamilton, 1998; Pinnegar & Hamilton, 2009).

To complement and to extend the work of design and craft researchers and writers such as Peter Dormer (1994), and Richard Sennett (2008), who have written very vividly about craft and design without having a craftsman's education or much personal experience of designing or making, there is now a new generation of researchers who are also trained as craftsmen. These researcher-practitioners provide us with new insights into what embodied knowing means in the field of craft and design, from an insider's point of view.

Many recent contributions in the field of experiential knowledge have been made by craft and design practitioners who study their own practice. Through her research and publication work, silversmith and design researcher Kristina Niedderer has developed an interest group within the field of design and craft research: the Experiential Knowledge Special Interest Group (EkSIG), which participates in general design conferences and also arranges its own conference biannually, disseminating practice-led

work on the tacit and experiential expertise that reside within design and craft practice. Textile artist and design researcher Nithikul Nimkulrat also contributes to the activities and content of this group.

In Norway, woodcarver and design educator Marte S. Gulliksen leads the Embodied Making And Learning (EMAL) research group, who are actively researching embodied ways of learning in design education. Similarly, textile designer and design researcher Katherine Townsend leads the Digital Craft & Embodied Knowledge Research Group in Nottingham, England. Alongside these, the growing community of researcher-practitioners includes academics from art as well as the design and craft research domains (Bang, 2010; Ings, 2014; Mäkelä & Latva-Somppi, 2011; Niedderer, 2009a, 2009b, 2012, 2013; Niedderer & Reilly 2010; Niedderer & Townsend 2014; Nimkulrat, 2009, 2012; Pedgley, 2007; and Riis, 2016 and in ceramics Berg, 2014; Boos, 2011; Brown, 2010; Falin, 2014; Hansen, 2010; Mäkelä, 2003, 2016; Slotte, 2010; Renshaw, 2014; Rylander, 2012; Scott, 2010; Wilson, 2016; Winkler, 2013).

Examples of practitioners who research their own craft practice through examining the embodied, and especially the tactile, aspects of the process include ethnographer Erin O'Connor, who trained as glassblower for two years while reporting on her learning experience through very vivid accounts of personal experience (O'Connor, 2005, 2007). A group of researcher-practitioners, Almevik, Jarefjäll, and Samuelsson (2013), physically re-enacted the sequence of a video documentary on a metalsmithing process from the 1970s in order to also be able to reflect on their own tactual and experiential knowledge of the same process. The tactile aspect of materiality is naturally of importance also in the field of textiles. Weavers Anne Louise Bang (2010) from Design School Kolding and Anna Piper (2016) from the Digital Craft & Embodied Knowledge Research Group at the Nottingham Trent University have both studied tactile experiential knowledge in their practices.

David Prytherch (2002) is a glass sculptor and engraver with 30 years of professional experience, whose research on haptic experiences in the making and sense-making of artists have been informed by his own practice, while the participants of his research are other glassmakers. In ceramics Bonnie Kemske (2007) studied the aspect of touching through huggable and body held ceramic sculptures. Astrid Heimer (2016) studies how her body makes shape take form through the clay material.

What all the above researchers have in common is that they study their own practice in a practice-led research setting. Many have a strong background in the crafts but contribute to the design research contexts. Although not necessarily connecting to the theory of embodied cognition as such, they describe the experiential knowledge they process in the act of manipulating material. By doing so, they also contribute to the discussion on *how* to research and disseminate this type of knowledge, and thus also shape the research environment by making it more open to the study of embodied knowing within design and craft practice.

2.5 Theory Synthesis

From Descartes' dualism, through Heidegger and Merleau-Ponty, we philosophically move towards accepting the mind as embodied and including the body in knowledge making. Enactivism extends this to include the plasticity of the mind that is created through physical interaction: knowing in action. In design research, knowing in action has been a fundamental concept since Dewey (1934/2005) and Schön (1983). In addition to these two writers, Noë (2004), Molander (1996) and Ingold (2013) speak of knowledge that is situated in action; together their writings contribute to theories of practice. Practice-led research is situated within the practice, and it tries to explicate this knowing through action and reflects on practice from the practitioner's point of view.

Parallel to these developments, design cognition studies develops understandings related to the problem-solving nature of design tasks and the internal and external representations. However, it seems that the scientific research model (described in section 2) that design cognition research has relied on until recently does not support the concrete material and embodied aspects of design and craft practice. Consequently, design and craft practice have sought solutions to this issue in concepts such as tacit knowledge, the theory of affordances, knowing in and through action, emotional and empathic design, and even human-centred design, all of which have strong links to embodied cognition theory.

Whether designing objects or interfaces, services or social structures, taking embodied cognition as the fundamental way of negotiating meaning by being a body in the world and creating knowledge through interacting with our environment seems purposeful also in the field of design and craft. The question that emerges from this background is: What does embodied cognition theory entail for the field of design and craft practice? Or, more specifically for the purpose of this research: How do design and craft practitioners make sense through their embodied interaction with materials?

3 Research Questions

The general research question in this study is:

How do design and craft practitioners think through their hands?

The specific sub-questions for each case are:

Case 1:

How do experts in tactile knowing use their enhanced tactile sense in a making situation?

Case 2:

What methods may be used in the study of embodied and experiential knowledge in crafts?

What is the role of emotions in connection to tactile experiences in a craft practice?

Case 3:

How do design students use embodied knowing in material exploration?

Case 1 deals with one sub-question that is answered in Publication I. Case 2 deals with two sub-questions, as the case was large and involved two rounds of analysis, thus two publications answer these separate questions, namely Publications II and III. Case 3 deals with one sub-question that is answered in Publication IV, as shown in the table (Table 2).

Typical for an explorative research process, the initial research questions have been modified alongside the advancement of the research and developed with the insights gained during the process. Therefore, the questions posed in the original publications reflect the initial research approaches. However, as the understanding of the theme and features of the knowledge to be had have developed, these have become more refined and modified to reflect the overall understanding and contribution in this summary.

Table 2. Summary of the cases and their relation to the sub-questions and publications.

Case	Sub-question	Publication
1	How do experts in tactile knowing use their enhanced tactile sense in a making situation?	I Making sense – What can we learn from experts of tactile knowledge?
2	What methods may be used in the study of embodied and experiential knowledge in crafts?	II Tactile augmentation: A multimethod for capturing experiential knowledge
2	What is the role of emotions in connection to tactile experiences in a craft practice?	III Emotions in risk-assessment and decision-making processes during craft practice
3	How do design students use embodied knowing in material exploration?	IV The knowing body in material exploration

4 Research Design and Methods

Material manipulation and exploration, either as a pastime or as the investigation of possible design outcomes, provide us with a setting for studying the interaction between mind and environment. As the present research design comprised three case studies, it provided an opportunity to visit three different contexts and perspectives for such activities. I first gained inspiration and a deeper understanding from experts in tactile knowledge, then I turned my attention inwards to study my own experiences in my practice, and finally I turned my gaze outwards again to study what this means for design students. Although quite different settings, they all focus on haptic and tactile experiences and sense-making in material manipulation.

4.1 General Orientation of the Research

The general orientation of this research follows the qualitative research paradigm as outlined by Denzin and Lincoln (2011). In this view, “qualitative research is a situated activity that locates the observer in the world” and that involves an “interpretive and naturalistic approach to the world” (2011, p. 3). Objectivity is not seen as a possibility, instead Denzin and Lincoln (2011, p. 5) state clearly that “[o]bjective reality can never be captured”. They further encourage the researcher to act as a “bricoleur”, learning how to borrow from many disciplines and creating a quilt of knowledge through the use of multiple methods (2011, p. 4).

The study of human experience is complicated and there are no useful measures or scales that may be utilised. This is especially true when studying experiential knowledge that is tacit and implicit, only revealing itself in enactments and in moments of time. The involvement of the researcher and her personal experience may be of value when attempting to analyse, interpret and make sense of experiences in this context. Therefore, I have used contexts familiar to my own practice as the site for this explorative and practice-led study.

The case study methodology developed by Yin (2009) was used as a frame and general design for this research, yet within each case a variety of methods are used for collecting data. The case study methodology is useful when researching *How* and *Why* questions during contemporary events that do not require a controlled research setting (Yin, 2009, p. 8–9). It allows the researcher to retain the holistic and meaningful characteristics of real-life events and can be used as exploratory research while still

providing the researcher with evidence for descriptive and explanatory dissemination and allowing for the inclusion of mixed methods studies (Yin, 2009, p. 4–5). Additionally, the case study inquiry benefits from the prior development of a theoretical proposition to guide the data collection and analysis (Yin, 2009, p.18).



Image 5. By using multiple case studies, I was able to shed light on the research question from three different perspectives.

The *multiple* case study methodology was chosen to study the research question in three separate environments (Image 5). Essentially, both Case 1 and Case 3 focused on two participants, which means that these cases evolved from being a case study on a group to concentrating on a two-case (Yin, 2009, p. 24) within the multiple case study of three separate cases. Since Case 2 contained very rich data and there was a clear new theme discovered in the first general analysis, Case 2 called for a new focus of analysis in addition to the first main focus. Therefore, this case involved two analysis processes and contributed to two publications (II and III). The first publication of this case (Publication II) then described the multimethod developed for the data collection, and the second (Publication III) describes some of the main findings.

The multiple case study design was not intended to be comparative; the settings are far too distinct to facilitate a comparison. Rather, the design allows for the creation of theoretical replications (Yin, 2009, p. 59) and comparison of the findings, thus revealing different perspectives on the same phenomena, that is, how design and craft practitioners think through their hands.

Within the constraints of one doctoral thesis, aiming for the inclusion of different perspectives allows for a deep dive into a relatively small portion of data in each case compared to a thesis that has only one perspective. Thus, this way of designing the research provides a larger width of view but with the results being gained from a rather specific condition within each perspective. Using a narrower perspective makes it possible to analyse a phenomena more deeply from that particular perspective. This present thesis follows a wider (A) design visualised in the image (Image 6).

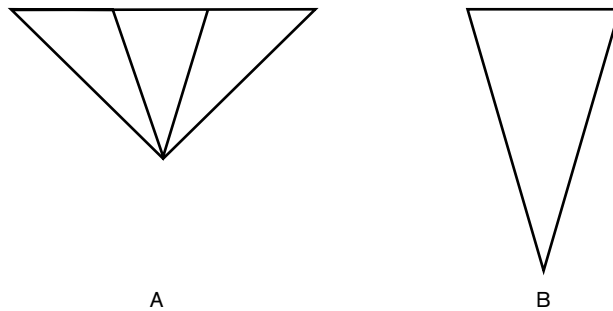


Image 6. Visualisation of two types of doctoral thesis.

As the research for this doctoral thesis is conducted within a larger research project called Handling Mind, there were also possibilities and constraints in relation to the research design of this individual work. Handling Mind is one of 12 projects that are part of the Human Mind research project initiated and funded by the Academy of Finland, and the Handling Mind research consortium includes the following: Aalto University, the University of Helsinki, the University of Turku and the Finnish Institute of Occupational Health.

The project is co-directed by Pirita Seitamaa-Hakkarainen (University of Helsinki) and Maarit Mäkelä (Aalto University). This large multi-disciplinary research project aims to provide a bridge between areas of neuroscience, psychology, design and educational research. In this way, the research done is concerned with embodied activities, social creativity and the expanded nature of the human mind.

Through four interlinked study tracks, researchers examine how participation in creative activities, associated with crafts and design, affects the participants' socio-emotional experiences, with the focus on the interaction between mind, body and materials. Track A addresses personal improvisational creativity, embodied and sensory experiences and emotions related to design processes and material exploration. Track B focuses on artefact-mediated sharing of expertise in craft design. Track C addresses neural correlates regarding relations between reproduction and innovation. Track D focuses on neural indications of the development of craft-design skills.

This doctoral research is situated within Track A, thus the data collection for this research was situated within the parameters of this project. However, the Handling Mind project was created around the initial research plan of my doctoral research; hence, the theme of the project was in line with my objectives. I had already begun my research and data collection for Case 1 when the funding was secured and the Handling Mind project was launched in January 2013; thus, the first publication (I) was already counted as a contribution to the Handling Mind project.

Case 2 was a natural continuation of my research, but at the same time the methods used were part of piloting data collection methods for Track A. This is the primary reason for including, for example, the contextual activity sampling system CASS-Q. Similarly Case 3 utilises the data collected in Track A that uses the Design Exploration and Experimentation (DEE) Masters course of the Design Department at the Aalto University, School of Arts, Design and Architecture as its research platform. However, the data collected within Track A of the Handling Mind project was considered suitable for the objectives of my doctoral thesis since the purpose was to investigate design and craft practitioners' material engagement.

In the following, the three cases and the data collected is briefly presented. A more thorough description can be found in the original publications in section 9.

Case 1 involves three exploratory ceramic workshops and a discussion seminar with deafblind persons concerning tactile knowledge. This case directly relies on methods inspired by sensory ethnography as I entered a culture that differed from my own with regards to sensory experiences. The methods used for data collection include participatory workshops, video and audio recordings, interviews using semi-structured questions and two recorded discussion forums. The data were analysed through ethnographic and qualitative content analysis. For the publication (I) I framed the analysis and discussion around the two participants in the third workshop.

Case 2 involved a practice-led study of my own tactile exploration process in ceramic craft practice. I was recording a five-day blindfolded studio working process and developed a method for studying sensory experiences. In practice-led research, data are typically collected using the diary method as well as other creative means of documentation. In the current research, I supplemented these with a contextual activity sampling system (CASS-Q) (explained in detail in the description of Case 2 on pages 45–47, and in Publication 2 on pages 115–117), together with video documentation facilitating think aloud accounts, which means speaking one's thoughts out aloud while working, together with a protocol analysis. The analysis was conducted in two parts, first through video-aided protocol analysis and later through the video-analysis software *Interact*.

In Case 3, I was utilising data produced by Masters' students during their course at the Design Department of Aalto University, School of Arts Design and Architecture. The data derive from two separate years and included

both verbal and visual material by a total of 19 students. All material collected was initially analysed through colour coding according to themes that were emerging from the data. From this data, two students' cases were selected as they involved processes rich in tactile and material engagement and literal references to the importance of the tactile sense. The two students chosen were also considered craft and design practitioners' in a more professional way as they both had a background as artisanal craftsmen before joining the Masters' course. The data produced in the course is very rich and it was necessary to make an appropriate selection in order to reduce the amount of data and to be able to make an in depth analysis of the emerging themes taking the theoretical aspects into consideration. In addition to using the existing material, I also interviewed two students, using a semi-structured set of questions. The data were analysed through a thematic content analysis.

The methods used in each case are further described in the following section that introduces the three cases, the data collection processes and the method of analysis. The results are presented in section 5 and discussed in section 6.

4.2 Overview of the Research Setting

Table 3 shows a summary of the participants, data, focus and method of analysis used in the different cases.

4.3 Case Description and Data Collection

In the following section, the three cases are described and the methods used for data collection and analysis are presented.

4.3.1 Case 1: What Can We Learn From Experts in Tactile Knowledge?

Due to both audial and visual impairment, a deafblind person's opportunities for interaction, either social or material, is drastically hampered. The one modality that is strengthened due to their condition is the haptic modality, and one activity that complements this haptic and tactile perception is craftmaking. Consequently, ceramics is a popular activity among this group of people. Participants for this study were invited to take part in ceramic workshops by the Finnish Deafblind Association, knowing that the teacher would be conducting research in connection to their making activities. The participants signed up voluntarily to join the class.

Table 3. Summary of the participants, data and focus / method of analysis of each case.

Case	Number of participants	Data	Focus of analysis	Method of analysis
1	16	2 h 30 min video and 1 h 56 min audio recordings, participants' verbal accounts during three participatory workshops and two discussion sessions, ethnographic notes.	Haptic / Tactile experiences and embodied knowledge.	Ethnographic and qualitative content analysis
2	1	10 h video recordings, think aloud accounts, contextual activity sampling, diary notes during five throwing events	a) Haptic / Tactile experiences and embodied knowledge. b) Emotions related to tactile experiences.	a) Protocol analysis b) Video analysis using <i>Interact</i>
3	19	Students' drawings, diaries, weekly reports, final reports, 48 min video recordings and two audio recorded interviews of 2h 40 min, during an 8-week design course.	Haptic / Tactile experiences and embodied knowledge.	Thematic content analysis

Research methods inspired by sensory ethnography were utilised in these workshops. In Pinks' description of the sensory ethnographic research method, she emphasises the necessity for the researcher to sensitise herself to her own sensory experiences in order to understand others' sensory experiences (2009, p. 51). She also advocates the need to employ mixed qualitative methods, gather multiple types of data and analyse these in different ways to make connections between the different levels of knowledge involved (Pink, 2009, p. 131).

Case 1 involves three ceramic workshops with deafblind makers: the workshops were conducted in the spring of 2012 and one discussion seminar in the autumn of the same year. The main task of the study was to investigate unique processes related to creative working in a setting where the haptic sense is enhanced.

The events were arranged over the following period during 2012:

April 17 Workshop led by ceramist Soile Paasonen with seven participants. This took place at the IIRIS Centre Helsinki and lasted for three hours. I assisted as well as collected research data.

April 30 Workshop led by me with three participants. This took place at the IIRIS Centre and lasted for two hours.

May 15 Workshop led by me with two participants. This took place at the Tampere Resource Centre for the Deafblind and lasted for two hours, plus a one hour discussion after the event.

October 23 A discussion seminar of two hours was arranged with seven participants. This took place at the IIRIS Centre.

The total number of individual participants in all workshops and the seminar was 16; some overlap of participants occurred. The total amount of audio recordings and video material from all sessions was 1 h 56 min and 2 h 30 min hours, respectively, together with photographs and ethnographic notes. The applied ethnographic analysis focused on references to tactility and embodied knowing occurring in the participants' use of language. Further, the participants' actions were related to my own practical and embodied knowledge in handling ceramic materials.

Due to their special condition, the participants had differing degrees of audiovisual impairment. Therefore, they brought their translators, and some brought also a personal assistant. All communication was translated using either tactual sign language (see Image 3 on page 101 in publication I), sign language or aided by an inductive hearing aid.

During the video- or audio-recorded workshops, I asked the participants semi-structured questions through an interpreter while they were working in order to capture their situated and un-reflected thoughts. The questions were based on a first question such as *What are you doing right now?* or *what are you thinking right now?* Followed by follow-up questions related to the answers. Due to the difficulty in communication, these workshops intuitively became participatory workshops.

After the two workshops in Helsinki, a third workshop was arranged in Tampere involving only two participants, who were invited to participate through the Finnish Deafblind Association. This was done in order to pursue a deeper and more concentrated study as the previous workshops were quite hectic and busy, including as they did the many additional assistants and translators. Publication I, which was written as a result of Case 1, mainly concentrates on data from this Tampere workshop, although it is informed by the general comprehension of the three workshops and the discussion seminar.

The workshop in Tampere was arranged in the Resource Centre for the Deafblind (Kuurosokeiden toimintakeskus). One of the participants was a 55-year-old man. He is deafblind, and communicates by tactile sign language, that is hand-on-hand signing; therefore, he had brought his

sign-language interpreter to the workshop. The second participant was a 36-year-old woman, who is deaf but uses a hearing aid. At the time, she had 10% eyesight left and communicated by using speech. Both participants work professionally in the area of art; the former uses mixed media in his artwork, whilst the latter is a painter.

The workshop started with a brief description of the layout of the workshop so that the participants would know about each other's presence and the available materials and the space layout. I asked the participants to provide a brief account of themselves and their relationship to clay as a material. They had some previous experience in sculpting and in using clay, including throwing, but were not experts. Then, the participants were handed a piece of clay, and they were given a free choice as to what to make.

During the two-hour workshop, I interviewed the participants while they were working, asking semi-structured questions as described above. I also helped them technically with their clay work in case of need. The male participant wanted to throw clay on the potter's wheel, and I helped him in this activity by throwing together with him. After the workshop, the whole team, that is me, the two participants, the translator, and the workshop facilitator from the association assembled in a coffee room for one hour to talk generally about the experiences during the workshop. The workshop activities, interviews and the discussion session were recorded on video.

4.3.2 Case 2: Tactile Augmentation in Ceramic Craft Practice

While using methods from sensory ethnography (Pink, 2009) by participating in the making process of the deafblind in Case 1, I came to the conclusion that it is not as feasible to study *someone else's* sensory experiences as it would be to study my own, and that I could complement this study with my own experiences. This led to the exploration of methods that could be used in a practice-led research setting, in order to gather data from an informed autoethnographic point of view. By combining different approaches and methods, I aimed to collect multiple types of data for my study.

Designer and researcher Owain Pedgley (2007) admits that the multiple roles of researcher and respondent are complicated; therefore, he argues for the importance of multiple data collection methods in order to triangulate data and results. In the practice-led research conducted in Case 2 of this thesis, both qualitative and quantitative data, introspection and visual documentation, are collected and triangulated, as also recommended by Denzin and Lincoln (2011, p. 5), who emphasise the use of multiple methods or triangulation to secure an in-depth understanding of a phenomena.

Research in the field of design cognition has traditionally not involved self-study, but rather designers' activities and cognitive processes have

been studied by a researcher through think aloud accounts and protocol analysis. Also, video-analysis and interviews have been employed in such studies. In Case 2, I combine the self-study approach with these more traditional methods.

Case 2 thus involved a practice-led self-study during which I documented a five-day blindfolded clay-throwing process, developing a method for studying sensory experiences, haptic and tactile experiences in particular. The study took place during the spring of 2013. The idea of augmenting my own tactile awareness by blindfolding was inspired by Case 1, which involved the deafblind participants and related theory on sensory replacement (Publication I). The main task during the throwing process was the ability to judge the shape and size of the piece using only my hands. The aim was to throw a cylinder meeting the general technical requirements within the ceramic craft practice.

Experience in itself is a discontinuous stream of experiences in which moments of consciousness are replaced by new ones (Varela et al., 1991, p. 73). This makes experiences difficult to capture and store as data. By combining different methods from the practice-led tradition, such as the diary method, with methods used in more traditional design and practice research, I managed to collect multiple types of data. As a result, I documented and analysed my own activity, experiences and emotions through the combination of three methods: (1) video recordings for visual data and think aloud accounts (Ericsson & Simon 1984/1993); (2) a diary method for qualitative data; and (3) a contextual activity sampling system CASS-Q query (Muukkonen, Hakkarainen, Inkinen, Lonka, & Salmela-Aro, 2008) for contextual and quantitative data.

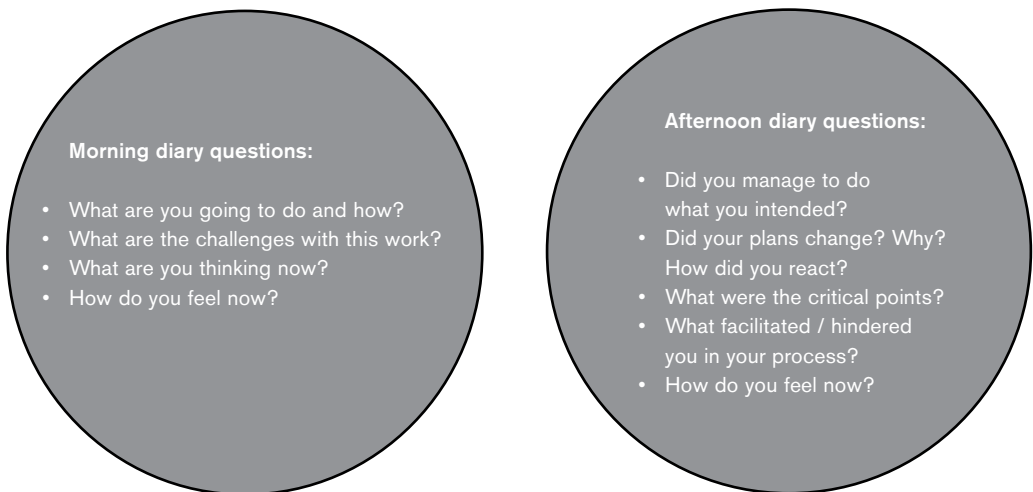
The environment for Case 2 was my own ceramic workshop. I spent five days working blindfolded in my studio, recording one clay-throwing event per day. Each event consisted of throwing 12 kg, and later when confidence grew, 24 kg of porcelain clay on a potter's wheel: one session lasted 1.5–2 hours. All the events were video recorded, which also enabled think aloud accounts, which means speaking one's thoughts aloud while working. In addition to video and related think aloud accounts, I made a diary entry just before and just after each of the throwing sessions. The CASS-Q query was also used in connection with the event: the query consisted of twelve questions to answer before the event and nine questions to answer after the event.

Think aloud accounts are thought to reveal the cognitive processes of an individual during an activity: for example, solving a design task (Akin 1986; Goel 1995, p. 217; Seitamaa-Hakkarainen, 2001). Therefore, they have been used in many studies on design cognition. In this present research, think aloud accounts were combined with the video recording, allowing for a video recalled protocol-analysis of all events (Ericsson & Simon (1984/1993)). The first and last video and related think aloud accounts were analysed by transcribing the accounts and making notes on the actions and sensory experiences connected to them on a protocol sheet.

The diary method is an established way of collecting autoethnographical data (Bolger, Davis, & Rafaeli, 2003; Chang 2008). This method has been developed further within the practice-led research tradition (Kosonen & Mäkelä, 2012; Mäkelä, 2003; Mäkelä & Routarinne, 2006; Mäkelä & Nimkulrat, 2011; Nimkulrat, 2009; Pedgley, 2007). Often, the diary is used as a process diary reflecting on the creative process as it happens from beginning to end – including visual representations.

In this case, the diary method was used in a more formal way as I updated the diary before and after the throwing events, answering a specific set of questions (Table 4). The questions before the event encouraged describing the challenges to be faced and emotions related to the upcoming event. The questions after the event encouraged describing the success or failure of the session and elaborating on the critical incidents that facilitated or hindered the process.

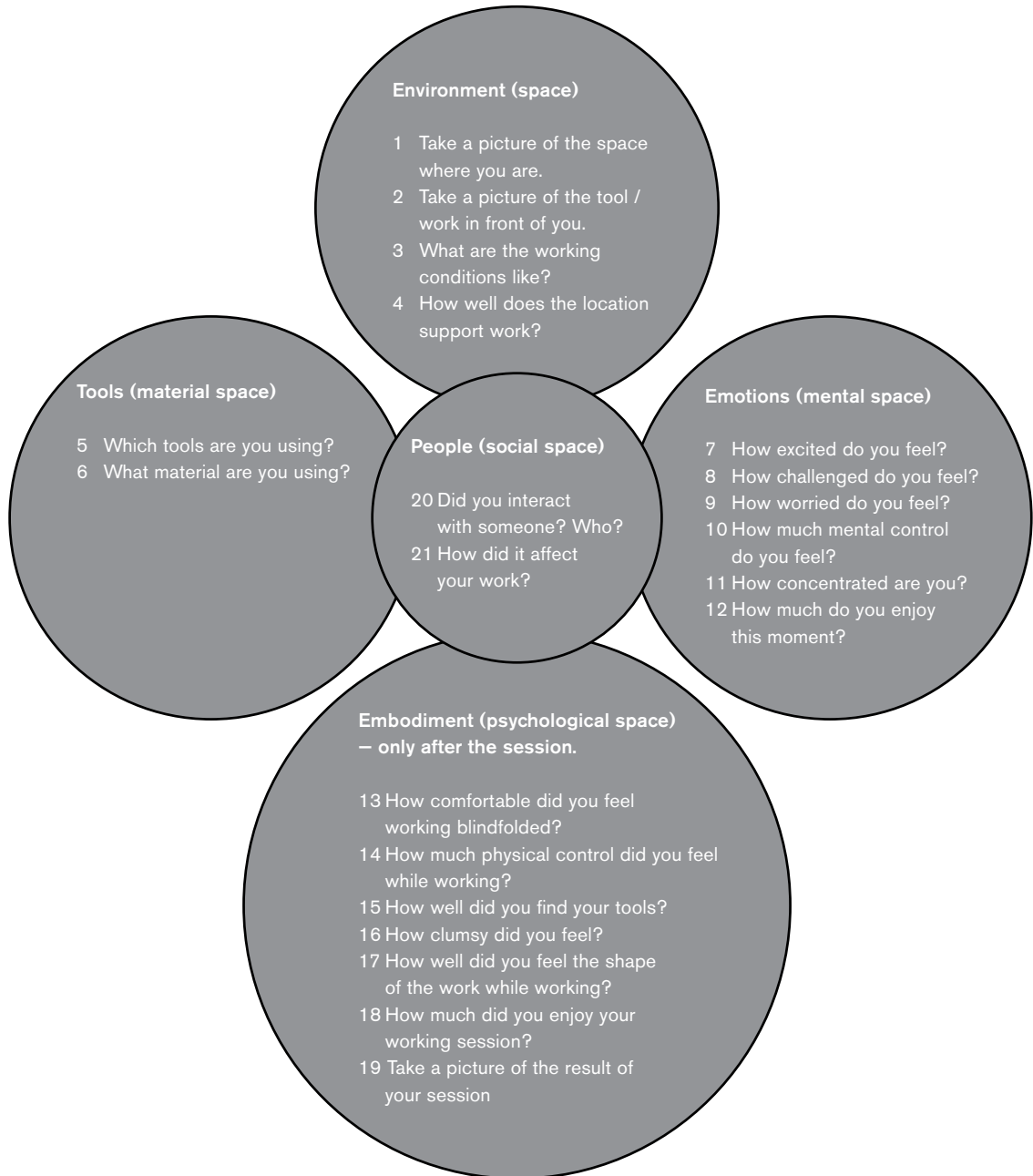
Table 4. List of diary questions.



The questions are structured but allow for open answers within the question themes. They are answered on a regular basis and within a short timeframe relative to the task in order to give a fresh account of the events without disturbing the process. They are designed to capture the intentions of the process and the evaluation of how well these goals were attained including the problem-solving activity and related emotions.

The CASS-Q query is based on the tradition of event sampling methods. Through event sampling it is possible to study everyday activities in a structured way including the respondents' activities and social, material and emotional states and events (Reis & Gable, 2000). The CASS-Q query has been developed to also include the context of the event by combining

Table 5. CASS Q questions.



the event sampling methods with mobile devices (Muukkonen et al. 2008). The questions are therefore designed with the purpose of capturing data in the persons' material, social, emotional and environmental context. For the purpose of this study, I added the embodied aspect to this strategy. In this case, this meant adding questions related to the experienced ability to control the material and working process blindfolded (Table 5). As I was in the end working alone, the social space was not relevant.

Essentially, this method allowed for more rigorous data collection than a normal paper-based questionnaire, including different kinds of response formats, such as taking images, recording voice messages or entering textual and numeral answers to questions. The questions were set to be event contingent, meaning that they were sent to my mobile phone on a regular basis just before and after the actual event (See Image 1 in publication II on page 115).

The diary data was analysed through qualitative content analysis using colour coding. The CASS data was compiled in charts showing the development of the event and related emotions and tactual abilities over the period of five days. The video and related think aloud account was analysed using a video aided protocol analysis.

The preliminary results of this research pointed to the importance of emotions in the many problem-solving instances during the course of the event. Therefore, I decided to extend this case through yet another iteration of the analysis that would focus more on the emotions that were connected to the tactual experiences. In order to find the relevant data for this analytical frame, I decided to concentrate on the critical incidents (Flanagan, 1954) of the throwing events. This technique consists of ways to identify incidents that fundamentally change the direction of, or have a positive or a negative effect on, the experience or the outcome of an event. In this case, a typical critical incident would be that the piece of clay becomes un-centred for some reason.

All video material was initially analysed to detect the critical incidents of the throwing events; in this way, 23 critical incidents were detected. The *Interact* video analysis software was used, and this allowed for the critical incidents to both be indicated and connected to risk assessment and decision-making activities. The video material included 10 hours of recording (two hours of recording every day, for five days). The part of the recordings where the clay was centred on the throwing board was omitted, because these did not include researchable critical incidents. This left five hours of recording that is one hour of recording every day, for five days. The critical incidents were separated into categories of starting Slow or Quick, or being Expected or Unexpected. Three different severity levels of critical incidents were detected and rated from one to three: one being not so severe and three being the most severe. The coding of the video material (see page 140 in Publication III for list of codes) was aided by the think aloud accounts that verbally described emotions and events as well as exclamations when things were either not working out as expected or when a problem was solved.

4.3.3 Case 3: The Role of the Knowing Body in Design Students' Material Exploration

Case 3 was set within the Design Exploration and Experimentation course given at the Department of Design in Aalto University. Each year, around 8–12 Master's degree students participate in this eight-week intensive course. At the beginning of each course, the student group usually travels to a distant location in Finland to gather inspiration around a given theme. During the entire period of the course, the students document their artistic or design-related process in working diaries that they share in weekly verbal and written reflections. The designs and artefacts produced are shown in an exhibition after the course. The exhibitions have been arranged in museums or galleries in Helsinki, sometimes also in the gallery on the Aalto University campus.

The data collected in Case 3 consisted of 19 students' own diary notes, their photographs, drawings, weekly reflections and final reflections produced during two courses, the first in early spring 2013 and the second in early spring 2014. As my intention was to research how design students use their tactile sense in their processes, I first made an initial analysis of all data available produced by the 19 students to identify the themes that were emerging from the data. Based on this initial analysis, I selected two students' work for deeper analysis, one from 2013 and one from 2014. The two selected students' data were especially rich in references to tactile aspects, both in the way in which they processed material and in their reflections on their experiences.

Therefore, these projects and data produced by these two students were considered closely linked with the specified theme for the research at hand, that is, embodied knowing in material manipulation. These two students were also interviewed. The interview questions were specific open questions that took the theoretical aspect into consideration, sometimes also taking into account what the students themselves had been writing in their own reflections (see table 6 and 7). These questions were then followed up by a directed question based on the themes of tactility/body and on the other hand material/exploration according to the answers of the students. The initial interview questions are presented here, omitting the follow up questions that were initiated on the basis of the answers but related to the theoretical framework; thus, the follow-up questions were different in the two interviews.

Table 6. Interview questions for Antti.

- What do you remember most from your DEE Course experience?
- What feeling do you have in your body when remembering the course?
- Do you have mostly positive or negative feelings in relation to the course?
- What were the most significant material tests' that you made?
- What comes to your mind when you see and touch these test pieces?
- What do the different materials convey visually and how does this change when you touch them?
- You write in your weekly report that you have known the difference between a fake and a real leuku knife since you were a little boy. What is this kind of knowing and what does it consist of?
- How does material exploration differ from drawing?
- Why was it important to make a prototype of your idea?
- Before you made any material tests, how did you think of these materials and how did you decide on making the tests that you ended up making?
- What senses did you use when deciding what materials to use?
- You write in your final reflection how the different materials gave you different feelings – tell me more!
- Tell me how your relationship to clay changed during the project.
- How did you get over this material challenge?
- What implications did your previous experience as a metalsmith have for your process?
- How did the feel of the material and your working process affect your decision-making during the project?
- You write that you did not have time to read about material experiences from books during your project; how would you describe your own material experiences from, let's say metalsmithing, in words?

Table 7. Interview questions for Salla.

- What do you remember most from your DEE Course experience?
- What feeling do you have in your body when remembering the course?
- Do you have mostly positive or negative feelings in relation to the course?
- How did the course affect you/change you as a maker?
- What experiences have you carried with you?
- What were the most significant material tests' that you made?
- What comes to your mind when you see and touch these test pieces?
- How does material exploration differ from drawing?
- Why was it important to make a prototype of your idea?
- What senses did you use when deciding what materials to use?
- Why did you find it important to make the pig in its natural size?
- You write in your final reflection how the different materials gave you different feelings – tell me more!
- You also write that you hate clay even though you don't know why – tell me more!
- How did the feel of the material and your working process affect your decision-making during the project?
- Again: Do you feel that the DEE course has changed you in some way bodily?
- What else do you remember as an important issue from the course?

The recorded interviews lasted 2 h (Antti) and 40 min (Salla) respectively and elicited 30 pages of verbal accounts. However, these have not been presented in their entirety in this thesis as they are in Finnish and the contents are at times personal. However, the overall impression of their answers is reflected in publication IV.

One of the students put great effort into finding the right feel of material that would fit her design (see Image 11a and 11b on page 167 in Publication IV). The other student explored the different connotations of materials when juxtaposed; thus, he also tested the embodied expectations of the different materials and how they gave a feeling of confusion and displacement when an unconventional material was used for a familiar object (see Image 6b on page 163 in Publication IV). Both students chosen for the interview and deeper analysis had backgrounds in other craft practices, namely metalsmithing and textiles, before joining the Master's course.

The analysis was conducted according to a thematic content analysis (Fereday & Muir-Cochrane, 2006). The combination of inductive and deductive coding enabled taking the theoretical aspects of embodied cognition into account in the analysis process. This meant that the initial themes were sought for on the basis of a theoretical framing, in this case words related to *tactility* and *body* as well as *material* and *exploration*. Subsequently, these were developed according to the themes that were emerging from the data. The students' own written data and the transcripts of the interviews were colour coded according to initial, developed and overarching themes. The drawings, images and artefacts were used as support for the interpretation of the textual data.

4.4 Research Ethics

Ethical questions were encountered during Case 1 and Case 3 in which personal data was collected. In Case 1, informed consent to participation in this research was given verbally by all the participants on all occasions and was recorded by either audio or video recording. Before any recording or video session, permission to do so was asked of the participants. All data gathered in the meeting with the deafblind participants have been handled carefully, and images have been shown only with the permission of the person being depicted. The participants depicted in the publications and in this summary have agreed to their image being published. In the session at Tampere, which consisted of two participants who both were active in the deafblind art scene, the participants wanted their images to be taken and their real names to be used as this was seen as beneficial for their profession.

However, in the writing of Publication I, based on Case 1, I did change the participants' real names, as I wanted to make sure I handled the data in an ethically sound way. When using their images, I have cropped the images to highlight hands or the actions made rather than their faces. There were

also other persons present, such as translators and assistants who did not want to participate in the recordings or the photographs, or even in audio recordings. All such requests have been respected.

In Case 3, too, where design students were involved, all students filled in an informed consent form prior to deciding on joining the course, and allowing the material produced in this course together with any photo or video material taken during the course to be used for research purposes and to be re-used in presentations and publications of the research, as long as their personal information is excluded.

All students agreed to sign the consent form during 2013 and 2014, the years from which this research case gains its data. However, the two students studied more closely wished to be mentioned by their real names in the publication (IV). As the names were first anonymised during the analysis process, the names were later changed back to the original names before publishing.

In Case 2, the practice-led research setting allowed all data to be collected on and by myself, and there are therefore no ethical considerations around this case in terms of participants.

5 Main Findings of the Study

5.1 Making Sense – What Can We Learn from Experts of Tactile Knowledge? (*Publication I*)

Publication I was written as a result of Case 1 and answered sub-question 1: *How do experts in tactile knowing use their enhanced tactile sense in a making situation?* The publication discusses how deafblind informants use their enhanced tactile awareness in their sense-making in a ceramic workshop, and what we could possibly learn from them.

A concrete example of the participant's use of his haptic and tactile sense and embodied sense-making emerged by coincidence during the workshop in Tampere. One of the participants wanted to throw some clay on the potter's wheel, but in order to facilitate this I would have needed to communicate verbal instructions for throwing to the participant through his interpreter. Since the participant normally uses his hands for communicating through the tactile sign language and his hands were now busy with the clay, it was not possible to interrupt his working while giving instructions. I therefore started throwing the clay *with the participant's hands*. I discovered that in the act of throwing clay tactile communication was sufficient to pass over to the participant my embodied and tacit knowledge in connection with the throwing practice.

Image 7 shows me and Olavi throwing clay together. Deaf and blind Olavi was able to receive my embodied and tacit knowledge of the throwing process, even though he could not see or hear anything during the process. The exact timing and pressure of the hand movements were conveyed from me to him entirely without language. As he gradually got the idea of how to act with the clay, I could feel him starting to lead the throwing process and become more independent in his actions. When he had finished this first piece, he still wanted to try throwing another piece without my help, and managed to throw a bowl that was unusually successful for a beginner (Image 8).

Through experiencing this tactile communication, I noted that language is not an appropriate mode for research into sensory experiences as it is of a different modality and thus not easily expressed through words, even in contexts where language is possible. The communication of tactile skills in particular may be better facilitated by a tactile communication method rather than merely through verbal instructions or visual examples. It should also be indicated that Olavi benefits from his enhanced haptic



Image 7. Image of myself and the research participant, throwing clay together during the workshop. Screenshots from the video.

abilities and tactile sensitivity and that he is also trained in using his tactile memory.

In addition to tactile communication, aspects of making sense through hands were also emerging in the act of modelling clay sculptures. I found that the participants both sought for and also gave form to (externalized) ideas simultaneously by manipulating the clay material. The clay, through its soft and manipulable properties, facilitated an iterative process that made interim prototypes unnecessary. One of the participants in the workshop said: “Clay is such a flexible material, I don’t need to make a model I just remake it straight away” (Publication I, p. 105). This reflection indicates that modelling is a continuous re-making process. The clay is flexible and the artefact emerges by re-making, through forming the material with one’s hands directly.

Following the workshops and discussions with the deafblind participants, I learned that these informants, although on the one hand suffering from their acquired disabilities, they had also gained new abilities due to their condition that some of them reported to be very positive. They gave many examples regarding how they used their haptic modality in their everyday life, from measuring the weight and size of objects to communicating with their family members. Some of the blind reported on a new relationship with their bodies, having become braver in their use of their haptic sense and acting without sight. This notion was also noticeable in the way in which they handled the clay material.

The aspect overarching the three cases was the emotions that were connected to the felt experience of material. In the case of the deafblinds, emotions were connected to their anxiety over technical skill and the mismatch of expectations as they embarked on a new material. As the participants were new to the porcelain clay that was used in the workshop, they expressed anxiety and a disbelief in their making abilities when the new material did not comply with their previous experiences of clay. When continued efforts with discouraging results finally became positive through a re-making and subsequent learning process, the expressed emotions of the participants grew more positive and a “catharsis” was experienced. This was linked to the acceptance of the new result although it did not comply with their initial plans or their initial mental image of the intended design.

Through the research done in Case 1, I learned that sensory experiences, awareness of these and even skills related to these, may be developed and augmented through an impairment of a sensory modality. It also made me realise that we take much of our haptic and tactile experiences for granted and that we have much to gain by attending to our sensory experiences. This case led to the doorstep of phenomenology and essentially towards embodied cognition theory, which helped frame the research design and overall positioning of the study.



Image 8. Image of the research participant, throwing clay independently during the workshop. Screenshots from the video.

5.2 Tactile Augmentation: A Multimethod for Capturing Experiential Knowledge (*Publication II*)

Publication II was written as a result of Case 2, and answered sub-question 2: *What methods may be used in the study of embodied and experiential knowledge in crafts?* The study was aimed at analysing my own haptic and tactile experiences during a practice-led self-study and was conducted in order to explore aspects of embodied knowing in craft practice. Essentially, the *method* I developed for studying this phenomenon became interesting.

First of all, the act of blindfolding as an attempt to augment my tactile sensibility was successful as it worked in the intended way. More attention towards haptic and tactile sensory experiences became available, and I was less interrupted by other sensory impressions during the act of making. Due to the blindfolding, I felt it easier to give verbal accounts of my experiences and on the different associated phenomena. However, it was essentially the protocol analysis of the video data performed after the event that enabled a proper dissemination of the sensory experiences, even though this was conducted at a later time.

The reason for this was the difficulty in processing material, thoughts and verbal expression at the same time as being fully focused on controlling the making activity. I felt that I knew more than I could say *at the time of making* (Publication II). This notion is familiar from the concept of tacit knowledge (Polanyi, 1958). However, the protocol analysis provided the opportunity to reflect on the events in *slow motion*, without simultaneously having to control the material in a making situation (Publication II and III).

The use of video recording was therefore felt to be particularly useful in this research as it facilitated reflection-on-actions in hindsight. Video was also useful in the way it allowed me to capture the experience in a format that I could return to at a later point, and by looking at the recording of the event I could recall my sensory experiences. It has also shown potential in communicating the experience of the research setting in the presentation of this research. The video was thus useful for research on sensory experiences on three levels; in data collection, data analysis and in the dissemination of research, including parts of the tacit aspect of knowledge.

Case 2 was inspired by Case 1, in which the deafblind participants showed augmented tactile skills. I initially questioned whether I, too, could achieve a heightened awareness and sensitivity toward my haptic and tactile experiences by working blindfolded for a period of time. I thus tracked the progress of my tactile ability through the CASS-Q questionnaire and noticed that my tactile skills were indeed enhanced over the period of five days. From having felt quite uncomfortable working blindfolded on the first day, by the fifth day I felt quite natural in trusting

my hands during the throwing process (see Cass-Q chart on page 121 in Publication II).

More importantly, I also noticed that the haptic and tactual feel of the clay and the conditions of the material affected my emotions in either a positive or negative way. This indicated that emotions guided me in my risk assessment and decision-making during the process, and they thus also guided me in the problem-solving processes. This new insight called for a renewed investigation of the same data but with a different research question, this time focused upon emotions connected to tactual experience.

5.3 Emotions in Risk-assessment and Decision-making Processes during Craft Practice (*Publication III*)

Publication III was the second publication written as a result of Case 2 but now answered sub-question 3: *What is the role of emotions in connection to tactile experiences in a craft practice?* Now, the focus was on carrying out an even deeper analysis of the role of emotions in connection with the haptic and tactile experiences during the critical incidents of the clay throwing event recorded in Case 2. I was particularly looking for the emotions that arise in connection to the haptic and tactile sensory experiences of throwing clay and how these emotions affected A) risk assessment, B) decision-making, and C) problem-solving.

In order to investigate this aspect further, I carried out a renewed analysis of the videos collected during the throwing sessions using the *Interact* video analysis software. This software enabled me to dive deeply into the experience of throwing clay and to pick it apart in its details and see the kinds of different aspects and new insights that arise from this kind of analysis. While analysing the videos, I understood that the critical incidents had different levels of severity, some were not so severe and the problems were solved easily while others were of a more serious kind. The incidents were either expected or unexpected, and some began abruptly while others developed over time.

The haptic and tactile experiences surfacing during the analysis of the critical incidents involved the density of the clay material: how hard or soft it was, the wetness of the surface, or the stickiness of the clay at different times during the throwing process. The position of the clay on the wheel, whether centred or not, was a clear factor during the critical incidents that affected emotions in a negative or positive way. The most central emotions that surfaced in connection to the critical incidents were to do with confidence, stress levels or spirits. Activities that were tagged in the videos were connected to risk assessment, decision-making and problem-solving (see example of the analysis on pages 145–146 in Publication III).

I found that during critical incidents feelings of low spirits and stress were present, together with the unstable conditions of the clay, in risk assessment, decision-making and problem-solving during the throwing process. However, I found that even negative emotions actually helped the process by aiding concentration and focusing on solving the problem at hand. The heightened alertness, stress and worry about the risky moment of the process involved, prompted extra sensitivity and attunement to the material that the critical incident called for. As a result of Case 2, I see making in a material as a continuous risk assessment process that includes constant decision-making and problem-solving elements and which emotions seem to guide and moderate.

In short, emotions aid the practitioner in applying the right amount of attention and caution in the management of critical incidents. Previous experiences are stored (as somatic markers) and give the maker hints on the available opportunities (affordances) and risks related to the situation. Emotions and sensory experiences are thus linked to the skills and sense-making of a craft practitioner and as such contribute to the embodied knowledge of a practice.

5.4 The Knowing Body in Material Exploration (*Publication IV*)

Publication IV was written as a result of Case 3 and answered sub-question 4: *How do design students use embodied knowing in material exploration?* It concentrates on analysing design students' haptic and tactile experiences and sense-making during a course that promotes material exploration as part of the creative process. The aim was to study the role of the knowing body in material exploration. The result highlights the body as an important contributor in the formation of knowledge in the field of design.

The two students, who were studied closely in Case 3, were using their touch sense in various situations during their explorative process. The tactile aspect of the materials and the use of active touch were important on many levels but especially so in the process of deciding which materials to use for the designs. The felt experiences of materials were often linked to emotions and shared social and ethical values.

A mental material exploration was detected as preceding the physical material exploration as both students listed materials in their diaries that they tried out in their imagination before making a decision on which materials to try out physically. In the interview, one of the students reported that she did most of her material exploration in her mind. As these materials were familiar to her it is assumed that she was reverting to previous physical experiences (embodied knowledge) of these materials, gained in other contexts.

Physical touch also played an important role in the decision-making process as it confirmed the imagined notion of the material. In the interview, one of the students explicitly said that vision provides only half of the perceptive view, and that touch fills in the missing part. Touch was seen by both students as the main means of evaluation when making choices on which materials to use or in evaluating the quality and potential of a material.

In addition, manipulating the material affected both students' self-esteem and image of themselves as practitioners. As the students experienced new materials in their exploration process, the new material behaviour disrupted their workflow and made them question their identity as makers in a manner similar to the case of the deafblind participants. The students' anxiety was overcome through resorting to familiar patterns and methods of solving material problems known to them from other domains. This is exemplified by one student being aided in her understanding of the shape of the intended design via modelling as simulation (see Image 12b, Publication IV on page 168). The student made a clay dough model in order to be able to concretely comprehend the shape of the leather material to be cut and sewn for the intended design.

This process could be described as re-knowing, rather than re-making, as the students were re-developing existing knowledge. However, among the other students participating in the course, there were also examples of students who had less experience of manipulating materials. In the case of one student, the discomfort of moving into the material realm hindered him from advancing his design from visual representations such as drawings and concepts into a material prototype. In a video-recorded workshop, the student talked about his frustrations with materials in general as the reason for not being able to progress. He said: "my hands were not skilled enough to manipulate the material," and he later said, "I could not make what I wanted, so I made something else" (Publication VI, p. 175).

In contrast to the deafblind participants and the more experienced students, this particular student did not come to terms with the changed image of the intended design, but instead re-conceptualised his project all over again, time after time, and continued frustration followed the student throughout the entire course. In all three cases, from the deafblind, through the single practitioner to the design students, a pattern of mental discouragement was detected when material conditions become unfortunate and, similarly, a pattern concerning how adaption through referring to previous experience overcomes difficulties.

In Case 3, both students used drawing in the initial phase of ideation but both also independently stated that drawing was insufficient as a method when exploring material options. As both students were interested in the material dimension in this project, drawing was not the preferred method of enquiry. One of the students considered materials to be too difficult to draw from memory and that a drawing does not describe the material properties.

As a result of Case 3, I consider material exploration an important part of a student's development into a skilful designer. Materials convey tacit understandings of shared ethical and social impressions and values. Drawing is fundamentally different from the information to be had through real-life material manipulation. The more experienced designer has the benefit of owning a larger asset of embodied knowledge of materials and may thus create more realistic mental images of intended designs, also by drawing.

5.5 Summary of Key Findings

The main purpose of this study was to discover how design and craft practitioners think through their hands. Through looking at making practices performed by practitioners of different levels and from a tactile and haptic perspective I gained a new view of design and craft activities. I became aware of the importance of emotions and the memory of related previous experiences in the meeting of new material challenges. The importance of touch and haptic experiences in decision-making processes and the link to emotions in this context was one of the key findings. The practitioner seems to gain not only manual skills and tacit knowledge during the making process, but he or she also builds him- or herself as a practitioner. As a result of this research, manipulating material may be seen as a way of being in and affecting the world as well as negotiating meaning related to our abilities and limitations.

An overarching finding of the entire study was surprisingly the many different levels and notions of emotions that surfaced through and in connection with haptic experiences. It may be said that emotions related to haptic and tactual experiences in a making process with material affect and regulate risk assessment, decision-making and problem-solving. Emotions also aid the maker in applying the right amount of attention and caution in the management of critical incidents. Previous experiences are stored and reactivated (by somatic markers), reminding the maker of the available opportunities and risks (affordances) related to a situation. When there are no previous experiences to lean on, as in the meeting of new material properties, similar previous experiences are related to instead. In this way, a form of re-knowing of previous knowing aids in overcoming challenges.

This re-knowing was seen in all three cases but perhaps especially in the design students' processes. When the design is taken from a 2D drawing to a 3D prototype or the other way around, there is a change in working modality that is risky for the novice designer but that is helped through reference to previous experiences of similar situations. It was found that design students used embodied knowledge of materials and their properties at all stages of the design process, even before physical material exploration. Touch was an essential *evaluation tool* for making decisions on materials and for testing materials, but also for communicating ethical and social aspects of the design.

In comparison to novice students, the more experienced students have the benefit of owning a larger asset of embodied knowledge of materials and may thus create more realistic mental images of intended designs.

Another aspect related to education was the result that tactile skills might at times even be better taught by tactile means, as the embodied knowledge of the teacher, including exact timing of movements and limb pressure, are more readily available to the student in such a setting. This way of teaching, especially in ceramics, might not be entirely new, as surely this must have been tested before. However, in this case there were no verbal instructions included in this setting; therefore, it shows that even entirely tactile teaching (without sight or hearing) could produce a beneficial learning experience for the person receiving the tactual guidance.

As seen in the students' processes, the transition between 2D and 3D was complicated. In relation to this, drawing was felt to be a good thinking tool as far as conceptualisation in 2D is concerned but was not seen helpful when deciding on concrete materials in 3D. However, concrete material offered a way of making sense through hands. The deafblind participants could not use drawing as a means to explore shapes, but they used clay as the clay offered the possibility to re-make the design until finished. Modelling may thus be considered an act of making sense in a similar way as drawing is generally considered, through its capacity to give form and initiate ideas and through its iterative properties. I found that the deafblind participants both sought for and gave shape to ideas simultaneously by manipulating the clay material. The clay, through its soft and manipulable properties, facilitated an iterative process that made interim prototypes unnecessary.

The research opened up issues for research practices in particular. For example, collecting multiple types of data in a practice-led research setting was found useful in the study of experiences and experiential knowledge in design and craft processes. By testing different data collection methods combined with more artistic attitudes such as blindfolding, a multimethod was developed as a result of this research. Video was found to be especially useful as it allowed capture of the experience of an event for it to be analysed later, it also facilitated a recall of haptic sensory impressions. Through this understanding, the use of video in the dissemination of the results might also transfer tacit aspects of embodied knowing to the audience through pseudo-haptic imagining and affect.

These research results speak much of the same language as found in the theoretical framework of embodied cognition (presented in section 2). What design and craft researchers have been noting in previous research in relation to skills and expertise, tacit and experiential knowledge is confirmed in this literature. Therefore, I found this theoretical frame useful in explaining the phenomena encountered in the practitioners' behaviour and related verbal statements. Also in my own practice-led study, issues found in practice were confirmed in the literary material found in an embodied cognition context.

6 General Discussion

In this section, I will first consider the *theoretical* implications that this study has for design and craft research in particular. Other *practical* implications are relevant to design and craft practice and design and craft education. I will also discuss methodological limitations of this research and future research aspects.

6.1 Theoretical Implications

The embodied approach, described in the introduction, has been useful for the purpose of this research as it resonates well with design and craft contexts in which concrete material manipulation initiates and transforms concepts and facilitates, sustains and informs meaning-making in action. The research findings indicate that the act of making may be informed by several concepts from embodied cognition theory. This has implications for the theoretical framing of design cognition, which still lacks substantial empirical research on embodied sense-making within design and craft practice. The research at hand is a contribution to this field at the same time as it recognises a need to further investigate both the empirical and theoretical foundations of embodied cognition in relation to design cognition in order to create a deeper understanding of how the body takes an active role in sense-making during design and craft practices.

The first theoretical implication of this research is that **embodied cognition theory lends itself well to informing design and craft related practice**. There are several concepts of embodied cognition theory that lend themselves well to extending the design cognition theory to include the bodily realm, such as enactive knowing in action, the theory of affordances, body schemata and image schemata, simulation and imitation through mirroring systems, and sensory cognition. However, the use of representations of the world instead of referring to the experienced world creates a differentiation in the mode that the design or making process goes through. Therefore, it is necessary to recognise these different modes, the representational that is an imaginary exploration of ideas and material implementation, and the non-representational that is a concrete and physical exploration of ideas and materials (see page 24 on non-representational theory).

Nilsson (2013) discusses architectural practice as an example of a making discipline that is concerned not only with representations and interpretations of the world, but also with the future-oriented creation of perfor-

mances and transformations (p. 3). Nilsson (2013) acknowledges the two modes that the practitioner is faced with and that material practices may produce concepts and theories initiated by material and practical procedures (p. 3). Consequently, the designer and craftsperson uses representations as tools but also manipulates material in a non-representational mode.

Design cognition theory is useful in explaining the representational mode, but often these studies do not investigate the designers' material manipulation process in depth. Embodied cognition theory is useful in explaining the non-representational mode of design and craft practice in which a body-based material manipulation and sense-making takes place. However, it is important to recognise the body as an informant in both modes, that is, also in the conceptual and immaterial stages of the design process as seen in the students' design processes. The students created mental images of their intended designs in their minds even before starting concrete material testing, but these mental images were very realistic and they were based on previous encounters with materials. Thus, they used their embodied knowledge of materials and their constraints in the formation of the initial image of their artefacts.

The practitioner moves between the representational and non-representational modes, the immaterial and the material, the imagined and the actual. Problem-solving occurs in both modes and is subject to various constraints and affordances that, however, differ in the two modes. As shown by Zeisel (1981/2006, p. 26), a design process is iterated in a spiral-shaped fashion and through a process of reconfiguring aims and means, by testing the imagined idea in reality. In this process, the initial mental image of the intended artefact is reformed and developed towards a more suitable or acceptable outcome.

In the following image (Image 9), I have sketched out the view of embodied sense-making in design and craft practices that emerges from this doctoral thesis, that is, how the craft or design practitioner is making sense through his or her hands. The purpose of this present model is not to replace models of design processes, as the purpose has not been to study the design process as such. Instead, the model describes the difference in the two modes presented above.

The most important aspect of this model is the suggestion that the knowing body, together with related sensory experiences and emotions, functions as an informant *both* in the more imaginary and representational as well as in the more concrete non-representational sense-making process.

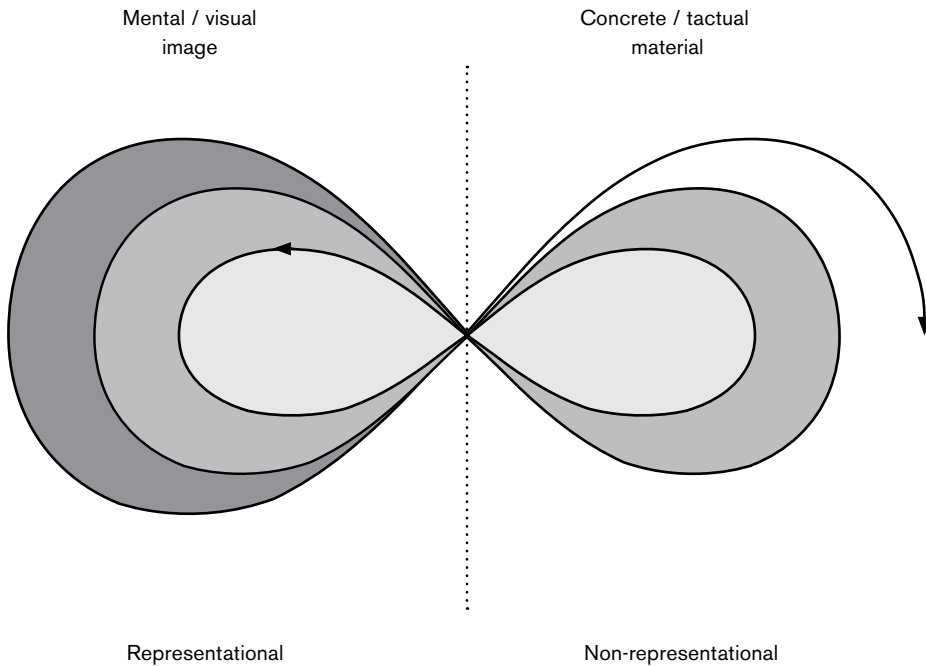


Image 9. Embodied sense-making in design and craft practice.

Activities that are linked to more conceptual or imaginary activities are taking place in the *Representational mode* loop on the left. Activities linked to bodily concrete manipulation of materials are taking place in the *Non-representational mode* loop on the right. The arrow shows how the practitioner is moving between the idea mode and concrete mode in loops, where knowledge is reinforced for each loop and the ideas are tested and re-configured through concrete re-making and re-knowing.

The contact point between the two modes is presented as a narrow passage. This proposes that the move from the representational mode to the more concrete non-representational mode may be abrupt and problematic, particularly for the novice practitioner as discussed in publication III. Similarly, the other way around might be equally difficult, since the negotiation and reflective conversation with the material that goes on in the non-representational mode, and that sometimes forcefully changes the imagined design, may be harsh before overcoming the challenges and moving into a new acceptance of the changed image.

The difference in attitude to sense-making in a distant representational mode that is concerned with a more objectifying view of what is visible and on the other hand the more immediate subjective and concrete non-representational mode does explain the difficulty in the transfer between these modes. In the non-representational mode, the embodied sensory reflection is highlighted and physical constraints are met concretely and bodily,

allowing “visibilities of the world in the subject’s felt engagement with it” (Gregory et al., 2009, p. 646) as discussed on page 24.

The non-representational mode equally allows for a sense-making process that also includes the voice of the material, the material agency. In addition, sensory experiences and in particular perceived haptic experiences influence the choice and concrete manipulation of the materials used. The material properties, affordances and constraints influence the process and may even suggest new un-expected developments and turns. As haptic experiences may be seen to influence emotions, these are essential parts of the knowledge developed in this mode. Emotions are also expected to affect risk-assessment, decision-making and problem-solving in relation to the making process, particularly in connection with possible critical moments or incidents.

As mentioned in the theory section, there are differing opinions in design cognition and embodied cognition on the issue of representation. The consequence of these philosophical differences could be that these two ways of understanding sense-making are incompatible and, therefore, that the successful combination of these theories would be doomed. However, the conclusion of this research is that the problem is rather present in philosophical terms but that the practitioner is capable of moving between representational ideas and concrete actions, making sense of the situation through the making, re-making or testing activity.

Aspects of what an embodied-cognition-oriented view contributes in relation to craft and design theory might be found in this space. Design cognition theory may be extended by non-representative theories such as embodied cognition, allowing direct sensory experiences, experiential and embodied knowledge of material agency, emotions and also social awareness of cultural aspects to function as informants in the embodied sense-making process of the practitioner.

Traditional design cognition studies put forward an idealised view of the designer’s sense-making that emphasises the cognitive characteristics of the design practice (Gedenryd, 1998, p. 2). By emphasising the thinking capacities of the designer, as described by Dormer (1993, 1991) and Lawson (1980/2005) (see page 15), we are contributing to a skewed view of the making practices as they are left with providing only the material implementation phase. This thesis proposes the view that the act of making is an act of sense-making. Further, it proposes that planning a design includes a mental crafting that relies on previous bodily experiences and material skills. Therefore, the second theoretical implication of this research is that **design processes include embodied knowledge even in the cognitive and immaterial stage of creating mental images of the intended physical designs.**

In addition, the aspect of material agency is not revealed in a design process that relies solely on cognitive activities and representations. In contrast, there is a notion of thinking through making/material/hands in many fields of the making practices. Design researcher Nigel Cross (2011, p. 4) writes in his book *Design thinking*:

In traditional, craft-based societies the conception, or 'designing', of artefacts is not really separate from making them; that is to say, there is usually no prior activity of drawing or modelling before the activity of making the artefact. For example, a potter will make a pot by working directly with the clay, and without first making any sketches or drawings of the pot.

This is the case in many material-based contexts where the practitioner has embodied the material properties and affordances. In this context, the process from material to artefact may even proceed without the processing of representations, thus seemingly without thinking or designing. However, this may be considered the kind of immanent, pre-conceptual, and non-propositional sense-making described by Anderson & Harrison, (2010) Johnson (1987; 2007, p. 34) Noë (2004) and Thompson & Stapleton (2008). According to these theorists: "thought is placed in action and action is placed in the world" (Anderson & Harrison, 2010, p. 10). The non-representational sense-making that takes place in action, through direct manipulation of material, may be un-reflective but equally contribute to the quality of the end product.

The research results formed through this thesis also highlight emotions as informants in sense-making through haptic and tactile experiences. This is not new, as emotions have been linked to tactile experiences in previous research (Karana, Pedgley, & Rognoli, 2015a, 2015b; Williams & Bargh 2008; Zuo et al., 2001). Emotions have also been connected to sensory experiences, and even decision-making, in, for example, cognitive science (Damasio, 1994, 1999). However, in the field of design and craft, the way that the tactual feel of the material affects emotional feelings in the process of making is perhaps known to the practitioners, but little elaborated on in research. Personal and subjective emotions have previously not been seen as valid informants, even in craft and design research (Niedderer & Townsend 2014); lately, however, researchers in craft and design, too, have begun to include this aspect (Groth, Mäkelä, & Seitamaa-Hakkarainen, 2015; Niedderer & Townsend, 2014; Mäkelä & Latva-Somppi, 2011; Seitamaa-Hakkarainen, Laamanen, Viitala, & Mäkelä, 2012).

Case 2 in particular highlights how emotions linked to tactual experiences served as contributors to risk assessment, decision-making and problem-solving in the making process. Emotions seem to guide the progress of the making situation, especially when the material qualities and affordances vary and a successful outcome depends on the skilful maker. Mark Johnson (2007, p. 9) attributes emotion to meaning making. In his view, it is precisely the sensory-motor capacities and our ability to experience feelings and emotions that permits us the ability to make meaning (Johnson, 2007, p. 9).

Emotions were also frequently aired in the think aloud accounts that facilitated the analysis process in Case 2. Even notions of fear emerged in the accounts as the process approached a risky phase or during sudden critical incidents (Publication III). Emotions as guides in decision-making

are familiar from Damasio's (1994, 1999) "somatic-marker hypothesis" (Damasio, 1994, p. 175). Johnson (2007) builds on Damasio's hypothesis and claims that our capacity to have emotions is the most essential way of making meaning out of our experiences. He writes: "emotions are processes of organism-environment interactions. They involve perceptions and assessments of situations in the continual process of transforming those situations" (Johnson, 2007, p. 66-67). Johnson (2007, p. 61) and Damasio (1994, p. xx and p. 244-245; 1999, p. 41) both argue for emotions being linked to reasoning instead of being the opposite of reasoning as is usually thought.

One of the reflections of Case 2 was that making in a material may be seen as a continuous risk assessment process that includes constant decision-making and problem-solving elements and which emotions seem to guide and moderate. This resonates with the problem-solving approach developed in design cognition studies (described in the theory section on page 17), but instead of highlighting an objective stance together with rational and disembodied decision-making, in the present study *emotions* are highlighted as key informants in this process. Therefore, research on design cognition might benefit from an in-depth study of emotional aspects in relation to the practitioners' processes.

6.2 Practical Implications

As noted in the theoretical implications, craft and design processes are helped by embodied knowledge and lived experiences that can be related to in new circumstances. In addition, emotions are important in the context of sense-making in craft and design practices as they guide the practitioner at important stages of the work. This has implications for design and craft practice on many levels but also for research practices in relation to craft and design. However, the potential *users* or readers of this doctoral thesis and the related findings might be found in the educational context, in the form of future practitioners and design researchers. Educational aspects were also present in all three cases in tactually guiding the participant in Case 1, my own haptic learning in Case 2, and the study of the learning through making processes of the students in Case 3. Therefore, I have included a section on how I believe the findings are also relevant in this context even though the research as such has not focused on the educational aspects. I will begin with the more general implications for craft and design practice.

On a more general level, haptic and tactile experiences were found to be important, both in the designing and the making process. When a craft or design practitioner knows his material, tactile aspects have a better chance of being communicated tacitly in the final product in the way the designer intended them to be conveyed rather than in an accidentally fortunate (or unfortunate) way as exemplified in the students' work in Publication IV and also in Ackerman's study on psychological effects of weight (discussed

in the theory section on pages 30–31). However, when material exploration, prototyping, crafting or production of a design is considered to be separate from the thinking or “designing” process, as Dormer describes (page 15), and as is realised in the case when designs are produced in an industrial setting without the control of the designer, there is a risk that the end product will be lacking in material quality.

This is exemplified in processes where the technology represents a “barrier” between the designer and the creative experimental engagement, as described by Taylor and Townsend (2014). Taylor and Townsend describe technology related to textile processes; however this notion of a “barrier” is also familiar from the ceramic processes. When production is, for example, moved from Europe to Asia, the European designer has less influence over material aspects and more design work is conducted virtually.

Although virtual making environments are constantly evolving to encompass greater sensorial and haptic engagement, embodied knowledge must be in the person, not in the computer, to be utilised in the way that was intended. The tactile experience of for example tableware is of outmost importance and defines the quality of the product. In this context, the designer benefits from gaining good skills and embodied knowledge of materials and technical processes simply to be able to construct a design in his or her mind that will be close to what is realistically possible to manufacture, also taking into account the tactile qualities. Instead of maintaining an idea that craft represents making, and design represents thinking, design activity benefits from craftsmanship that is integrated into the holistic design process of the designer. In this way, the designer is better prepared for material constraints emerging in manufacturing processes, and better in control of the entire production and the quality of the final product.

Sensory experiences are keys to knowing in making with a material. What is seen by the eye is confirmed by active touch. Through our hands, we are able to interact and test different materials and shapes, learning by doing and acting, and thus also shaping our minds and affecting our future abilities to act in relation to similar or new materials. Previous bodily interactions, emotions and meanings play a key role in design students’ understanding of new material experiences and are relied upon in the choice of materials and techniques during the design process. If these experiences are not gained during early professional life or in design education, as seen in Case 3 (Publication 4), the designer has a poor base to stand on in his professional life and may not be in control of the distant manufacturing processes.

Haptic and tactile aspects are important additionally in the evaluation and choice of materials for design, even when forming mental images of tactile expectations (Publication 4). Imaginary material exploration and mental images of physical experiences are based on previous bodily experience of materials, and the body and sensory experiences thus play a role in design processes. Tactile- and material-based forms of education are therefore key in learning as experiential knowledge may only be acquired

through situated and embodied interaction with materials. Likewise, embodied, emotional, social and even ethical aspects of the material's properties play a role in the designer's judgment and selection of materials. Some of these notions are commonly shared embodied knowledge that consequently also plays a part in the communication between designer and user.

This aspect is further emphasised in this research as the word *feeling* in tactile sensations and *feeling* in felt emotions merged in the students' descriptions of their sensory and emotional experiences (Publication 4). The students also used this aspect consciously in their careful selection of materials. This led to the understanding that materials convey shared notions that are triggered as mental images even when only mentioned in speech.

These findings are confirmed by Zuo, Hope, Castle, and Jones (2001) who claim that not only physical but also cultural and psychological responses and expectations are attached to material properties. Similarly, Karana et al. (2015a) emphasise the experiential perspective of designing and describe materials as actors that play roles that the designers have assigned to them. They also point out that "deciding on the role that a material will play in an artefact is one of the creative challenges that designers face" (Karana et al., 2015a, p. 17-18).

While highlighting sensory experiences and the importance of tactile and haptic ways of making sense and learning skills, as in the 'tactile communication' experienced in Publication I, it is important to recognise the limited resources in education for that kind of *show, don't tell* (Sennett, 2008, p. 179) and *bodily mimesis* (Pallasmaa 2009, p. 15) so essential for transferring and embodying skills in a design and craft context.

Design education has moved towards a more computerised era (Harris, 2012, p. 92; Evans & Al-Doy, 2011, p. 346) as a natural consequence of the general advancement in technology and digitalisation. As thinking through materials is both costly and time consuming (Evans & Al-Doy, 2011, p. 360), institutions are looking for savings in material equipment if they can be replaced with simulations. Can we skip the material manipulation all together? The practical implications of this study suggests that material manipulation is necessary for the development of experiential and embodied knowledge and skills of a variety of materials that the design and craft practitioner may lean on in future projects. How is this potential realised in the digital era?

Design researcher Jane Harris, a pioneer in digital imaging design and creative computing disciplines, describes how this move towards the digital has contributed to the unstable financial situation for "certain established material processes, in particular ceramics and glass" in the United Kingdom (2012, p. 92). She claims that this development has led to a lack of skills in these fields (2012, p. 92): "An initial decline in specialist skills in materials, processes and provision of equipment has ensued, the loss of which has been significant, possibly in ways we are unable as yet to measure or hope to reinstate".

While digitalisation has enabled unimaginable material constructions that would be impossible to construct manually, manual skills in relation to materials are not to be marginalised in pursuit of technological advances. Harris (2012) points out that many practitioners who utilise digital manufacturing on a small scale first trained in a material discipline (p. 108); therefore, she suggests that craft practice has much to contribute to computing media (p. 109).

Whether or not the designer is interested in specialising in a certain material, the development towards the digital has implications for how the designer is equipped when graduating from design education. With less experience of material manipulation, the designer is left with sketching, drawing and virtual means for developing a material image of the intended design, and the risks of surprises emerging during manufacture when the representation is made real are transferred to the client (Lawson, 1980/2005, p. 249).

In design cognition research, it has been found that sketching is closely linked to the designer's thinking process (Goel, 1995; Purcell & Gero, 1998; Seitamaa-Hakkarainen & Hakkarainen, 2004). Through drawing, the designer is able to externalise the imagined design (Cross, 2011). While acknowledging that 2D drawing is used mostly in the initial phases of the design, it is interesting to note the limit of how far the act of drawing goes in exploring the physical. As seen in the students' processes (Publication 4) it is difficult to use drawing in the exploration of material choices; instead, physical touch seems to be inevitable.

Evans and Noor Al-Doy (Evans & Al-Doy, 2011), introduced in the theory section in relation to visual representations, have investigated the potential for a design course for students that would solely use computer-aided methods in the design process. They found that professional designers and design students alike value the freedom and instantaneous nature of freehand drawing in the initial stages of designing and computer aided drawing tools were rather used for the more refined precision drawing of details in the later stages of design (Evans & Al-Doy, 2011). Lawson, too, (1980/2005, p. 285) comments on computer aided drawing as less "conversational" as it does not facilitate the reflection-in-action and reflective conversation with the situation described by Schön (1983).

However, the computer is very useful in enabling the mental rotation of a three dimensional design that may be very difficult to produce merely in one's mind. The 3D computer model rotates a view of the intended design from all sides before its manufacturing process. The concern that emerges in the present thesis is how well a computer-aided model or drawing facilitates the understanding of a material's agency, and how well the student is able to evaluate materials and the weight and density of the drawn object. As a result of its flat nature, a screen or drawing gives a poor sense of weight, density, flexibility, temperature or surface structure (see also Bamford, 2015, p. 4; Fulton-Suri, 2003, p. 46).

Evans and Al-Doy (2011) suggest that students in particular need concrete material exploration to gain the knowledge that they will lean on in later projects (see also Lawson, 2004), but that, in contrast, the more experienced designer already knows what materials are like and thus could manage with an entirely computer-aided design process (2011, p. 361). This gives further reason to suggest that embodied sense-making also plays an important role in the conceiving and further development of designs, even when concrete materials are not present in the design process, but also that this is only possible after the materials have become embodied over time.

Anna Piper (Piper & Townsend, 2015, p. 22), who in her doctoral research combines analogue and digital craft processes, draws on Taylor's (Taylor & Townsend, 2014) notion of "reprogramming the hand" when she describes the importance of experiential knowledge gained in physical interaction with materials in this process:

By integrating hand loom weaving and digital Jacquard processes, the weave practitioner is able to draw upon the embodied knowledge, craft skills and enhanced technical understanding that can only be derived through the haptic engagement of handcrafting. If primed to 'think digitally' by the machine-mediated experience of hand weaving, it is possible for the weaver to negotiate the transition between manual and digital construction.

Similarly, Townsend (2016) describes how artists previously unfamiliar with digital textile manufacture were able to utilise the full potential of this technology through close and reflective collaboration with another designer, more experienced with the technology. The more experienced designer may benefit fully from the digital aid provided by technology; however there is no short cut here for the inexperienced designer or student. The knowledge does not reside in the machine, but is embodied in the person and is gained over time through repeated interaction with concrete materials.

Although there were no digital drawing processes present in my research data, the students in Case 3 were using 2 D drawing to some extent in their initial ideation processes. However, they found drawing a limitation in their further processes. Thinking through drawing seemed fundamental when determining the shape and the function of a design, but did not come as close to the lived experience, as did the material prototyping. This indicated that when the imagination and drawing skills of the designer reach their limits, physical material exploration and the resulting prototype take the concept to the next level, the non-representational mode that is the experiential mode, where the design may be experienced and developed physically.

This is exemplified in Case 3 (Publication IV), in which the students frequently used their previous embodied knowledge in their individual learning and problem-solving activities. When confronted with a spatial problem in her two-dimensional design, one of the students built a three-dimensional model in order to be able to physically experience

the imagined design and to manipulate its different angles. She also used the model to measure the intended covering material over the shape (Images 12a and 12b in Publication IV). She described this physical exercise as necessary because her imagination was not enough to create the design only in her mind or through drawing.

According to design cognition studies, conceptual design ideas, and visualisations of these, rely on the visual mental images created in the mind of the designer during the design process (Ferguson, 1994; Suwa & Tversky 1997; Kosslyn, 2005). As mentioned in the theory section, the ability to imagine the idea from different angles in a three-dimensional manner requires mental rotation (Purcel & Gero, 1998). However, mental rotation of the imagined designs may be aided not only by computer graphics but also through taking the design into the lived experience by the construction of a physical prototype. Design researcher Kaiju Kangas reflected on the body as a mediator in her study on collaborative design processes, in which children used their physical surrounding in interaction with their bodies while solving a spatial design task (Kangas, 2015, p. 61).

Physical interaction that goes further than mere intramental material manipulation or referring to known external constraints seems an important method of enquiry when merely cognitive capacities become inadequate. Further, sedimented knowledge (Keller & Keller, 1996) accumulated through practice in other domains may emerge in a new domain, allowing students to progress in an otherwise stagnated design process. This reflection is supported by the research of teacher and design researcher Biljana Fredriksson (2011), who, in her research, showed that understandings emerge from the 'meetings' between past and new experiences, stimulated by the material's affordances and resistance (p. 1).

Lawson (2004) writes about a similar behaviour in expert designers versus novices and describes the different levels of design learning, including the fact that the expert has had time to create schemata of previous experiences that may be applied in new contexts (p. 454). As a conclusion, Lawson highlights the length of time that expertise in design requires in comparison to many other fields (2004, p. 457). Although Lawson also draws on Gibson's affordance theory, he does not explicitly refer to these schemata as embodied schemas based on physical and sensory experiences.

As well as using their bodies, haptic sense and previous embodied knowledge from other craft-related domains, the students in Case 3 (Publication IV) created their mental images relying on previous tactile experiences and the tactile memory of materials. As mentioned earlier, the research at hand therefore suggests that the mental image also includes embodied tactile memory that is based on previous experiences with the imagined materials.

This conclusion is supported by the research of Akter Ahsen (1984), who in his work on mental imagery also included the somatic (bodily) realm in his triple coding model: Image-Somatic-Meaning (ISM). Further, recent research on designers' ideation process supports the inclusion

of multimodal material inspirational sources as part of the creation of the mental image in the ideation phase (Laamanen, 2016, p. 45). Design researcher Tarja-Kaarina Laamanen (2016) came to the conclusion that mental images needed in the ideation process of designers are created from sensory, perceptual, language and material elements (p. 45).

As well as creating mental images for design, students also create themselves and their identity in the process of manipulating materials, reflecting on both their physical and mental capabilities in doing so. Building on previous positive or negative experiences, future challenges and related personal capabilities are evaluated accordingly. Psychologists and researchers on haptic and tactile experiences, Ackerman, Nocera & Bargh, (2010, p. 1) elaborate on how haptic sensations influence social judgement and decisions:

Touch is both the first sense to develop and a critical means of information acquisition and environmental manipulation. Physical touch experiences may create an ontological scaffold for the development of intrapersonal and interpersonal conceptual and metaphorical knowledge, as well as a spring board for the application of this knowledge.

The notion of creating a difference in one's own perceived body image (and related physical capacities) was eminent in all three cases from the deafblind makers through my own tactile augmentation process and especially in the design students' experimental processes with new materials.

Johnson (2007) supports the notion of interaction and "intimate connection" with the world as being of "monumental importance", which facilitates insights into our own nature, capacities and limitations (p. 20). On a fundamental level, physical interaction with our environment through material manipulation is a way of confirming our being in the world, a notion important not only in childhood but throughout life (Ackerman et al., 2010; Gallace & Spence, 2010). It is a way of being in touch with ourselves as well as with the world (Gallace, 2012). This notion was especially present in the case of the deafblind participants (Publication I) but featured in all three cases.

Physicists and neuroscientists Marcus Kiefer and Natalie M. Trump (2012) write on embodiment in relation to education, and they point to the importance of real-world material manipulation in general but particularly in this context. They believe that appropriate sensory motor experiences are necessary for human cognition to develop at the highest level (Kiefer & Trump, 2012, p. 19). They claim that, in line with embodied cognition studies, it has been found that sensory-motor interaction with the environment during learning results in more durable and richer knowledge (Kiefer & Trump, 2012, p. 20).

When encountering new material challenges, previous skills, experiences and physical material explorations help in making sense of the new material and its behaviour. Physical material explorations thus seem to strengthen the student's confidence in managing new situations, providing the student

with a wider and deeper skills toolbox to work with in the future. A third, practical, implication that could be drawn from this research is that **making may be seen as a way of negotiating meaning through interaction between the embodied mind and the material environment, thus it may affect intrapersonal growth and provide a useful platform in educational settings.**

Essentially, there is a need to add the embodied aspect to studies in design cognition. As it appears now, neither the emotional nor the physical realm of designing or making is properly accounted for in the concept of design thinking. Studies on the particular way that the designer makes sense in practice need to pay attention to the embodied and tacit dimension as well as the subjective and emotional processes of the practitioner.

Through the methods used in this research, it was possible to study the interaction of maker and material very closely, with informed accounts from a researcher-practitioner who has intrinsic motivation in revealing aspects of experiential knowledge. This takes the study on design cognition in relation to the craft practitioner a step further than merely considering the planning or representational aspects of the making process. Therefore, as a last practical implication, I consider that **design and craft research benefit from a combination of research approaches that aid in investigating both representational and non-representational aspects of the practice.**

6.3 Methodological Reflections of the Study

My research path may be described as a search for ways to discuss my practice in a scholarly manner. Ultimately, I was looking for a way to theorise my practice. The theory of phenomenology and situated cognition was discovered as a result of Case 1, but the theory of embodied cognition was not properly understood until halfway through Case 2. Therefore, the research advanced through both theoretical and practical means.

There are many alternative methods that could have been used for this study; however, the multiple case study methodology suited the examination of one phenomenon in different environments, including a practice-led setting. The research now includes a large selection of data collection methods that are interlinked.

As a theoretical foundation for studying a practice, Practice theory developed in the social sciences could have been another choice. Practice theory would have led the research away from the subjective setting of sensory experiences and tactility towards a more socially-orientated direction. However, this was not the point of this study as here I am seeking to examine the relationship between the maker and material. A suitable match of practice and theory was found in the study of embodied cognition. For methods of analysis, Grounded Theory could have been one option, but since a theoretical perspective was already guiding the research, content analysis and thematic content analysis felt more appropriate.

While acknowledging that vision and the hand-eye connection is very important in skill-related performance and expertise, perhaps especially so within the field of art, design and craft, the importance of visual perception is in this study taken for granted. It has also not been my intention to separate the tactile sense from the other modalities as they are mutually intertwined and embodied in each other (Pink 2009, p. 26–27, 2011, p. 4–5; Shifferstein & Wastiels, 2014, p. 19). Furthermore, the concept of the five separate senses is a Western cultural construct, and does not even exist in all cultures (Pink 2009, p. 51). While it is important to acknowledge these issues, Pink finds the Western sensory categories; vision, touch, smell, taste and sound useful in a research context as “first, they constitute the local categories researchers seek to understand and secondly, they are useful analytical categories in research” (Pink, 2011, p. 6; Pink, 2009, p. 125–126).

Case 1, its related workshops and the discussion seminar were conducted intuitively. Although not being able to do an anthropological (Ingold, 2013, p. 3) study by spending a long time living as one of the research participants and participating in their culture, I tried to participate in making together with the deafblind participants as a way of getting close to their experience. In this way, I approached this group as a researcher-practitioner, inspired by ethnographic methods.

Think aloud accounts have been criticised for affecting the performance of the subject and being incomplete or irrelevant (Cross et al., 1996, p. 2). However, in a practice-led setting, verbal accounts situated within the making process were found particularly valuable in capturing the emotions that were not seen in the actions of the video. These verbal accounts also provided detailed explanations of the problem-solving activities, and as such were especially useful as a compliment to the audio-visual material in the analysis process.

Collecting only visual data, in the form of video-recordings without any spoken accounts, would have placed a considerable demand on the ability of the researcher to remember the events. It is known that the memory of an event changes with time, and even a very short time lapse between an experience and its recall will affect the way we remember an event (Ericsson & Simon 1984/1993; Kujala & Miron-Shatz, 2013; Robinson & Clore, 2002). Think aloud accounts in connection to video data help in overcoming some aspects of this problem.

Self-study, autoethnography, and practice-led study are research settings in which part of the analysis is based on memory, as practice is first documented and then reflected upon. As mentioned, this may be problematic due to the inaccuracies of memory. Teacher educators and developers of the self-study approach Stefinee Pinnegar and Mary Lynn Hamilton (2009), however, remind us that self-research into practice does not attempt to give one ultimate truth, but the understanding of the practice as the practitioner has experienced it. With regard to Case 2 (Publication

II and III), it is therefore acknowledged that previous experiences of clay throwing situations also play a part in the analysis of the video.

Self-study also requires the double position of being a practitioner as well as being a researcher (Borgdorff, 2006; Elo, 2009). In this study, the two roles are intertwined but not simultaneously, as when performing the practitioner role is very much enhanced and the actual analysis is conducted at a later point. The description of embodied knowledge also follows these two roles as in the practice the experiences are subjective and the events are experienced *through* the body as opposed to in the analysis when events are reflected on as *having* a body (Thompson & Stapleton, 2008). However, in the dissemination of research on subjective embodied and experiential knowledge, the separation of these is inevitable as the explicable part of the sense-making process and related findings have to be communicated verbally.

In Case 3, the focus on two design students brought forward aspects of embodied knowing that were perhaps hidden even to the students themselves. When the students read the research report on themselves, they agreed on the findings although they were at first surprised. It would have been interesting to try to generalise the patterns found and refer back to the data of the other 17 students as well. This leads to the challenge of estimating how generalisable the results of this research are not only in the general design and craft practice, but also in other body-based practices.

6.4 Recommendations for Further Research

When studying design and craft practice in an academic setting, it becomes clear that other research practices work within paradigms that exclude factors important in this field, such as subjective experiences, sensory experiences and emotions, together with an attempt to describe and explicate the experiential knowledge that they involve. This means the inclusion of three areas that are generally considered difficult to include within research: a subjective setting, emotions, and tacit knowledge.

As seen in the discussion, self-study in a practice-led setting allows for the subjective experience of the practitioner to reach the academic audience; it gives a voice to practical, situated and experiential knowledge. These subjective insights reveal aspects which objectivity cannot access. Therefore, it is important to encourage practice-led enquiries that lead to new knowledge in the field of design and craft that emphasise the role of embodied knowledge within the creative process.

Tacit knowledge is a concept that is unavoidable when researching design and craft practices. According to design researcher Claudia Mareis (2012), there are reasons to believe that the discussion on tacit knowledge within design practice is influenced by a “romantic idealization” (p. 71) of the practice and the well-kept secrets of master practitioners (p. 70). Mareis further suggests that design researchers must re-consider these

historical influences and make them compatible with current knowledge debates, including also socio-cultural dimensions (p. 71). Whilst, acknowledging that the theories around tacit knowledge are created in another time and with such different knowledge structures, the design researcher should not avoid attempting to research her practice on the grounds that the knowledge that she will handle is tacit and therefore inaccessible.

Aspects that previously fell into the tacit knowledge category might be accessible through our new audio-visual media. As video allows for a slow motion analysis of actions and behaviour, a video analysis of actions provides the craft practitioner with the time to speak about his or her experiential knowledge. Acknowledging that truly tacit dimensions will always remain tacit, *Practice* may now be researched in a new way, quite different from the time when Michael Polanyi (1958, 1966) introduced the concept of tacit knowledge.

While craft practice is largely tacit, through her research Wood (2009) has shown that craftsmen do know quite well what they are doing, but articulating it might be challenging. However, the intrinsic interest of the researcher-practitioner in explicating the knowledge of her practice has an advantage over practitioners who participate as research subjects (Seitamaa-Hakkarainen, Laamanen, Viitala & Mäkelä, 2013, p. 15-16). The practice-led research setting, including the multimethod developed for this study (Publication 2), was thus found useful in explicating personal knowledge and sensory experiences as well as related emotions during the making event. The studio as research laboratory and the subjective perspective of the researcher-practitioner enabled a reflection on experiential knowledge that would have been challenging to uncover in a distant and objective research setting.

As emotions were found to be a major theme in the data, especially regarding their role as contributors to risk assessment, decision-making and problem-solving in the design and making process, but also in connection to social and ethical contexts and in relation to personal growth, it would be interesting to see further research into emotions in the context of making from other domains to elucidate whether the same patterns are visible there. Emotions also seem an important aspect of any making activity and, as such, making activities have the potential to be used in affecting emotions purposefully.

Subjective felt sense and emotions have traditionally been out of the scope of scientific research practice; however, as we have seen, there are many benefits from a subjective research position. Further, Johnson (2007) claims that when it comes to bodily felt sense experiences, these are not subjective since they are qualities of organism-environment interactions and they are thus shared with other people, who naturally also have a body (p. 25). That means that felt sense and emotional bodily responses to felt experience might be similar in other bodies; as a result, what we call subjective experiences might after all be generalisable to some extent.

Sensory experiences may also be recalled by their activation through memory. Pink (2011, Pink & Leder Mackley, 2012), who uses video extensively in her research, found that video enables the viewer to either recall previous experiences in a multimodal form if personally experienced previously, or to recall similar experiences if the events are not subjectively experienced. Pink has developed a video method as part of her sensory ethnographic research and even displays video clips as an integral part of a journal article that she wrote with Kerstin Leder Mackley that is published on-line (Pink & Leder Mackley, 2012). In the article, Pink and Leder Mackley (2012, p. 8) refer to MacDougal (2006, p. 220) and say that “visual media allow us to construct knowledge not by description but by a form of acquaintance”. They continue (2012, p. 8):

...forms of acquaintance might include both the idea or feeling that we understand something because we can access it through a similar personal memory or experience, or conversely by seeking to use our own resources of experience to try to understand that which is quite different to our own.

Piper (2016, p. 2961), too, has come to the conclusion that the image conveys the tacit dimension better than only the written word. She thus created a “visual essay” in the form of a video that she presented at the Design Research Society conference in 2016, bridging the gap between implicit and explicit knowledge, in order to maximise the reach of her research.

This is a very important dimension for researchers who wish to disseminate studies in embodied knowledge in relation to implicit aspects of a practice. As our language is conceptual and general, we have a difficulty in communicating our very particular and lived experiential knowledge through text (Tin, 2012). Polanyi (1966) writes that if we want to communicate tacit knowing, we have to “point” at it and rely on the receiver’s “intelligent co-operation” in catching the meaning of the demonstration (p. 5).

In an academic context, the “pointing” is commonly done through text. Design researcher and organisational theorist Antonio Strati (2003) writes about the “reader’s imaginary participant observation” (p. 69). He argues that the reader of research texts, too, through his imagination, may become a participant researcher, drawing on his own sensory-based experiential knowledge in the interpretation of the read text: “By virtue of participant observation conducted through the imagination, the readers see, hear, perceive and are aware of the research process in which they are imaginatively taking part through sensorial faculties rather than intellectual abilities” (Strati, 2003, p. 59). Strati’s reflection is supported by Gallese and Lakoff (2005), who present neuroscientific arguments for the *multimodal language*, arguing that “[t]he same neural substrate used in imagining is used in understanding” (p. 456).

The above discussion indicates that the audience of the research form their own knowledge on the basis of what the researcher is presenting

combined with their own previous experiential knowledge. The audiences form this knowledge partly by imagining and thus re-enacting the experiences of the researcher. Audio-visual media in particular is encouraging this empathic behaviour as it also awakens the audiences' pseudo-haptic experiences (see also Loukola, 2014; Tikka, 2008). As is familiar from the theory section of this thesis, we may attribute this type of empathic behaviour to mirroring systems.

Mirroring systems, (introduced on page 21) have been claimed to help understanding of other people's actions when looking at them acting, especially if we have acquired those motor skill ourselves (Calvo-Merino, Glaser, Gre'zes, Passingham & Haggard, 2005). Hence, the audiovisual dimension could provide an opportunity for design and craft researchers to disseminate research on experiential and embodied, and maybe also tacit, knowledge, especially in cases where the audience consists of practitioners from the same domain as the presenter. This aspect has been evident in the many video presentations of the research at hand in conferences and seminars.

Additionally, research in New Materialism (Coole & Frost, 2010; Bennett, 2010) is very interesting and also a promising continuation of the embodied quest in relation to understanding our relationship to materials in design and craft.

7 Summary

The objective of this study was to investigate aspects of embodied sense-making within the practice of designing and making with hands. Through three case studies, the question of how design and craft practitioners think through their hands was studied in three different settings in which designing or making take place. The results of this research indicate that design and craft research benefit from including the embodied dimension of design and craft practitioners' processes. It further suggests that this concrete mode of design and craft practice may be explained by concepts developed within the theory of embodied cognition. This indicates a reason for why other theories leaning towards this line of thought have already been utilised by both practitioners and researchers in the field of design and craft for some time.

The making practices confirm the theory of embodied cognition, and embodied knowing is enacted in the making practices. However, as designers and practitioners also deal with representations of envisioned designs and artefacts, two modes of sense-making may be detected: the imaginary representational and the concrete non-representational. A model showing the embodied sense-making that emerges through this research has been presented in this thesis (page 64).

One of the case studies involved an investigation on students' use of their embodied knowing. It was found that design students use embodied knowledge of materials and their properties at all stages of the design process, even before physical material exploration. Touch was not only an essential tool for making decisions on materials and for testing materials but also for communicating ethical and social aspects of the design.

When the design process is taken from a 2D drawing to a 3D prototype, there is a change in working modality that is risky for the novice designer, but may be overcome through reference to previous experiences of similar situations. The more experienced designer has the benefit of owning a larger asset of embodied knowledge of materials and may thus create more realistic mental images of intended designs. Thus, even "concept designers" benefit from a craftsman's education.

The understanding formed by the above conclusion is that hands-on teaching methods including various material explorations should still preferably form *the basis* of design and craft education, as previous training in material manipulation makes a difference in how students are equipped for future projects. These embodied skills are of fundamental importance particularly in the virtual design contexts now inevitable in the making practices.

In addition, tactile skills might at times even be better taught by tactile means since the embodied knowledge of the teacher, including limb pressure and the exact timing of movements are more readily available to the student in such a setting. Additionally, manipulating material may be seen as a way of being in, and affecting, the world as well as negotiating meaning related to our abilities and limitations. This process is important in intrapersonal development and, as such, affects educational issues.

An overarching result of the entire study was the many different levels and notions of emotions that surfaced through and in connection with tactual experiences. As a result, it may be said that emotions related to tactual experiences in a making process with material affect and regulate risk assessment, decision-making and problem-solving. Emotions also help the maker in applying the right amount of attention and caution in the management of critical incidents. Previous experiences are stored and reactivated by somatic markers that remind the maker of the available opportunities and risks (affordances) related to a situation.

Emotions and sensory experiences are thus linked to the skills of a design or crafts practitioner and as such constitute the tacit and embodied knowledge of a practice. Emotions were also linked to decision-making made regarding which materials to use for an intended design. As subjective emotions have such an impact on the sense-making processes of design and craft practitioners, emotions appear to be an important research topic in design and craft research, not only in connection to well-being but also in connection to risk-assessment, decision-making and problem-solving.

Collecting multiple types of data in a practice-led research setting, was found useful in the study of experiences and experiential knowledge in design and craft processes. Video was found especially useful as it allows for a threefold benefit, A: in the collection of the data, B: in the analysis of the data, and C: in the dissemination of the results. The multimethod developed as a result of this research may be utilised in cases where researcher-practitioners are recording an event to gain detailed and articulated information of the embodied knowledge they possess. The use of video in the dissemination of the results might also transfer tacit aspects of embodied knowing to the audience through pseudo-haptic imagining and affect.

The methodology formed during this research process combined methods from design cognition studies such as protocol analysis and the contextual activity sampling system as well as practice-led self-study on sensory experience and sensory ethnography coupled with the activity of making. A methodology that grows out of the practice may reflect that practice more accurately. In addition to research methods that take embodied sense-making into account, there is a need for a theory that stretches beyond the merely representative mode of designer's activities and into the material realm. Ultimately, this study puts forward a view of the act of *Making* as a way of making sense through hands.

The above discussion shows that this study extended the realm of design cognition studies and needed support from concepts developed in embodied cognition theory. This observation invites us to build on the theory of design cognition to include a more embodied approach to both research methods as well as theory.

The research thus puts forward four theoretical and practical implications: 1) Embodied cognition theory lends itself well to informing design and craft related practice; 2) Design processes include embodied knowledge even in the cognitive and immaterial stage of creating mental images of the intended physical designs; 3) Making may be seen as a way of negotiating meaning through interaction between the embodied mind and the material environment, thus it may affect intrapersonal growth and provide a useful platform in educational settings; 4) Design and craft research benefit from a combination of research approaches that aid in investigating both representational and non-representational aspects of the practice.

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9 Original Publications

9.1 Publication I

Groth, C., Mäkelä, M. & Seitamaa-Hakkarainen, P. (2013)
Making Sense - What Can We Learn from Experts of Tactile Knowledge?
FORMakademisk Journal, 6, (2), 1–12

9.2 Publication II

Groth, C., Mäkelä, M. & Seitamaa-Hakkarainen, P. (2015)
Tactile augmentation: A Multimethod for Capturing Experiential Knowledge.
Craft Research, Intellect, UK. 6, (1), 57–81

9.3 Publication III

Groth, C. (2015)
Emotions in Risk-Assessment and Decision-Making Processes
During Craft Practice. *Journal of Research Practice*, AU Press,
Canada. 11, (2) article M5

9.4 Publication IV

Groth, C. & Mäkelä, M. (2016)
The Knowing Body in Material Exploration.
Studies in Material Thinking, AUT, University, Australia. 14, article 02

Making Sense – What Can We Learn from Experts of Tactile Knowledge?

Camilla Groth, Maarit Mäkelä &
Pirita Seitamaa-Hakkarainen

Abstract

This article describes an embodied way of making sense through making with the hands. We examine the potential of tactile experience in the making process and analyse what tactile experiences mean. The study takes place in the context of an era marked by audio-visual dominance. The article presents a case study that observed and interviewed deafblind makers while they worked with clay. The findings reveal that modelling in clay resembles the visualisation process of sketching. As such, it may contribute to thinking through the hands. Language is not a self-evident communication tool for transferring tactile skills. Based on our case study, we propose the use of tactile communication in the process of transferring tactile knowledge through making with another person's hands.

Keywords: tactility, embodied knowing, making, clay, deafblind

Introduction

'Touch is a kind of communication between person and world, a corporeal rather than a cognitive positioning.' (Rodaway, 1994, p. 148)

In Japan, the expression '*Te de kangaeru*' means 'thinking through one's hands'. This expression is very common, and there is no doubt about its meaning. It is, as Paul Rodaway stated, a bodily rather than a mental positioning. In this article, we investigate the experience of 'thinking through one's hands'. Although this is a poetic expression that may not be taken literally, artisans and craft people use similar expressions when describing their tacit and embodied experiences in their making process (Dormer, 1994, p. 4; Sennett, 2008, p. 9).

The case presented in this article focuses on tactility and involves people working in the area of ceramics. In this study, the tactual experience is isolated, as visual perception is not in use. In this way, we study whether removing sight enhances the sense of touch. Before conducting the case study, one of the researchers, who is also a professional ceramist, used a potter's wheel with her eyes closed to practise her skills in a new way. During this exploration, she realised that her tactile awareness was clearly enhanced. She noticed that she was able to throw clay just as well with her eyes closed, since throwing clay is largely a tactile skill. Based on that experience, we propose that makers and artists who have lost their vision are experts in the field of tactile knowledge (see Nicholas, 2010, p. 16).

The starting point for the present research is learning from people who have lost a modality and investigating what they have gained instead. These gains could take the form of an augmented, enhanced or trained ability in another modality—in this case, the tactile. The sense of touch is an essential element in the making process. By exploring and augmenting the tactile sense, we can learn something new in the area of designing and making. We could use blindfolding as a way to augment tactile experiences in people who have not lost their eyesight. This leads to the following questions: Can a person with all modalities in use enhance the modalities less in use? If this is the case, how could we benefit from this? In his book *The Thinking Hand*, architect Juhani Pallasmaa wrote that, in any creative field, the process of un-learning is just as important as learning, forgetting is as important as remembering, and uncertainty is as important as certainty (2009, p. 143). The present case is based on the idea that, by temporarily forgetting how to perceive with our eyes, we can learn how to perceive through our body and to explore with our hands.

Both the making experience of working with clay and the enjoyment of finished ceramic pieces are strongly tactual. Working with the deafblind people has shown us that many of them are fond of making ceramics because it is one form of making that they can do without needing to see

or hear well. In the following sections, we first introduce some theoretical discussions related to tactility and embodied knowing. Second, we describe how the case study was conducted, and we analyse the outcomes. Finally, we discuss the implications of the study and how these findings might be pursued further.

Towards Embodied Knowing

While visual and auditory cognition have been investigated extensively, there is relatively little research about tactile cognition (Nicholas, 2010, p. 5). There appears to be a hierarchy of the senses, which has changed over time. The present era is characterised by audio-visual dominance, where cognitive skills based on reading and writing are valued more than bodily skills relying on the bodily senses of smell, taste and touch. This is the case even though we use all our senses simultaneously to perceive and to create meaning from the world. In his book *The Eyes of the Skin*, Pallasmaa stated that, in Western culture, sight has historically been regarded as the noblest of the senses, and thinking has been thought of in terms of seeing (2005, p. 15). Hence, the link between seeing and understanding has gained a fundamental position in Western thinking. Pallasmaa added that,

during the Renaissance, the five senses were understood to form a hierarchal system from the highest sense of vision down to touch. The Renaissance system of the senses was related to the image of the cosmic body; vision was correlated to fire and light, hearing to air, smell to vapour, taste to water, and touch to earth. (2005, p. 15)

It is plausible that in pre-ancient times, when survival depended on sensing danger with the whole body, sight was not the only primary sense. It would have been equally necessary to hear someone or something advancing from behind and to smell a fire. French historian Robert Mandrou supported this idea of a different hierarchy of the senses in the medieval era. He proposed that the hierarchy was not the same:

The eye, which rules today, found itself in third place, behind hearing and touch, and far after them. The eye that organizes, classifies and orders was not the favoured organ of a time that preferred hearing. (Mandrou, 1977, p. 76)

According to Professor Walter J. Ong (2002, p. 117) the shift from oral to written speech was essentially a shift from sound to visual space. He suggested that, as hearing-dominance has yielded to sight-dominance, situational thinking has been replaced by abstract thinking. In our opinion this transformation from situational to abstract thinking is clearly visible as one watches children grow up. By the time they start school and learn to process information on an abstract and conceptual level, the embodied

exploration evident in smaller children has started to fade away. This development is permanent; Ong proposed that a literate person cannot fully recover a sense of what the world is to purely oral people (p. 12). Similarly, it is impossible for a person with eyesight to imagine what the world is like to someone who was born blind.

Situated and Enactive Cognition

There are grounds for thinking differently about this hierarchy of the senses and for thinking of the brain as the only location of cognition. For example, situated cognition supports a more whole, embodied attitude. It suggests that knowing is inseparable from doing and argues that all knowledge is situated in activity (Brown, Collins, & Duguid, 1989; Robbins & Aydede, 2009, p. 3). Cognition depends not just on the brain but also on the body (the embodiment thesis). Cognitive activity routinely exploits structure in the natural and social environment (the embedding thesis), and the boundaries extend beyond the boundaries of the individual organism (the extension thesis) (Robbins & Aydede, 2009, p. 3). The enactive approach is closely linked to this way of thinking and was originally proposed by the neuro-phenomenologist Francisco Varela. It is a theoretical approach to understanding the mind; it emphasises the way that organisms and the human mind organise themselves by interacting with their environment (Varela, Thompson, & Rosch, 1991, p. 173).

Enactive knowledge is not simply multisensory mediated knowledge, but knowledge stored in the form of motor responses and acquired by the act of doing. Examples of enactive knowledge are tasks such as typing, driving a car, dancing, playing a musical instrument and modelling objects from clay. (“Enactive Interfaces,” n.d.). Philosopher and neuroscientist Alva Noë has been developing this idea in his research on enactive perception. He claimed that,

to understand consciousness in humans and animals, we must look not inward into the recesses of our insides; rather, we need to look to the ways in which each of us, as a whole animal, carries on the process of living in and with and in response to the world around us. The subject of experience is not a bit of your body. You are not your brain. The brain, rather, is part of what you are. (Noë, 2009, p. 7)

To conclude, perception is a combination of all modalities forming an embodied understanding of the world. But what happens when one or multiple modalities are blocked? In the next section, we will connect the primary focus of our article, tactility and touch, to the ideas of sensory substitution and neuroplasticity.

Sensory Substitution

Sensory substitution was developed and mainly used to help people with one or multiple modal impairments achieve a better quality of life by augmenting other modalities to make up for the lost one. It was first conceived by neuroscientist Paul Bach-y-Rita, who proved the brain's capacity to transform itself by enhancing other areas of the brain when one or several modalities were injured.



Figure 1. Early sensory substitution experiments by Paul Bach-y-Rita.
<http://www.lumen.nu/rekvelld/wp/?p=383>

Figure 1 shows an early sensory substitution experiment by Bach-y-Rita. A camera records what is seen through the glasses, transforming the image into electric impulses. The image is then flashed onto the body via a tactile display. Through this vision substitution by tactile image projection, the blind subject is able to see through his skin. His tactile sensitivity and tactile skills grow through training of the tactile sense due to the lost visual modality. Learning typewriting using a keyboard without letters to exercise the tactile memory of the letter key positions is, in a way, a reverse use of sensory substitution. We could even call it a form of partial sensory deprivation, performed to augment the tactile memory by reducing the visual modality. This is the basis for attempting the reduction of the visual modality to achieve tactile augmentation. The above theoretical frame provides grounds for believing that we can, to some extent, 'think through our hands'. Consequently, making can be seen as a way of thinking through the hands by manipulating a material (Nimkulrat, 2012; Nicholas, 2010, p. 16).

According to Gray and Burnett (2009), craft is a dynamic process of learning through material and sensory experience leading towards a broader understanding (see Sennett, 2008, p. 9; Nimkulrat, 2012). In craft and design, visual and material artefacts and tools have a central role in mediating the thinking and making processes (Goel, 1995, pp. 128, 190;

Keller & Keller, 1999). Craft can also be seen as a form of embodied knowing that involves materials, tools and social communication. Patel wrote about embodied thinking as an anchor linking the mind and body, with emphasis on understanding the relationship of the body to the process of making and thinking, i.e., how artisans relate their bodies, tools, materials and space in their work setting (2008, pp. 18, 131). The case study introduced here forms the first in a planned series. The purpose of this study is to learn from experts of tactility: How do these experts make sense through making? How do they think through their hands?

Case: Augmented Tactility

The study was conducted at the Tampere Activity Centre for the Deafblind in the spring of 2012. A workshop with two adult deafblind makers in ceramics was arranged. The makers were interviewed during their working processes, partly with the help of an interpreter. The setting was recorded on video, documenting both the working process and the interpretation. The interviews and videos were then transcribed and analysed. Participants of the workshop were invited through the Finnish Deafblind Association and participation was voluntary. The real names of the participants have been changed. The first participant in this study is 55-year-old Olavi. He is deafblind and communicates by tactile sign language, i.e., by hands-on signing and using a sign language interpreter. The second participant is 36-year-old Laura, who is deaf (but uses a hearing aid), has 10% sight and communicates through speech. Both participants work professionally in the area of art: Laura is a painter and Olavi uses mixed media in his artwork. The accounts of the participants presented in this article are translations from Finnish to English.

Working with Clay

The session began with a brief description of the layout of the workshop. One of the authors, who was conducting the workshop, asked both participants to give a brief account of themselves and their relationship to clay as a material. The participants had some experience sculpting and using clay, including throwing, but were not experts and were not familiar with the type of clay used in the workshop. They were handed a piece of smooth porcelain clay and were given free rein as to what to make out of it. They both started working without hesitation.

During the two-hour workshop, the working process was stopped from time to time to interview the participants in the middle of their work. This was done to obtain a fresh account of what was going on in their minds while making, as opposed to an account given after the workshop based on



Figure 2. Laura's sculpture of a hand showing the sign for the letter R. Photo by Camilla Groth.



Figure 3. Olavi's bowl thrown on the potter's wheel. Photo by Camilla Groth.

memory. Laura worked on one sculptural piece depicting a hand (Figure 2). Olavi made a female sculpture, and with time left over, wanted to do some throwing on the potter's wheel. The researcher assisted him on the wheel by throwing a bowl with his hands. After that, Olavi took more clay and threw one bowl himself (Figure 3). After the workshop, the whole team, i.e., the researcher, Laura, Olavi and the translator, assembled in a coffee room for one hour to talk about their experiences during the workshop.

In the workshop, the participants were asked to work with porcelain clay, which is very smooth and can be tricky to handle. Since the material was new to the participants, it caused some surprise and a little suspicion at the beginning. Olavi asked, 'Is this a bit bad, this clay, worse than the other one [that I was used to]?'

By the time the session ended, they had both gotten used to the way the clay behaved. Laura was very fond of it. She said, 'I really like this clay; it is really smooth and feels good to work with. It doesn't start cracking as much as other clays.' After the session, even Olavi said that the porcelain had grown on him and that he was happy to have tried a new type of clay. When asked to describe briefly what the session meant to him, he answered that he was happy to have experienced a new sensation, the new type of clay, and that his throwing had gone well. He said he had increased his skills and felt more confident in his making.

The authors have held classes with seeing and hearing adults in the past; the most striking difference of this class from their previous classes was the fearlessness with which the participants started working. Both makers were very brave in the way they handled the clay. They did not have a tendency to be overly careful. Both worked briskly. While she was working, Laura said,

My relation to using my touch sense has changed, and I'm no longer afraid of using my hands; for example, if there is something lying on the ground, I would just go and touch it even if it turned out to be a dead rat ... I used to go running but had to stop when the limbs of the trees started to hit me in the face [as my eyesight deteriorated]. I still run everywhere, running after my three sons, and sometimes I run into things or fall over. But if I fall over, then I fall over; that's the way it has to be.

When Olavi was asked if it was possible to think through one's hands and if he had any experience doing so, he replied,

As I can't see anything, I kind of have to also think through this tactility. I got completely blind around the age of 40 and turned tactile at that point, so yes I would say that thinking partly happens that way. When I could still see, I never thought with my hands; but now I always have to use my hands, for example in measuring sizes and so on. It is easy for me to use my hands, especially when working with clay.

Laura also supported the idea that it is possible to think through one's hands:

Yes, I think it is possible to think through one's hands. My opinion of this comes from having taught deafblind people art in the art classes here [at the activity centre]. There, I have noticed how people really engage with and familiarise themselves with different materials through their hands.

They were also asked whether they had ever tried thinking through clay, such as by making a model as a 'tryout' before making the real piece. Laura said she had never done so and would always just start making a piece and finish it as it came out: 'Clay is such a flexible material, I don't need to make a model; I just remake it straight away.'

This reflection indicates that modelling is a continuous remaking process. The clay is flexible and the artefact often emerges by remaking, through modelling with one's hands directly in the material. As sketching is considered the main thinking tool for designers (Goel, 1995, p. 198; Seitamaa-Hakkarainen & Hakkarainen, 2000), we suggest that thinking can also be attributed to the act of modelling in clay (Dormer, 1994 p. 24).

During their work, the participants were asked, 'What are you thinking right now?' This was done with the assumption that the participants would not have processed their thoughts through any analysis, but would give a fresh picture of what was going on in their working process. Olavi answered,

I have to do the head now, and I need to be really careful as the clay is so soft.

Meanwhile, Laura replied,

I'm not thinking of anything, maybe just about yesterday's meeting. When I'm making, it is the best time to think about all the things I should be doing, and still I am only making this.

Working Patterns and Confronting New Materials

According to Patel (2008, pp. 18, 131), the artisans carefully relate their bodies, tools, materials, and space to each other in their work setting. Similarly, the deafblind have to organise their workplace immaculately before working to know where the tools are. During the workshop, both Laura and Olavi arranged their immediate surroundings and the table with their tools to have everything within reach. They found the tools they needed before starting to work and then kept the tools in one place on the table. When Laura dropped one of her tools on the floor, she said,

Now I'm in trouble.

The participants' actual finger movement patterns were quick but trembling and tended to feel rather than press onto the material. Laura said she had difficulties seeing the piece she was working on; touching it to feel what it was like would already change it, as the clay was so soft. Another observation is that blind makers do not need to turn the work over to see it from all angles. They can work on the back of the sculpture as well as on the front, with the piece remaining in the same position. This serves as a new positioning towards the relationship of the body to the material.

We can understand our bodily limitations through making with a material. For example, there is a limitation to size, or how large or small one can make an object. When our body is in communication with a material, the material also responds to our body. The imprint we make tells us about ourselves and our limitations. The piece that we produce can be seen as an extension of ourselves, as it always includes some self-expression. When we touch a material, we simultaneously feel ourselves and become aware of 'being'. In this sense, making can be considered a way of being in contact with oneself. Our body is in contact with a material that bends to our will, but the material also has its own will; thus, there is a struggle between our will and the material. We make concessions to the material and we make compromises with ourselves, due to the will of the material. It is as if there is communication with and through the material, and the outcome is an expression of this struggle or collaboration. Therefore, the outcome of this process is not a pure expression, but rather evidence of that process. In other words, it is an artefact that embodies the self and the material. This struggle was evident in both Olavi's and Laura's processes as they familiarised themselves with, and eventually won the struggle with, the new material.

At some point in the middle of working, when the work had reached a 'critical point' of starting to crack or wanting to bend, both participants expressed some stress over their lack of technical skills. Overall, the participants expressed stress over their lack of technique and worry that they would not succeed at what they had imagined they would make. In the end, the participants were happy with their results and the whole experience. A kind of catharsis appeared to be reached when the worry turned into contentment. The end result was accepted through the process, as their image of the piece changed while they were working.

Shared Tactile Experience

After finishing his sculpture, Olavi tried throwing porcelain on the wheel, aided at first and then on his own (Figure 4). He had tried throwing a few times before and had even taken a throwing course. Although he felt some frustration during the workshop over not being able to make a narrow neck on his vase, he was still very pleased that the throwing resulted in a nice

bowl instead. Previous tryouts had sometimes resulted in the clay being flung onto the floor.



Figure 4. Olavi throwing with the researcher. Still photo captured from video clip by Camilla Groth.

As the researcher was throwing with Olavi, she could not speak with him or guide him in throwing by speaking through his interpreter, since he would have needed his hands for conversation. Instead, she was tacitly guiding him with her hands by placing them over his and throwing the clay with him. Based on this experience, we propose that this teaching method was efficient. The researcher was able to pass the exact timing of muscle pressure against the clay, and all her collected tacit knowledge was available for Olavi. She realised that she was performing a kind of transferral of her embodiment with the material to him. At the same time, he could also feel the material moving and shaping under his own hands.

Concepts such as tacit knowledge (Polanyi, 1966, pp. 9–11), knowing-in-action (Schön, 1983/2008, p. 59) and reflection-in-action (Schön, 1983/2008, pp. 49–69) are attempts to characterise the knowledge and practices of skilled performers in art, craft and design. According to Michael Polanyi, the founder of the concept of tacit knowledge, ‘an art which cannot be specified in detail cannot be transmitted by prescription, since no prescription for it exists.’ (1958, p. 53). Polanyi proposed that such a skill may be passed on only by example from master to apprentice. The craft skills are taught through modelling, coaching and scaffolding; hence, they are the core of traditional apprenticeship, which is supported through the processes of observation and guided practice (Wood, Bruner, & Ross, 1976; Collins, 2006).

In addition, according to Pallasmaa (2009, p. 15), learning a skill is not primarily founded on verbal teaching, but rather on the transference of the skill from the teacher’s muscles directly to the apprentice’s muscles through the act of sensory perception and bodily mimesis. Explicit knowledge, the part of tacit knowledge that can be articulated, always rests on a much larger, hidden foundation of implicit knowledge. We propose that the skill of throwing clay also rest on such a foundation. Therefore, we agree with Polanyi’s (1966, p. 4) basic idea that we can know more than we can tell.

Instead of having a pupil watching from the side, it might be more efficient to take his or her hands and perform with him or her. If a tacit skill is taught tacitly, the tacit knowledge can be transferred more easily than by merely watching and hearing instructions. Imaginary tactile learning by hearing or by using a tactile memory of a similar experience through watching is not enough. We also propose that the tactile experience of blindfolding can be used in education to further enhance tactile awareness in a learning situation where the pupil is sighted.

The Problem of Language

One of the problems of this case study was the use of language. Language has been proven a problem both in communication with the deafblind and in the processing of experiences. In addition, we found that abstract concepts are difficult to communicate via tactile signing. The main questions of this study are abstract and somewhat poetic ones: ‘Do you think it is possible to think through your hands?’ and ‘How do you think through your hands?’ This way of speaking requires a culture and a language that supports abstractions and conceptualisations. This observation is linked to the pre-literal condition discussed earlier in this text. Even though many deafblind people are or have been literate, there may be less literal culture in their everyday lives after losing both modalities. Situational experience moves to the forefront. As language is not an exact mode of representation, there are also a number of different ways to understand the spoken language. A word has different connotations to different listeners. When working with the deafblind, communication passes through a number of filters. This is evident especially in the use of a translator, as the information changes at every step of the translation process (Benjamin, 1923/2005, p. 152).

This problem with language led us to realise that language is not the appropriate mode for this type of research. As a tactual modality is also available, it might be more suitable to use this. This means that, especially in the context of tactility, we should show and communicate through making. This suggests that we are also capable of understanding by making and thinking through our hands.

Discussion

In contrast to an ocular-centric worldview, the material arts and crafts are largely tactile-centred. We could benefit from an augmented tactile awareness in our working process with a material. We can try tapping into our embodied knowledge simply by closing our eyes. Modelling in clay resembles sketching, and as such, may contribute to thinking through one’s hands. Language is not a self-evident communication tool when it comes to

transferring tactual skills. Based on our case study, we propose that tactile skills can be taught to another person by ‘hands-on’ communication, which is similar to tactile communication, rather than through verbal and visual communication only.

Art, craft and design activities are fundamentally creative in nature; they require the implementation of conceptual ideas in the design of materially embodied artefacts (Keller & Keller, 1999). Traditionally, the body and mind have been studied separately. While design and craft processes are usually considered to represent a high level of cognitive and motor skills, there is little research that reveals the neurological basis of these skills (Alexiou, Zamenopoulos, Johnson, & Gilbert, 2009). In recent years, the embodied dimension and its reflection in designers’ and artisans’ work have gained increasing attention (Patel, 2008; Mäkelä & Latva-Somppi, 2011). Furthermore, research on mirror systems in particular has begun to provide knowledge concerning the neural foundations of embodiment and social interaction, which are crucial aspects in designing and learning craft and design skills (for a review, see Hari & Kujala, 2009). These recent developments in cognitive neuroscience, i.e., neuroimaging, have provided more knowledge about the mechanisms underlying tactile cognition than ever before (Nicholas, 2010, p. 5).

More interviews with experts of tactile knowledge who have worked professionally with one material over a long period needs to be conducted. Expert practitioners have handled material countless times; thus, without conscious effort, they can imagine and predict the perceptual consequences of their actions. In the next step of the study, one of the authors will spend a week working with clay while blindfolded. She will record her experience, the progress of her work and her thoughts during the process.

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Tactile Augmentation: A Multimethod for Capturing Experiential Knowledge

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Abstract

The experiential knowledge of practice resides within the practitioner and is out of the immediate reach for other researchers. Only when practitioners have an intrinsic motivation to research and make their practice explicit can their embodied experiential knowledge reach an outside audience. The present case study is an attempt to access and understand such experiential knowledge in the act of throwing clay on a potter's wheel. To enhance her tactile sensitivity and awareness, one of the researchers has thrown porcelain clay blindfolded for five days. Her experience has been documented and reflected upon through diaries, a Contextual Activity Sampling System (CASS-Query) and videos that include thinking aloud accounts. The findings reveal that the researcher was able to articulate her tactile experiences and share her experiential knowledge to a greater degree than before. Patterns in the making, such as dividing hands into categories of active and perceiving, and metaphorical language use were identified that may be of value in an educational setting. Feelings were acknowledged as major contributors to risk assessment and decision-making in the material problem-solving process. We propose the multimethod approach developed through this study for researcher-practitioners to capture and analyse their sensory experiences and experiential knowledge of a making situation when researching their practice.

Keywords: multimethod, tactile augmentation, clay, experiential knowledge, practice-led research, embodiment.

Introduction

It is in the interest of design research to gain access to the practical knowledge of skilled practitioners and to articulate this knowledge from within the field. The embodiment of skills and materials' knowledge is evident in the practice of professionals, and the theoretical and conceptual work on the issue of embodiment is sophisticated (Varela et al. 1991; Merleau-Ponty [1962] 2002; Johnson 1987; Lakoff and Johnson 1999). However, there is still little empirical research applying this work to documenting design practices (Seitamaa-Hakkarainen et al. 2013). Ways of studying the making from the practitioners' point of view have been discussed in the relatively young tradition of practice-led research (Frayling 1993; Candy 2006; Niedderer 2007; Mäkelä and Routarinne 2006; Pedgley 2007; Niedderer and Reilly 2010; Nimkulrat 2012; Wood et al. 2009), and methods such as diaries and thinking aloud accounts are now supplemented by Event Sampling Methods (ESM) (Reis and Gable 2000; Seitamaa-Hakkarainen et al. 2013) such as the Contextual Activity Sampling System (CASS-Query).

The use of practice-led research methods – also referred to as research through design – has become increasingly common among practitioners in art, craft and design who wish to document, reflect on and research into their own practice (e.g., see Rust et al. 2007). The discussion on how to research in art and design is still vibrant (Mäkelä et al. 2011; Candy 2006). One major contribution in the field of experiential knowledge in practice-led research has been made by Niedderer (2009; Niedderer and Reilly 2010.) In this article, we consciously use the term practice-led research when referring to a research setting where the process of making, rather than the artefact, is in focus (Candy 2006).

Practice-led research emphasizes the reflection on experiential knowledge that the practitioner has embodied. In his book, *The Reflective Practitioner*, Schön ([1983] 1991: 76) encourages the practitioner to reflect in action in order to obtain access to this knowledge. Cross (1982: 5) supports this idea in his claim that there is a particular designerly way of knowing that is inherent in the designer, the process and the products themselves, and that access to it can be gained through reflecting on one's own activity. Pedgley (2007) admits that the multiple roles of researcher and respondent are complicated and that the results might be biased through the subjective research setting. Therefore, he argues for the importance of multiple data collection methods in order to triangulate data and results.

In our research, both qualitative and quantitative data, introspection and visual documentation, is collected and triangulated as supported by Denzin and Lincoln (2008:5). They emphasize the use of multimethods to secure an in-depth understanding about the phenomena. According to Pedgley (2007), a practice-led research setting provides a suitable platform for investigating areas of interest that the conventional research methods may not be able to access. As practitioners and researchers, we are able to carry out auto

ethnographic research about our own practice, and in this way we are able to articulate intrinsic knowledge from inside the field of design. This is also the position from which we argue throughout this article – even though from this point onwards, we will call ourselves purely ‘researchers’.

In this present case, one of the researchers challenged herself with a demanding task related to her field of expertise. She used the act of throwing clay on a wheel as a means to create a tactual interface with the material and an event where making takes place. In addition, to enhance the tactual experience, the visual modality was omitted through blindfolding. The main issue for the task was the challenge and control of the throwing process and the awareness of, or ability, to judge the shape and form of the piece solely with her hands. Through this exercise, we have sought to collect data and analyse the embodied experiences of the researcher.

This case study builds on our previous work, which investigated the role of the body in knowledge making processes (Groth et al. 2013). In the previous work, one of the researchers arranged ceramic workshops with deafblind adults and, working with them, she collected interviews and video recordings on their enhanced tactual sense-making process. The ceramic processes included a high degree of tactual experiences, in particular the throwing process that was found to be very interesting from an embodied cognition point of view (Groth et al. 2013). The same theme is also the focus of the research at hand. However, in the present research the practitioner was also the researcher. Through blindfolding, we aimed to enhance tactual awareness and make tactile sensory experiences more explicit.

The researcher documented and analysed her own activity, experiences and emotions through the combination of three methods: (1) video recordings for visual data and thinking aloud accounts (Ericsson and Simon [1984] 1993); (2) a diary method for qualitative data; and (3) a CASS-Query (Muukkonen et al. 2008) for contextual and quantitative data. In the following, we will introduce the research setting. Then, we explain the methodological framework and present the case. Finally, we discuss the analysis process.

Research in a Studio Setting

One of the researchers spent five days working blindfolded in her studio, recording one clay-throwing event daily. Each event consisted of throwing 12 kg, and later when confidence grew, 24 kg of porcelain clay on a potter’s wheel and lasted 1 1/2–2 hours. All the events were video recorded, which also enabled thinking aloud accounts made by the researcher while working. In addition to video and related thinking aloud accounts, the researcher made a diary entry just before and just after each of the throwing sessions. The CASS-Query was also used in connection to the event: the query consisted of twelve questions to answer before the event and nine questions to answer after the event.

Using thinking aloud accounts, it is thought to be possible to track the cognitive processes of an individual during an activity, as the method provides content-rich information about, for example, solving a design task (Akin 1986; Goel 1995: 217; Seitamaa-Hakkarainen and Hakkarainen 2001). In our case, thinking aloud accounts were combined with video documentation as the researcher spoke to the video camera while performing her task. In this research setting, the method also enabled capturing various aspects of the tactual activity and later analytically reflecting on tactual experiences. Especially critical incidents (Flanagan 1954) were actively captured in the talking aloud accounts. To enable triangulation, the data were supplemented with the diary and the CASS-Query.

The diary method is a well-established way of collecting auto ethnographical data (Bolger et al. 2003; Chang 2008). The value of the method has also been recognized in the art and design field, especially within the context of a practice-led research approach. It allows the researcher-practitioner to document features related to her creative process and, in addition, provides a medium for analytically reflecting on her process (Mäkelä and Nimkulrat 2011). The diary has been used in diverse ways (e.g., see Pedgley 2007; Mäkelä 2003; Mäkelä and Routarinne 2006; Turpeinen 2005; Nimkulrat 2009; Mäkelä and Nimkulrat 2011; Kosonen and Mäkelä 2012). Usually, the diary is updated regularly alongside the working and thinking process, documenting the entire creative process from initial thoughts to the final outcome – including drawings, images and text, test results, personal experiences and feelings. In our case, we utilize the method in a more formal way as the researcher updated the diary before and after the throwing events, answering a set of questions (Table 1). The questions before the event encouraged describing the challenges faced and the emotions related to the upcoming event. The questions after the event encouraged describing the success or failure of the event and elaborating on the critical incidents that facilitated or hindered the process and related emotions.

Table 1. List of diary questions.

Morning diary questions:

- What are you going to do and how?
- What are the challenges with this work?
- What are you thinking now?
- How do you feel now?

Afternoon diary questions:

- Did you manage to do what you intended?
- Did your plans change? Why? How did you react?
- What were the critical points?
- What facilitated / hindered you in your process?
- How do you feel now?

The CASS-Query is a research instrument under development that uses mobile phones for sampling various aspects of learning, designing or making in their actual context of occurrence. Event Sampling is a generic term and refers to the research strategy for studying on-going daily experiences as they occur in everyday life (Reis and Gable 2000). The richness of the data collection captures occurring events, experiences, emotions or social activities at specified time intervals, depending on the focus of the study. ESM are new in the study of design practices (Seitamaa-Hakkarainen et al. 2013). For our case, we developed a specific set of questions that were answered during the actual event through responding to the CASS questionnaire that was sent twice daily to the researcher's mobile phone.

The query consisted of 21 Likert-type structured questions (Table 2) that called for ratings according to a seven-step scale, as well as open questions and instructions for taking photos (Figure 1). Questions 1, 3 and 4 related to the context of physical space. The researcher was requested to respond to questions concerning the environment, in which she was working, to evaluate how well it supported her work and to photograph the space. Questions 2, 5 and 6 were related to physical tools and instruments as well as the materials used. For Questions 7–14 and 20, we utilized part of Jackson and Marsh's (1996) 'Flow state scale' as we were interested in the mental states that the researcher passed between during the events. Questions (15–19) were related to the particular interest of this research, i.e. embodiment and the ability to control the material and to augment the tactile ability. Questions 20 and 21 enquired about the possible collaboration the researcher had, with whom she was interacting and how or if it supported her work. Ultimately, this question was not relevant. The entire set of questions was designed to be completed in five to ten minutes. The results are sent via the mobile phone to a server collecting all the answers in a database.



Figure 1. CASS-Query application on mobile phone, 8 April 2013. Photo by Camilla Groth.

Table 2. List of CASS Query questions.

CASS question before each session:

		Type of answer
Enviroment		
1	Take a picture of the space where you are.	image
2	Take a picture of the tools / work in front of you.	image
3	What are the working conditions like?	text
4	How well does the location support your work?	1-7
Tools and materials		
5	Which tools are you using? Enviroment	text
6	What material are you using?	text
Emotions		
7	How excited do you feel?	1-7
8	How challenged do you feel?	1-7
9	How worried do you feel?	1-7
10	How much control do you feel?	1-7
11	How much do you enjoy this moment?	1-7

CASS questions after each session:

Embodiment		
13	How comfortable did you feel to work blindfolded?	1-7
14	How much physical control did you feel while working?	1-7
15	How well did you find your tools?	1-7
16	How clumsy did you feel?	1-7
17	How well did you feel the shape of the work while working?	1-7
18	How much did you enjoy your working session?	1-7
19	Take a picture of the result of your session	image
People (if external video-assistant.)		
20	Did you interact with someone? Who?	text
21	How did it affect your work?	text

The CASS-Query is generally designed to capture occurring experiences and emotions and their context – in this case, the ability to control the material and to augment the tactile ability. CASS-Query data include quantitative data and can be presented in flow charts; however, due to the small sample size we were here unable to perform any larger statistical analysis. Essentially, it allowed for more rigorous data collection, including different kinds of response formats. The context, space, materials used and images of the work made were documented in the CASS application alongside describing text and numerical values.

Throwing Clay Blindfolded

Although the researcher is a proficient thrower, throwing blindfolded was a new experience for her (Figure 2). Except for the pilot study related to this case (Groth et. al 2013), the researcher had not tried to throw blindfolded, and the event was at the limits of her skills. The main challenge of throwing a large amount of porcelain on a wheel in general is the fact that porcelain is not very plastic and therefore difficult to throw. The researcher had chosen porcelain as her material for this experiment in order to further enhance the tactual experience. For judging the result of the event, the researcher aimed at throwing a straight cylinder that would meet the aesthetic and technical criteria commonly used within the community of potters (Dormer 1994: 18).



Figure 2. The researcher throwing blindfolded.
Screenshot from video.

In this section, we give an account of how the chosen exercise proceeded. It is based on the data collection, as explained in the previous section. By triangulation of the collected data, we aim to reveal the embodied experiential knowledge of a craft process, in this case throwing clay. We seek to articulate some of the tacit knowledge involved in the making process, and

we explore tactile augmentation and its benefits in connection to knowledge making. We will begin with excerpts from the diary.

Insights from the Diary

On the first day, before starting her first throwing task, the researcher reported her feelings in the diary before the event: 'I must admit I'm a bit nervous. I don't really want to fail in throwing a 12-kilo porcelain cylinder on my potter's wheel, which is my task today and every day of this week' (First day morning diary). Over the period of five days, the events went smoothly, with some disruptions in the process. The CASS-Query application had a few technical difficulties, but all events were successfully documented with all three data collection methods. On the first day, the requirements of the task were not met, and the result was recorded as a failure of controlling the making process as the clay collapsed during the throwing session (Figure 3).



Figure 3. First day, 8 April 2013.
Photo by Camilla Groth.

As the researcher reflected on her activity in the diary, she was able to provide a quite exact account of what had happened with the clay, even though she had been blindfolded during the entire process. Mistakes were analysed and problem solving occurred both in the making and in the reflection on the making. Tactual memory (see Nicholas 2010: 13) became a tool in the attempt to *see* through the hands. It was important to remember the felt sensation of the shape in order to judge how to act in the next movement. There was also a new sensation in the way that her hands conveyed a *false* size of the piece to her mind. Before starting her second day task, she notes in the diary:

I'm ready for today's challenge and am determined to concentrate better and to respect the material and the centrifugal power. I will strive to see the piece better through my hands, try to sharpen my tactile memory if possible. (Second day morning diary)

Already on the second day, the researcher found herself to be more comfortable with the situation of not seeing what she was doing while working on the wheel. There was still a gap revealed between her tactual perception of the shape and the actual shape of the pot when taking off her blindfold. The thinking aloud accounts, taken during the video recording of the event, provided a description of what the researcher was doing and what she was thinking at the different points of making. Although at first it was a step out of the researcher's comfort zone to start talking in the empty studio:

About talking to the camera while working, it feels much more natural now than yesterday. I feel that it is useful because I would otherwise never remember exactly afterwards what I was thinking while I was working. It also keeps my mind with me as I am aware of what I am doing all the time. (Second day afternoon diary)

After succeeding with her task on the third day, there was a clear increase in confidence and positive spirit. The researcher was redefining her goals, as she felt confident that she could master an additional challenge, and decided to double the amount of clay for the next day.

On the fourth day, the added challenge affected the researcher's feelings and added an equal amount of nervousness and slight discomfort. Now that the challenge was to throw an even larger amount of clay, the additional challenge of keeping aesthetic preferences at a high level seemed overwhelming. But for motivation reasons it was still essential, as the researcher would not be content with simply meeting technical criteria. In her fourth day diary, she referred to the aesthetic criteria in the context of good craftsmanship:

I managed what I set out to do, to centre and to throw an amount of clay weighing 24kg into a shape that I felt was aesthetically pleasing and met technical requirements of skill. But the shape was not the intended cylinder. (Fourth day afternoon diary, Figure 4)



Figure 4. Fourth day, 11 April 2013.
Photo by Camilla Groth.

The event was hindered by several critical incidents that followed one another, for example, the breaking of the throwing board, and these complicated the successful end to the event. But the feeling of being able to handle the material blindfolded was still reflected on in a positive manner. The challenges for the fifth and last day of the case study were laid out in the morning diary:

I'm excited but fear that I am not feeling concentrated enough at this point. But taking it bit-by-bit, concentration may build up later through the centring process. I just have to remember to keep feeling actively with my hands and fingers and keeping the overall memory of the piece present in my tactual understanding. And enjoy. (Fifth day morning diary)

Although the aesthetic criterion of throwing a straight cylinder was not achieved during the last day, the technical criterion was met (Figure 5), and although there were critical incidents, these did not hinder the outcome of the event. Feelings caught up with the process of making, and confidence grew during the unfolding of the event.



Figure 5. Fifth day, 13 April 2013.
Photo by Camilla Groth.

Reflections on the Analysis Process

In the analysis of the diary, *skill* emerged as the dominant theme, and second was *challenge* followed by *material* and *emotions*. Evaluation of the *process*, *critical incidents* and *problem solving* constituted the bulk of the text, with some room for *environment* and *conditions*. The reflections in the diary revealed little detail concerning particular actions and even less about the sensory experiences as such, but highlighted the emotional aspects related to each theme. The challenges, decision-making and problem solving were at the forefront in these reflections, indicating that the emotions were initiators for adjusting actions and behaviour in a more beneficial direction.

The CASS-Query was also a good tool for capturing feelings and moods during the events. Two CASS questionnaires, ten in total, were answered each day. Some of the results of the mental state (i.e., feelings, emotions) of the afternoon queries are displayed in Figure 6, showing, for example, positive and negative feelings, comfort in working blindfolded and feelings of clumsiness, over the five days of events.

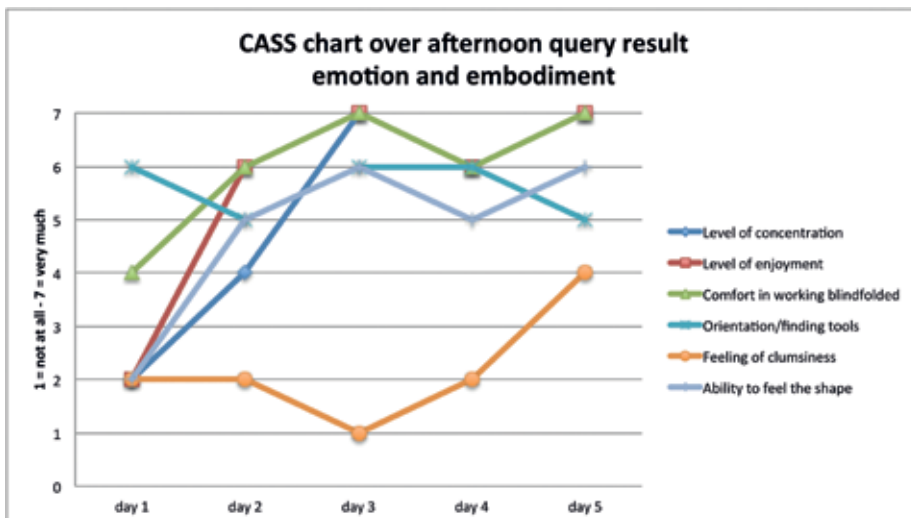


Figure 6. CASS-Query data: Result of the afternoon questionnaires.

The result of the first day’s throwing session was a failure, and this was captured in the low mood of the afternoon CASS questionnaire responses. Despite this, both the orientation and the ability to find tools around the throwing wheel were experienced as surprisingly positive. On the fourth day, the added challenge of doubling the amount of clay is shown in a dip of spirits. Otherwise, there is an overall synchrony in the curves over the five days, with a tendency towards more positive experiences at the end of the time period. The feeling of clumsiness is higher as the challenge grows and demands are higher, but nonetheless the ability to feel the shape is still at a high level on the last day.

As we collected reflections in action and reflections on action – together with diary notes after the event – the analysis was partly situated within the knowledge production process. Analysis is often an evolving process, beginning in the mind of the researcher already in the midst of collecting the data, as the researcher starts to see patterns of knowledge forming. Especially in the case where the researcher is already an expert in the practice she is researching, it is impossible to exclude the embodied knowledge of the subject of research. In this research, this is an asset as we aimed at exposing exactly this insider’s knowledge. The video recordings of the events serve as a ‘living’ memory from which the researcher may also reactivate sensory experiences and embodied knowing about the time of collecting the data. It may be hard to differentiate the real memory of that particular event with

countless other memories from similar experiences. On the other hand, the embodiment of a skill is dependent upon this bulk of information processed through the body countless times (Sennett 2008: 38), and since a video of one event can make the researcher recall the sensory experiences she usually has in a similar situation, these reflections may also be of interest.

For the purpose of creating rigorous research also from auto ethnographic and self-analytic processes, it was still important to find a suitable analytical frame that included the messiness of self-reflection, the particulars of sensory experience and at the same time facilitated a credible and systematic analysis. Therefore, in addition to the reflective analysis of the researcher's diary, part of the thinking aloud accounts are described through protocols (Ericsson and Simon [1984] 1993). We analysed the first and last video and related thinking aloud accounts by transcribing the accounts and making notes on the actions and sensory experiences connected to them.

Thinking aloud accounts have been criticized for affecting the performance of the subject and being incomplete or irrelevant (Cross et al. 1996: 2). Through this case study, we found that these verbal accounts, situated within the making process, were valuable in capturing, in particular, the emotions that were not seen in the actions of the video. The accounts gave detailed explanations on what the researcher was thinking and doing, and why it was necessary to take those actions. Together with the CASS-Query data and the diaries, our research included multiple types of data that shed light on the studied activity from many directions. The resulting artefacts are documents of the events and as such part of the research data (Figure 7).



Figure 7. Finished pieces each day, 8–13 April 2013. Photos by Camilla Groth.

While transcribing the thinking aloud accounts that were expected to consist mostly of references to the actions taken, text material describing sensory experiences began to accumulate. Although the verbal account had not yet even started, the reflections on actions and particularly on sensory experiences were already filling the transcript page. Since the researcher herself had been the actor in the situation, her experiential knowledge was recalled by viewing the video. When she looked at the video-recorded data, she could detect her breathing rhythm in connection with muscle straining in the actions. Where the thinking aloud accounts only states 'Mmmmmph' at the same time the following sensory experience account emerged: 'Pushing the clay hard from the sides with both hands, arms stretched unsupported in the air, straining belly and upper back. Keeping the breath until the release of the pressure' (Sensory experience account 18:38 minutes into throwing on the fifth day).

The researcher felt that she knew more than she could say at the time of making, partly because of the physical strain she was under and partly due to her attention being fully occupied with the work. Consequently the transcription process elicited the need to add a third column that contained the researcher's reflection on the actions. The third column deepened the transcript process to include more specific sensory experiences, such as orientation, temperature, sounds, wetness, stickiness of the clay surface and muscle pressure that would not be known to any other researcher than the researcher-practitioner herself (Table 3).

The protocol provided the possibility to reflect on the events in slow-motion, following each second of the video and writing out all the information the researcher felt she had about that instance, without simultaneously having to control the material in a making situation.

As the video transcript advanced, the researcher discovered a pattern in relation to her way of using her hands. She named her left hand the 'looking hand' as she used it for keeping track of where the clay was on the board and seldom let go of the clay to use it for other purposes. She named

Table 3. Example of the video transcription process, 10 October 2013.

Thinking aloud accounts	Actions	Sensory experiences
	00:00 Walking slowly from the camera to the throwing wheel, blindfolded feeling the way around the throwing wheel and the wooden board, so as not to hit them with my legs.	00:00 Walking blindfolded, the air is a bit cool against the arms. Bending back forwards and down a bit and reaching for the kitchen bench to navigate around the throwing wheel. Feeling the wooden board with the edge of the clothes and slightly hitting the knee on the board when passing. Feeling the board with one hand's fingers and the bench with the other, then turning and feeling the chair on the outside of the right leg.
00:19 I should probably start with changing the water.	00:19 Reaching across the chair and throwing wheel, over to lift up the full and dirty water bucket. with both hands. Finding it straight away. Lifting it up and towards the body, turning towards the bench.	00:19 Reaching straight in the front and finding the cold and wet water bucket. Grabbing hold of the sharp edges with the fingers on the outside and dipping the thumbs into the cold water and the soft excess clay on the inside and lifting the heavy bucket that is far from the body. Turning in the opposite direction and walking slowly passed the chair to the bench.
00:25 Because it is full of soft clay.	00:25 Pouring out the water and looking for a sponge by the bench (with difficulty) and starting to wash out the soft clay from the bucket.	00:25 Pouring out the water into the sink. Looking for a sponge on the bench but finding a towel, realizing that the body position is further to the right from that imagined; the water had been poured mistakenly into the bucket for recycle clay and not into the sink. Feeling of a mistake. Finding a sponge and cleaning out the soft excess clay, into the bucket, that is now swimming with water.
00:35 And I need fresh water to be able to feel the clay... to be able to feel... where is it? To be able to feel the surface of the clay, otherwise I will just get stuck on the clay surface with my fingers.		

the right hand the ‘acting hand’, as it would be the one used for taking more water, using tools like the sponge or the needle, reaching for new clay or adjusting the speed of the throwing wheel. Other metaphors for how the clay felt and how the clay should be treated also emerged: ‘It feels like a pregnant belly that should not be pressed too hard’ (Transcript of thinking aloud account 06:35 minutes into throwing on the fifth day). These insights may be developed into an account for teaching through metaphors and visual language in an educational setting.

The ability to *see* through the hands grew in only five days. A verbal account from the first day video transcript reveals some of the sensory experience of throwing clay blindfolded at the beginning of the event:

I know what the shape feels like but I have no idea what it looks like. I cannot see with my hands. It’s a different world. It’s a different... I don’t know... perception. Just feeling. I guess the feeling does only exist in the feeling world, or something, and the visual world is now not here. But I know what it should feel like when it’s done. (Transcript of thinking aloud account 20:43 minutes into throwing on the first day)

On the last day, the diary account reveals a different attitude: ‘I felt almost full control of what I was doing, only sometimes I really felt like taking the scarf off my eyes to do a reality check. But then my hands convinced me I had sufficient information to continue blindfolded’ (Fifth day afternoon diary).

Discussion

Blind touch has been a topic of interest in many different professions, not least in philosophy (Merleau-Ponty [1962] 2002: 267) but also in anthropology (Ingold 2004). In architecture, blind touch and awareness of the space and atmosphere may be helped by the knowledge of the blind, who take the tactile experience into consideration in a more concrete manner (Vermeersch et al. 2011; Pallasmaa 2005: 20). We have also sought to understand that special skill of accumulated sensuous awareness, in the making process of a clay vessel thrown on a wheel. The questions this has posed is whether we are able to reach a heightened tactile awareness, what the benefit of this might be? Generally, the sensory awareness needed for one’s skill is accumulated through everyday practice under normal conditions. In this experiment, we have enhanced sensory awareness of the much taken-for-granted tactile sense. In addition, the challenge of throwing an unusually large amount of clay on the wheel was used to enhance the tactile experience and to reveal more clearly the special events and critical incidents occurring.

In the process of working with the material, from centring the clay on the wheel to pulling up the sides of the cylinder, the researcher unexpectedly felt that there were not that many choices to be made. The concept of affordances, based on Gibson’s (1979) ecological psychology, involves

possible actions in the environment and the situation that the actor may recognize as opportunities. The affordance of the throwing situation guided the explorative progression of the events in a manner that left only a small space for other opportunities. From previous encounters, the researcher knew what was at stake in each situation, and she performed according to the best of her skills, concentrating to the fullest on the contact point of the fingertips and the soft and wet, moving and constantly changing, clay surface. Many times, there was only one action possible at that specific time, any other action would have been risking the successful continuation of the process, for example, pulling the clay wall outwards at a stage where the clay is too soft to support itself will immediately make the pot crumble. It was a game of staying on the right track to avoid mistakes in order to be able to continue.

By writing these actions out and looking at the process in detail even on the sensory experience level, and in slow motion, the protocol helped in gaining a clearer understanding about how certain choices were made and why they were inevitable. In the process of transcribing the sensory experiences of the throwing sessions, a pattern of anticipating the next stage emerged. In the end, the thinking aloud accounts were only the tip of the iceberg when it came to describing the meaning of the actions involved in the process. The sensory experience given as reflections on actions provided the real dimension of the events: 'The sponge puts something in between the skin and the clay, but as it numbs the fingers' sensitivity it also provides protection and a tool for handling the situation with a new means' (Reflection on sensory experience 09:31 minutes into throwing on the fifth day).

A subjective standpoint has traditionally been looked down upon in the field of research, especially subjective self-analysis of one's own activities (Cross et al. 1996: 2; Pedgley 2007). In the field of practice-led research, however, it has been noted that the combined profession of the researcher and the practitioner allows access to the inside knowledge of a practice (Pedgley 2007). This intrinsic motivation to reveal the particulars of the actions and to visualize and articulate them has an advantage over interviewing experts as an outsider of that practice. In this exploration, experiential knowledge plays a large role. The previous experiences gathered through working with clay – the tactile memory collected over time in the researcher's body and particular muscles and sensors, situations encountering this particular material countless times, the feeling of a change in a situation before it is understood explicitly – all play a part in the decision-making process that carries the event towards its successful or unsuccessful conclusion. This is further considered in the following:

When throwing clay walls, the only part that touches the clay surface is the tip of the fingers. Through these, the practitioner receives sufficient information on the orientation of the work, the temperature, the resistance of the material and the wetness or softness. These haptic experiences directly provide a feel or a feeling of the working

conditions and the possibilities available in working the material. These conditions and affordances may change within seconds, so an update of the conditions at hand is continuously made through the sensory points of the fingertips.

When conditions begin to become unfavourable, for example, when the clay is getting too wet and soft, this is experienced as a negative feeling; the practitioner knows that the available choices for action are cut down and decisions have to be made concerning whether or not to pursue certain actions or if these can be considered too risky. The feelings evoked by the sensory experiences thus instantly affect risk assessment and the decision-making for the next steps.

As a conclusion of this case study we think that making in a material can be seen as a continuous risk assessment, including constant decision-making and problem-solving and that feelings play a key role in the assessment of risk. As a result of this research, we believe that feelings need to be further investigated in connection with decision-making in material problem-solving.

Conclusion

In this case study, we experimented with methods of data collection within a practice-led research framework. We acknowledged the difficulty in researching practitioners' activities through single data collection methods. To overcome this we explored a multimethod that included sensory experiences in the data collection, and this allowed us to investigate the experiential knowledge involved in the event researched.

Together with the diary method, we found thinking aloud accounts and video protocols very useful, especially in the study of embodied and experiential knowledge as the researchers experience was relived when revisiting the video data. The video protocol also enabled a slow motion analysis and reflection in detail that was impossible during the act of making. CASS-Query data was in this case relatively small, and therefore limited, but it was found to have good potential as a rigorous data collection tool and enabled us to collect quantitative, as well as multiple types of data. CASS may be used as such, but the tradition of CASS builds on a range of experience-capturing data collection methods that may also be used regardless of the CASS system (see Muukkonen et al. 2008; Reis and Gable 2000).

We worked with the assumption that sensory experiences are key in the formation of knowledge in a making process. As a result we found that sensory experiences affect emotions that initiate decision-making processes. Our analysis also revealed unexpected patterns of behaviour and language used when describing sensory experiences. These may be developed to facilitate teaching through metaphors and visual language in an educational setting, as words describing tactile experiences are relatively

underdeveloped and metaphorical language might be a way to describe tactile experiences better. We propose that this multimethod can be utilized in cases where researcher-practitioners are recording an event to gain detailed and articulated information of the embodied tactile knowledge they possess. Although this research was conducted within the special case of ceramic practice, we believe that the research design can be transferred to many other fields where practice-led research is taking place, due to the focus on sensory experiences.

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Emotions in Risk-Assessment and Decision-Making Processes During Craft Practice

Camilla Groth

Abstract

Traditionally subjective experiences and emotions have been overlooked in the practice of scientific research. In the field of design and craft research too, feelings and emotions have been considered as interfering with the rigour of research. However, as a result of findings in neuroscience, a new understanding has emerged, providing emotions a central role in risk assessment and decision making processes. This has implications also for how we understand craft practice. In this practice-led research, a craft practitioner analysed five video-recordings of herself while throwing clay blindfolded. The researcher-practitioner specifically studied critical incidents in the throwing process and made a detailed analysis of how sensory experiences and emotions guided her in risk assessment, decision making, and problem solving during the clay-throwing sessions. She found that her tactile experience gave her important clues on the condition of the material and its consequent possibilities at different stages. These experiences in turn affected her emotions in either positive or negative ways, affecting her risk assessment, decision making, and problem solving activities. This research has shown that sensory experiences and emotions influence the craft making process and are thus important elements in the expertise of the craftsman. The role of such emotions remains to be studied in the expertise of researchers in general.

Index Terms: sensory experience, practice-led research, embodied cognition, enactivism, somatic-marker hypothesis, emotion, risk assessment

1 Introduction

Emotions and feelings have traditionally been overlooked in science (Damasio, 1994; 1999; Niedderer & Townsend, 2014) and thought of as interfering with logical thinking and an objective stance (Damasio, 1999, p. 39). In the field of design, too, it has been said that general accounts on experiential feelings are less interesting than the meaning of that experience, that is, the content (Biggs, 2004, pp. 3-4). However, research on the theory of somatic markers by neuroscientist Antonio Damasio (1994) in particular indicates that feelings which arise in the body of the subject are important in decision making processes (pp. 173-175). This aspect is also interesting from a design and craft research perspective, as there are now several examples of research where emotions and feelings are elaborated on as contributors to knowledge in the field (Groth, Mäkelä, & Seitamaa-Hakkarainen, 2015; Niedderer & Townsend, 2014; Seitamaa-Hakkarainen, Laamanen, Viitala, & Mäkelä, 2013; Mäkelä & Latva-Somppi, 2011).

It is natural to talk about emotion in an art context and emotion is generally considered relevant in craft practice too. However, the connection of emotion to the felt experience of working with a material is less discussed in design research. In user-experience tests and in co-design contexts, the feel of a product is considered important and well discussed. However, in research on design and craft practice, the subjective sensory experiences of the maker are not recognized as important. Connecting emotions to decision making and problem solving in design and craft practice is perhaps elaborated on in general speech, in a studio setting, but not examined in research. However, new opportunities for research are arising due to the relatively new possibility for craftspersons to examine their own practice in a systematic way.

This present research investigated the effects of emotion in risk assessment and decision making processes in clay throwing practice. Sensory experiences related to the feel of the material affect emotions that help the maker in his or her sense making of the throwing process. The research questions were: (a) what emotions arise from the tactile sensory experiences of throwing clay and (b) how these emotions affect risk assessment, decision making, and problem solving. The research involved analysing critical incidents (Flanagan, 1954) during five clay-throwing sessions recorded during an earlier case study (Groth, Mäkelä & Seitamaa-Hakkarainen, 2015).

The original case study was conducted in order to explore ways in which a craftsperson thinks through her hands (i.e., aspects of embodied cognition in craft practice). The research design included blindfolding as a means to enhance the tactile aspects of the clay-throwing experience. The idea for enhancing the tactile aspects and the whole research context is grounded in the author's doctoral research on tactile and embodied knowledge in crafts and the related previous study on deaf-blind maker's

ways of making sense through their enhanced tactile sensitivity (Groth, Mäkelä & Seitamaa-Hakkarainen, 2013).

This research is situated in a larger research project called *Handling Mind*, funded by the Academy of Finland, which aims to link together art, craft, and design research with neuroscience, focusing on the socio-emotional, embodied, and brain-functional aspects of making with hands. The research examines experiences that are difficult to catch as they are always situated, multimodal, temporary, and ever-changing. A narrative and phenomenographic research method might have been useful too. However, in order to gain details of what is really going on in the clay-throwing practice, the researcher used activity sampling (Muukkonen, Hakkarainen, Inkinen, Lonka, & Salmela-Aro, 2008), thinking aloud accounts, protocol analysis (Ericsson & Simon, 1993), and critical incidents (Flanagan, 1954), coupled with less traditional and more experimental methods such as blindfolding.

The use of video analysis software assisted in studying the rapid progress of the clay-throwing sessions and the thinking aloud accounts given by the researcher-practitioner during the events. Critical incidents were detected in the video recording, subsequently related emotions and felt experience of the material were identified and studied in relation to risk assessment, decision making, and problem solving.

In order to draw out the relevance of this research for craft processes and similar other processes, it is necessary to first examine some theoretical starting points. This is followed by a detailed description of the specific research setting and how results were obtained. This leads to a discussion on how embodied knowledge and expertise may form in craft practice.

2 Embodied Cognition and Somatic Markers

In design and craft practice, a large portion of knowledge and expertise arises in the contact between body and material. In order to research this space, we need epistemological frames that include the body as a provider of information. Phenomenology and embodied cognition provide such frames, introducing the body as a contributor to knowledge formation. The idea of embodied cognition suggests that we are a psychophysical whole and all our knowing is reflected in and by our sensory experiences (Johnson, 1987; Lakoff & Johnson, 1980; Merleau-Ponty, 2013).

The philosophical strand of neuroscience that embraces this idea is called enactivism (Varela, Thompson, & Rosch, 1991). Enactivism applies the embodiment idea and explains that a person learns in action and accumulates knowledge through her embodied experiences with the surrounding environment (Noë, 2009; Varela et al., 1991). This also means that without our body we cannot have any experiences; the body is integral to all knowing (Johnson, 1987; Lakoff & Johnson, 1980; Noë, 2009; Varela et al., 1991).

Emotions are enacted through the body, for example, in facial gestures and body positions. Emotions are also felt in the body as cognitive neuroscientists Nummenmaa, Glerean, Hari, and Hietanen (2014) display in their seminal research on where in the body we feel different emotions. Emotions also arise in the body according to research by neuroscientist Damasio (1994, 1999). Feelings and emotions might be confused with each other, but they are rather distinct, although causally related: emotions lead to feelings:

It is through feelings, which are inwardly directed and private, that emotions, which are outwardly directed and public, begin their impact on the mind; but the full and lasting impact of feelings require consciousness, because only along with the advent of a sense of self do feelings become known to the individual having them. (Damasio, 1999, p. 36)

Emotions are described as short lived, but feelings may occur although we are unaware of them; we may become aware of them at a later point (Damasio, 1999, p. 36). Keltner and Gross (1999) further elaborate on the function of emotions and define emotions as “episodic, relatively short-term, biologically based patterns of perception, experience, physiology, action and communication that occur in response to specific physical and social challenges and opportunities” (p. 468). This indicates that emotions are connected to physical and psychological experiences, arise in response to something, are felt in the body, and affect our reactions and actions on our environment. Emotions give rise to feelings that work in the background (i.e., “background feeling,” Damasio, 1994, p. 150).

In their article on Phineas Gage, Damasio et al. show that decision making is connected with emotion (Damasio, Grabowski, Frank, Galaburda, & Damasio, 1994). Phineas was hit by a metal rod that injured his frontal lobe and could not make decisions after his injury. Damasio’s research team make a reconstruction of Phineas’ injury and, through research on subjects with similar injuries today, find that the processing of emotion is affected or even absent in these subjects and subsequently their ability to make even simple choices is complicated (Damasio, 1994, pp. 44-45; Damasio, 1999, p. 41; Damasio et al., 1994). This gives us a reason to believe that emotions are crucial in decision making processes and also an understanding of the role of emotions within rational thought (Damasio, 1999, pp. 40-41). “[T]he purpose of reasoning is deciding” (Damasio, 1994, p. 165). One of Damasio’s (1994) central claims is that bodily experiences, or gut feelings, generate emotions that guide us in intuitive decision making, especially when the problem is closely related to our personal or social space (Damasio, 1994, pp. 169 & 173). Damasio calls this the “somatic-marker hypothesis” and explains it as follows:

In short, *somatic markers are a special instance of feelings generated from secondary emotions. Those emotions and feelings have been connected, by learning, to predict*

future outcomes of certain scenarios. When a negative somatic marker is juxtaposed to a particular future outcome the combination functions as an alarm bell. When a positive somatic marker is juxtaposed instead, it becomes a beacon of incentive. (Damasio, 1994, p. 174, italics in the original)

Somatic markers (*soma* in Greek means body) are important in the study discussed in this article. In this study, experiences that are felt in the body of the maker are closely connected with the emotions that guide the maker in her risk assessment and decision making process. Thus, these bodily experiences and emotions help to solve problems in her practice.

Knowledge related to bodily or sensory experiences and emotions during craft practice has been out of the scope of research in the crafts. This is so perhaps due to the fact that craft research has been the domain of art historians, ethnographers, and sociologists. They did not possess the specific insider knowledge of the craft practice they were describing.

3 Methods

Recently, due to the inclusion of art schools in the academic realm, craft practitioners have had the opportunity to research the tacit and tactile aspects of their profession in a practice-led research setting. Some examples: Almek et al. (Almek, Jarefjäll, & Samuelsson, 2013) researched the tacit knowledge of craftsmen in the 1970s through enacting their actions in a documentary video. Erin O'Connor (2007) made an autoethnographic study on glass blowing, by starting her apprenticeship in a glass blowing studio and reflecting on her experiences of learning the craft. A practice-led self-study research setting provides insights into what matters in craft, including emotions and feelings, sensory experiences, and experiential knowledge.

When researching any practice, we are faced with the challenge of documenting experiences. Body based practices are best reflected on from an embodied perspective, as experiential knowledge is linked to sensory experiences. Experiences can be fleeting; knowledge connected to these experiences is embedded in actions, and therefore best reflected upon “in action” (Schön, 1991). However, a reflection-in-action may be difficult to produce if the action contains elements that require full attention of the practitioner. If documented carefully, these actions may be reflected on afterwards, to some extent, in a so-called reflection-on-action (Schön, 1991).

The strategy of reflection-in-action, and later reflection-on-action, was used wherein data were collected in the studio of the researcher-practitioner. Over the course of 5 days, the researcher-practitioner threw 12-24 kg of clay each day on her potters' wheel, blindfolded. This was done in order to test the augmentation of her tactile sensibility and ability to control the clay throwing process entirely without eyesight. To further enhance the challenge of the task, and thus highlight the expertise and amount of embodied

knowledge needed to perform the task, the clay chosen was specifically difficult to handle and the amount of clay was unusually large. Multiple methods were used for collecting data during the event, including video-recordings with thinking aloud accounts, diary notes, and a contextual activity sampling system (CASS-Q self-report questionnaire), as described in a previous article (Groth, Mäkelä, & Seitamaa-Hakkarainen, 2015). The act of blindfolding was useful as it allowed the researcher-practitioner to become more aware of the tactile information often taken for granted in the clay throwing process. The sensory experiences became key in shedding light on the emotional feelings connected with the touch and feel of the clay material at different stages.

In the act of observing and reflecting on an activity, whether it is another person's or one's own, there are more and less important events mixed over time. It may be challenging to pay proper attention to the relevant issues, such as the events that change the situation or the course of the whole process. These events are called critical incidents. A technique for studying critical incidents in a human experience was developed by Flanagan (1954). The technique consists of ways to identify incidents that have either a positive or a negative effect on the experience or the outcome of an event.

In this research, the focus was on critical incidents producing negative effects, as the positive effects tend to go quite unnoticed in the clay throwing process. Although the researcher-practitioner was blindfolded, the process of clay throwing progressed unhindered, following a typical pattern. The critical incidents found were commonly occurring incidents with the addition of a few related to the blindfolding, such as dropping tools on the floor and taking extra time to find them, or missing the water bucket during already stressful moments.

The *Interact* video analysis software was used. This software allowed for the critical incidents to be indicated and connected to the risk assessment and decision making activities. The video material included 10 hours of recording (2 hours of recording every day, for 5 days). The part of the recording where the clay was centred on the throwing board was omitted, because there were no critical incidents. This left only 5 hours of recording (1 hour of recording every day, for 5 days). From the video data, critical incidents were separated and categorized into three severity grades (1 to 3).

4 Data Analysis

Critical incidents were identified in the video data. It became clear that the critical incidents had different degrees of severity. Some were less severe and the problems were solved easily, while others were of a more serious kind. The incidents were also either expected or unexpected, some started abruptly and some developed over time. The critical incidents were coded as following:

Slow / Quick (i.e., whether slow or quick to start and develop)

Expected / Unexpected

Severity Level 1 / 2 / 3

The tactile experiences that were found in the analysis of the critical incidents were to do with the density of the clay material—how hard or soft it was, and the wetness of the surface—the stickiness of the clay at different times during the throwing process. Further, the position of the clay on the wheel, whether centred or not, was a clear factor in the critical incidents that would affect feelings in a negative or positive way. The key emotions involved confidence, stress levels, or spiritedness. The activities of risk assessment, decision making, and problem solving were known to play a part in the clay throwing process from previous study (Groth, Mäkelä, & Seitamaa-Hakkarainen, 2015).

The analysis was supported by the thinking aloud accounts frequently provided by the researcher-practitioner. Feelings were also re-lived through the tactile memory that the researcher had in connection with the events and knowledge of similar events in the past. Stress was physically experienced during the analysis process, and the researcher-practitioner went through the emotions of the events multiple times during the analysis process while tagging the codes to the video clip.

Video and spoken accounts were analysed simultaneously as they affected the coding during the video analysis. The thinking aloud accounts were useful in the analysis of decision making, risk assessment, and problem solving activities. These activities occurred at different intensities and partly overlapping, throughout the whole process. In the analysis however, they were separated according to their intensity. The thinking aloud accounts helped to determine which activity is to be noted as the strongest of the three at any specific moment. These verbal accounts also spelt out what the immediate problems were and gave suggestions on dealing with them. The codes used in the analysis are shown in Table 1.

All codes were provided with a code key that included a description for when the code would be applied. The coding of the video material was aided by the thinking aloud accounts that verbally described feelings and events as well as exclamations when things were either not working out as expected or when a problem was solved. Some examples of critical incidents are presented below, together with related quotes and reflective notes.

Table 1. List of Codes Used in the Analysis of Video Data

Class: Tactual feel of clay: Density

Code hard density

Code medium density

Code soft density

Class: Tactual feel of clay: Stickiness

Code dry surface

Code Semi dry surface

Code Wet surface

Class: Emotions: Confident

Code confident

Code un-confident

Class: Emotions: Spirits

Code low spirits

Code high spirits

Class: Emotions: Stress

Code stressed

Code relaxed

Class: Activity

Code risk-assessment - notes on what risks were present and why

Code decision-making - notes on what decisions were made

Code problem-solving - notes on how it was solved

4.1 Examples of Critical Incidents

Day 1, 12 kg

Incident 2 Starting at 00:32:06, lasting for 1:12 minutes; Slow, Unexpected, Severity Level 2

Quote (at 00:33:54) “This is the point where I have to start working quickly, because the water, which I have to add quite a lot now, will make the clay so soft that I soon cannot work with it anymore. So, this is the critical moment I would say.”

Reflective Note The clay is too wet and soft to handle, it has gone soft while being centred and should have been harder to begin with. The pot is moving too quickly from side to side in an uncontrolled manner while being thrown and the clay is already losing its plasticity, giving me only a short time to work it. I stabilize the clay shape into a cylinder and solve the immediate risk of it collapsing but conditions are not good.

Incident 4 Starting at 00:33:56, lasting for 2:50 minutes; Slow, Expected, Severity Level 3

Quote (at 00:34:45) “The next actions will determine whether it is going to fail or succeed, because it’s already quite an ugly pot.”

Reflective Note The clay is now so soft and un-plastic that it cannot adjust to my pushing at all.

Quote (at 00:35:12) “Where is the water? I’m getting nervous!”

Reflective Note When stressed about the situation, I have difficulty in concentrating on anything other than resolving the problem, and the fact that I’m blindfolded gets in my way, I can no longer easily find the water bucket with my hands. One side of the clay pot stretches out (Figure 1) due to the centrifugal power from the spinning wheel, and I turn down the speed to be more in control, but it is too late. The clay starts tilting down on one side, the piece is lost and the process is interrupted.



Figure 1. Screenshot, Day 1, collapsing clay wall.

Day 2, 12 kg

Incident 5 Starting at 01:19:52, lasting for 5 minutes; Quick, Expected, Severity Level 3

Quote (at 01:21:49). “I don’t see any point in continuing this . . . but one part of being a skilful thrower is to be able to fix mistakes, so I’m going to give this a try anyway.”

Reflective Note. Learning from yesterday’s mistake of using too soft clay, I had wedged today’s clay on a plaster-board to make it dryer and harder. Now this clay is much stiffer to work with and considerable pressure has to be applied to the clay to be able to move it. This affected the throwing board, making it loosen its grip from the actual wheel head and the whole board and clay piece became un-centred (Figure 2). I managed to push the board back into place and to press down on the whole piece to try to fasten the board again. Although this incident happened quickly it was expected as the clay that keeps the board attached to the wheel head has been drying overnight and the weight of the clay is very heavy.



Figure 2. Screenshot, Day 2, feeling the condition of the clay.

Day 5, 24 kg

Incident 18 Starting at 00:16:36, lasting for 1:10 minutes; Quick, Unexpected, Severity Level 3

Quote (at 00:16:43). “That was so scary. The board almost tilted. The clay is now a little bit un-centred, but . . . That was a major critical point. I definitely should be more aware of pressing from above at the same time as moving the clay sideways, otherwise that will happen again.”

Reflective Note. The board is not very well stuck on the throwing wheel, and the area of the thrown piece goes outside the area of the wheel head, so when throwing on the edge of the wheel the board tilted heavily, making the whole board and 24 kg of clay jump. Luckily, it did not move far out of place, and I solved the problem by pressing the clay down and avoiding pressing from the sides.

Incident 20 Starting at 00:37:06, lasting for 1:20 minutes; Slow, Expected, Severity Level 1

Reflective Note The edge of the pot was becoming uneven due to the slightly un-centred position of the clay, but, more importantly, the edge was also becoming a bit too thin. I wanted to keep the edge thick so that the rim of the pot would not get a weak look. To solve this problem, I needed to cut off the edge, because just pushing it further down just made it more uneven, it being un-centred. Looking for the needle with which I could cut it took a while, but cutting the rim was easy (Figure 3) and did not create any further problems.



Figure 3. Screenshot, Day 5, cutting the rim of the clay pot.

Incident 23 Starting at 00:57:21, lasting for 1:16 minutes; Slow, Expected, Severity Level 3

Quote (at 00:58:33) “I think that’s all I dare to do.”

Reflective Note The clay is too soft to be thrown anymore (Figure 4). The wall of the pot is starting to sway from side to side, and the centrifugal force can easily bring the pot down if I continue to touch the clay. I make a last widening of the base to adjust the shape of the pot so that it becomes more cylinder-like.



Figure 4. Screenshot, Day 5, making decisions.

5 Results

The clay throwing process usually consists of the agenda of making a pot that includes centring the clay, making a hole at the top of the clay, widening the form and shaping the base, and then making the sides of the pot upwards. Critical incidents of varying severity occur during this process. Some critical incidents are severe enough to affect the conditions of the process over the long term, even though the immediate problem is solved.

Most critical incidents during the 5 days were due to the fact that the amount of clay was too large to be thrown on the wheel directly as the diameter was not wide enough. This meant that the throwing had to be made on a separate wooden board that was attached on top of the wheel head by a bit of soft clay. As the clay on the board was heavy, the clay under the board did not resist the pressure and kept moving. It was important to throw the piece so that most pressure was applied from the top and less from the sides, as the whole board would move otherwise. Also, pressing down on the very outer parts of the board made the whole board tip at one time. This, in combination with the blindfolding and the large amount of stiff clay made conditions even more challenging than a normal throwing session.

In this setting with extreme conditions, tension and stress built up quickly and accumulated in the critical incidents that needed immediate risk assessment, decision making, and problem solving. In contrast to

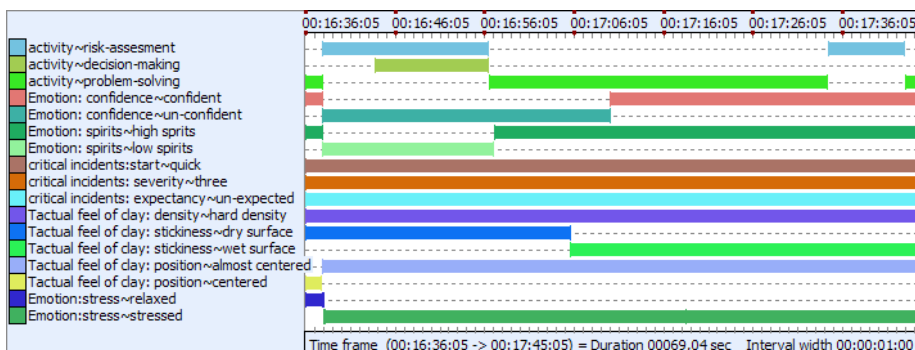
normal conditions, this setting provided the opportunity to highlight the emotional feelings connected to the throwing process more clearly and to detect the tactile experiences that affected the emotions.

However, the average critical incidents during the 5 days were expected, developed slowly (rather than abruptly), and were of low severity. These were coupled with a relaxed and confident state of mind; problems, if any, were solved while maintaining good (high) spirits. The clay was mostly soft and wet, and was almost centred. It was only in the more severe critical incidents that stress emerged and confidence dwindled. The author's reflection is that critical incidents of Severity Level 1 or 2 can affect a novice's work, leading to termination at times. The more severe Level 3 incidents may threaten the success of the throwing process even for a more advanced thrower.

The general rule was that if the critical incident started quickly, it was also unexpected, and if it started slowly it was expected. Only one case was slow starting but unexpected. This was when the clay was too wet on the first day and it had gone soft while being centred as it should have been harder to begin with. Similarly, only in one case did the critical incident start quickly but remain expected. This was when the board came loose and the whole piece became un-centred. A quote from that incident: "I kind of expected this."

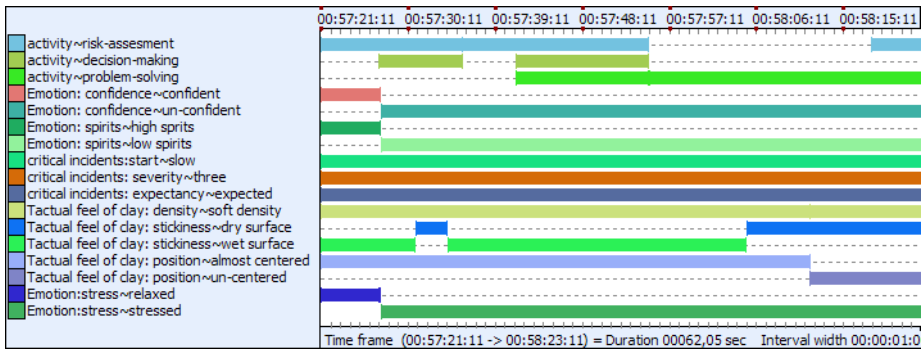
In Table 2, the progress and coding of a Severity Level 3 critical incident is shown from beginning (left) to the end (right), displaying both the tactile feel and emotion. Stress, un-confidence, and low spirits go hand in hand with risk assessment, followed by decision making and the attempt to solve the problem. In this incident, the problem is solved and the good (high) spirits is restored.

Table 2. Emotion, Feeling, and Problem Solving During a Critical Incident (Problem Solved)



In Table 3, another Level 3 critical incident is presented. However, this particular incident is disruptive enough that led the making process to be terminated.

Table 3. Emotion, Feeling, and Problem Solving During a Critical Incident (Problem Unsolved)



6 Discussion

In this study, the felt experiences, emotions, and activities followed a pattern. Stress was almost always connected with low spirits and un-confidence, and these were present during the start of the critical incidents, especially in the unexpected ones. Low spirits and un-confidence were present to a greater degree as the severity of the incident became higher. In some of the expected and less severe incidents, the problems were solved with confidence and high spirits, without experiencing stress.

At the beginning of an incident, risk assessment was coupled with decision making and/or problem solving. As the incident progressed, more problem solving and occasional risk assessment occurred. Risk assessment was generally combined with stress and un-confidence, but problem solving also appeared together with confidence and high spirits. During risk assessment, a slowing down of activities was observed. After a period of risk assessment, decision making and problem solving generally took over. Risk assessment continued occurring simultaneously with the problem solving process. This was reflected on as a way to ensure that the decisions and solutions were still appropriate for the situation.

When the clay was of a hard to semi-hard density, the surface was wet, and the clay was centred, conditions were considered optimal and small incidents were not experienced as severe. When conditions were different from this, stress was closer at hand. At these moments a high risk of recurring critical incidents was detected.

Critical incidents also enhanced the practitioner's vigilance and readiness to avoid new incidents, as conveyed in this quote: "The tilting of the board really made me much more focused, and much more careful, which reminded me to respect the conditions and the materials more."

Risk assessment and problem solving tasks seemed to be accompanied by low spirits. But this could be understood as reflecting the practitioner's serious intention to solve problems. It could reflect the worry and stress that was experienced until the problem was solved. Although these tasks

are accompanied by negative feelings, these feelings helped the practitioner to concentrate, make proper effort, and avoid further risks. A quote from Day 4 runs as follows: “I just have to be really careful and not make any mistakes.” At all stages, previous embodied skills and material knowledge were utilized in order to foresee and control the next moment of the process. A sense of living in the next moment or in the immediate future was present during the whole process.

Problem solving occurred both verbally and in action simultaneously. On Day 2, the board had lost its grip from the throwing wheel head and the whole clay piece was un-centred for a moment. It was important to throw the sides up without pressing the clay too much from the outside, but there was a risk of the board getting loose again, so the problem was solved as captured in the following account: “I’m trying to move the clay upwards, but pressing more than pulling though, as when pressing, the clay cannot go downwards but has to escape upwards, and then there is no pressure from the side, that would move the board.”

The word *feeling* as in tactile sensations and *feeling* as in felt emotions are very closely linked. The way something feels (tactile) affects the way we feel (emotional). This is an important aspect in the field of design and craft, and sensitive practitioners use this aspect in their careful selection of materials (Groth & Mäkelä, 2014). We have many shared notions of the feel of materials that are triggered as mental images even when only mentioned in speech, such as velvet, leather, or wet clay.

We may even feel the expected sensation in our bodies as we imagine what those materials feel like, because we have embodied this knowledge through previous experiences of these materials. Similarly, the feel of the material as it is actually touched gives us both the tactile feel and emotion, and thus also the anticipation of what this material has to offer us. For an experienced ceramist, the density of a bit of clay immediately gives an idea of its possible uses, together with an either positive or negative background feeling simultaneously. If the clay is too hard, it is not good because it cannot be easily handled and needs to be soaked. If the clay is too wet, it is also not good and it needs to be dried until workable. A perfectly smooth and dense bit of clay gives a good forecast for any project, and it is therefore experienced with positive emotions. This kind of internal connections were researched in this project and it was found that strong emotions and background feelings connected to the possibilities of the material were experienced throughout the whole throwing process.

6.1 Emotions in the Making

When working conditions turned bad in the critical incidents, negative emotions and stress emerged, prompting actions to put things right again. This illustrates the theory that emotions are important in risk assessment

as they help in our survival (Damasio, 1999, p. 42; Keltner & Gross, 1999, p. 472). According to Damasio (1999), feelings guide risk assessment in order to make us choose wisely in life (p. 42). On a larger scale, this is a life-saving ability that we have as humans and something we also share with other organisms. In craft, it is not that serious, but in a similar way emotions are adjusted to the threat of losing a piece in which one has invested time and effort. Survival in this context is to be able to continue the process and the success of the piece that is being produced. A quote from Day 5 exemplifies this:

So, it seems like I'm a bit braver now than before. Maybe I have lost respect for what I am doing. I should maybe take it easy and concentrate more, otherwise I will start making mistakes. I don't want to lose this piece now after centring it for, I don't know how long. It would be such a waste.

Quite often claims of fear emerged in the spoken accounts. Even if the actual fear emotion was not coded in this analysis as it was considered to be included in the stress and low confidence, the words "I'm afraid" or "that was scary" appeared, especially when an incident was sudden and severe. Further, the balance of being brave and careful was elaborated frequently in the spoken accounts, as exemplified in an account from Day 5: "It's difficult to be somewhere in between brave and careful. But that just what it's about. Brave can all of a sudden be too brave, and careful needs to be not too scared." These accounts are directly linked to the somatic-marker hypothesis and illustrate the function of emotions in regulating behaviour in craft practice.

6.2 Critical Incidents and Verbal Accounts

The use of the critical incidents as a frame for the research was useful as there were generally more emotions present and exposed during the critical incidents, compared to non-critical periods of the throwing process. The more severe the critical incident was, the more stress and negative emotions emerged. Although risk assessment, problem solving, and decision making occur also in the neutral non-critical periods of the throwing process, they are more highlighted and intensive during the critical incidents. Therefore, this study focuses on the content of these critical incidents rather than on a comparison between critical and non-critical incidents in general.

In their book *Protocol Analysis: Verbal Reports as Data*, Ericsson and Simon (1993) thoroughly investigate how verbal accounts during an action may give access to cognitive processes. By thinking aloud, speaking out his or her thoughts, the subject reveals what is going on in his or her mind during an action, and the researcher is thus able to detect the cognitive process together with the actual actions of the subject. Ericsson and Simon

also show how verbal accounts are viable reports on sensory stimuli and affirm that attention can be directed towards information in the sensory stores and that many kinds of verbal reports rely directly on our ability to process sensory information selectively (Ericsson & Simon, 1993, p. 31). In this research, the researcher-practitioner's attention was already directed towards the tactile stimuli due to the blindfold (Groth, Mäkelä, & Seitamaa-Hakkarainen, 2015).

Collecting only visual data, in the form of video-recordings, would have put a large demand on the ability to remember the events. We know that the memory of an event changes with time, and even a very short time lapse between an experience and a recall will affect the way we remember an event as we have had time to analyse it (Ericsson & Simon, 1993; Kujala & Miron-Shatz, 2013; Robinson & Clore, 2002). Therefore, the more immediate the reflection is, the less misleading post-analysis occurs or fewer interpretations are made. Thinking aloud accounts facilitate this type of data collection.

6.3 Limitations of the Research

It is important to mention that self-study, autoethnography, and practice-led study are all research settings in which part of the analysis is based on memory, as practice is first documented and then reflected on more carefully afterwards. As mentioned, this may be problematic due to the inaccuracies of memory. Pinnegar and Hamilton (2009) explain in their book *Self-Study of Practice as a Genre of Qualitative Research* that self-research into practice does not attempt to give one ultimate truth, but the understanding of the practice as the practitioner has experienced it, and that the quality of such research is reflected in the resonance the reader finds in it.

However, there are a number of methods to help practitioner-researchers to note their experiences in real time, such as diaries, photographs, or videos, in order to be able to reflect on the data at a later point. Video is a viable tool for capturing experiences in its multimodal forms, as these may be re-lived through looking at the recording later.

According to visual anthropologist Sarah Pink (2009), sensory experiences are ultimately embodied in each other—they work together and trigger each other. Therefore, the audio-visual material may trigger not only visual memories but also olfactory and tactile experiences from the time of the lived experience, giving the researcher the full array of sensory experiences from the time of the event (see also Pink, 2011).

In this case, the researcher had no visual memories of the actual events due to the blindfolding, but an enhanced tactile or haptic memory in her body. The video recording of the event served as a recall of the lived experiences of the researcher, bringing back the embodied experiences to mind. Pink and Leder Mackley (2012) claim that “the potential of video to

acknowledge and explore sensory experience beyond the audio-visual is increasingly recognised in visual anthropology practices of research” (p. 8). This is grounded in the connectivity of the senses and in the ability of the researcher to both re-live previously experienced sensory experiences and also the ability to empathize with research participant’s sensory experiences (Pink & Leder Mackley, 2012).

It is acknowledged that previous experiences of similar situations are also expected to play a part in the analysis of the video. The outcome discloses something about the practice of throwing clay, from an insider perspective. An objective view from a non-practitioner would not have been able to access this information, as the objective researcher would not possess the tacit and embodied knowledge of the situation.

Another limitation of the study is the evaluation of expertise by the practitioner herself. It is difficult to estimate what expertise is, or when expertise has been reached, other than as outlined in the five stages of skill acquisition proposed by Dreyfus and Dreyfus (1980, 1986). In craft practice, skill accumulates throughout one’s professional life. In a case where the practitioner is also a researcher, research skills also need to be accumulated. The time for studying to become an expert researcher is removed from the time available to spend on becoming an even more skilful practitioner. However, it requires quite some skill to throw 24 kg of clay blindfolded, and quite a few of the processes described above include aspects of tacit knowledge, situational, and intuitive workflow as mentioned in Dreyfus brothers’ work (Dreyfus & Dreyfus, 1980, 1986).

6.4 Hindrances in Research Practice

Craft practices are a relatively young research area. By including the crafts in academia, it has become possible for practitioners to research their own practice. When studying craft practice in an academic setting, it becomes clear that many research practices work within paradigms that exclude important factors in craft practices. The study of craft practices by crafts practitioners themselves includes subjective experiences, such as sensory experiences and emotions coupled with an attempt to describe and explicate the experiential knowledge that they possess.

This means the inclusion of three areas that are considered difficult to include within research: (a) subjective setting, (b) emotions, and (c) tacit knowledge. As mentioned above, in a self-study or a practice-led setting, subjectivity foregrounds aspects which objectivity will not reveal. This article’s main argument is to demonstrate the importance of the body and related emotions as contributors to knowledge.

Tacit knowledge is difficult to research, but it is unavoidable when researching design and craft practices. The concept of tacit knowledge was coined in another knowledge economy (Mareis, 2012), at a time when

audio-visual technology was not as advanced as today. Our new tools now, such as audio-visual media, allow for a slow motion analysis of actions and behaviour, thus they provide the craft practitioner with the time to speak out his or her experiential knowledge. Practice may now be researched in a new way, quite different from the time when Michael Polanyi (1958, 1966) introduced the concept of tacit knowledge.

7 Conclusion

The researcher-practitioner explored emotions as connected to tactile experiences and how they affect decision making and problem solving during craft practice. Due to the practice-led self-study research approach, she was able to study her knowledge and expertise as a practitioner. This research provided insights into the clay-throwing process, which, despite its long history, has been researched relatively little in depth.

The results indicate the role of sensory experiences and emotions in craft practice. Sensory experiences and emotions seem to guide the practitioner in risk assessment, especially during critical incidents. This influences the practitioner's decision making and problem solving during the craft making process. Thus sensory experiences and emotions appear to be integral to a craftsperson's knowledge and expertise in craft making.

The researcher-practitioner found that the condition of the material and the tactile feedback she received in the clay-throwing process directly affected her feelings. The feelings triggered either negative or positive emotions, depending on her forecast of how the process would develop. When conditions became difficult due to a critical incidents in the process, her emotions turned negative and she became careful in order to prevent further damage. The decisions made during these critical moments affected the progression of the event and, as the critical stage was overcome, she became optimistic again. During such periods of optimism, she took more risk, as she felt greater confidence in her ability to handle the situation. During periods of negative emotions and negative forecast for the immediate future, risk-taking was out of question and all her concentration was aimed at either maintaining the status quo or solving the problem, while attempting not to panic or give up the battle with the material.

This research has shown that sensory experiences and emotions condition the craft making process and are thus important elements in the expertise of the craftsperson. The emotions involved in craft practice are not always as pleasant as often assumed. The challenge of mastering a complicated process can include fear of failure, stress, and disappointment as much as pleasure and satisfaction. Based on this insight, researchers in other fields may also consider the role of emotions so that connections between creative practice and research practice may be established.

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The Knowing Body in Material Exploration

Camilla Groth & Maarit Mäkelä

Abstract

This article explores the role of the knowing body in material exploration and highlights the body as an important contributor in the formation of knowledge in the field of design. Our research involved gathering drawings, diaries and weekly and final reflections from 19 Masters students in Design during an eight-week course. Out of this data, we selected two student cases for our study. We analysed their material exploration processes from the point of view of their embodied engagement with material and found that previous tactile impressions and images of materials are important in the choice of materials, and that the actual physical manipulation of materials helps in resolving complicated spatial design problems, as the design is taken into the lived experience. The findings suggest (1) that the transition from the student's two dimensional design process to physical material explorations is complicated due to the change of modality, and (2) that previous material experiences, gathered through the body, guide the student already in the imaginary material exploration, even before physical manipulations start. As a result we suggest that experiential knowledge formation in physical material exploration is an important element in general design education.

Key words: body, experiential knowledge, material exploration, design education

Introduction

The role of the body is not yet fully recognised in the process of knowledge creation in today's society, where cognitive abilities are valued and stressed (Claxton, 2012, p. 1). In contrast to this, the creative fields—art, craft and design especially—are concerned with knowledge generated through bodily interaction with material. This experiential knowledge relies on sensorial information that is situated, subjective and often implicit, evading explicit formulations (Biggs, 2002 & 2004; Niedderer, 2007; Neidderer & Reilly, 2010).

Considerable amounts of research in the art, design and craft field are focused on investigating the possibilities of gaining knowledge through making, and reflecting on the produced artefact (Biggs, 2002 & 2004; Mäkelä, 2007; Niedderer, 2013). In contrast, only little attention has been attributed to the body in the formation of knowledge in this context. Through the emergence of embodied cognition studies (Johnson, 1987; Lakoff & Johnson, 1999; Noë, 2004, 2009; Varela et al., 1991), the theoretical ground is laid for including the body in the knowledge generating process and also in the field of art, design and craft. Although art and design fields to a large degree involve the senses and the performance of the body in daily practices, relatively few researchers have touched the issues of embodiment in connection to design and material exploration (for examples see: Fredriksen, 2011; Groth et al., 2013; Groth et al., 2014; Kangas et al., 2013; Ojala, 2013; Rompay & Ludden, 2013). While embodied cognition studies have not yet considered design issues properly, design studies have just recently started considering issues of embodied cognition.

For this research we utilized the Qualitative Case Study Methodology developed by Robert Stake (1995) and Robert Yin (2003). We present two students' material exploration processes that took place in an educational context. The students were participants of the Design Exploration and Experimentation course (DEE) at the Aalto University, School of Art, Design and Architecture, Department of Design, in Helsinki, Finland. The course supports the students' own explorative process from concept to artefact, and material explorations are recommended.

Some of the themes that emerged from the analysis were touching on issues such as: the students' use of their previous embodied knowledge in overcoming challenges with new materials; the importance of the tactile aspect (using the sense of touch in the decision making process regarding materials); and the felt experience of materials (including its link to emotions and shared social and ethical values). Most importantly, we detected an imaginary material exploration phase which preceded the physical material exploration.

In this article we focus on this imaginary material exploration in between the sensitive transition from drawing and planning to material implementation in the design process. We discuss how the phenomenon

may be seen from the point of view of embodied cognition, as we believe that the students used their experiential knowledge in overcoming their difficulties during this phase of designing. Following from this, we present the theoretical frame that has informed our study by discussing how embodied cognition is rooted in phenomenology and the study of experiential knowledge. We then link this way of thinking to how embodied cognition might be understood from a practitioner's point of view in the field of art, craft and design. Finally, we describe our research setting and discuss the two cases in detail.

The knowing body

Many fields, not least the creative arts, are based on implicit knowledge that is intuitive and immediate, without apparent reasoning. This may seem as not requiring the mind to work. For example sport is sometimes mistakenly referred to as an occupation that 'involves lesser kinds of thinking, or none at all' (Claxton, 2012, p. 1). The body is thus being perceived of as the non-thinking agent, and the mind as the thinking agent.

This dichotomy is being challenged by embodied cognition theory. Embodied cognition theory is based on the philosophy of the mind, specifically phenomenology that most strongly argues for the knowing body. Phenomenology holds that, due to having a body, we are restricted to a subjective view of the world seen from the perspective of our situated body. The world shows up for us and we perceive it as such through our senses (Husserl, 1907/1989). But, since our body is kin-aesthetic, we can move to a new position and perceive the world from another perspective. In this way we accumulate our knowledge by movement and interaction with our surroundings.

The French philosopher Maurice Merleau-Ponty further developed the idea, especially in his book *Phenomenology of perception* (1962/2010), where he elaborates on the body as the centre of knowledge making and lays part of the foundation for embodied cognition theory. Enactivist theory, a branch of neuroscience, confirms the embodied cognition theory and shows how the human mind is built by the interaction with the environment (Varela et al., 1991). Neuroscientist and Philosopher Alva Noë further elaborates the research of Francisco Varela et al. (1991) in the field of cognitive science and questions the mind as the sole knowledge creator and even the brain as the sole place for the mind or consciousness (Noë, 2004, 2009).

Through embodied cognition theory, we may draw a different image of the body and mind that is perhaps easily recognizable by practitioners in the creative fields. We can suggest that the mind, instead of being situated only in the head, would be distributed throughout the experiencing body (Noë, 2009). Through our attention we specify a part of the body that is extra mindful at specific times (Varela et al., 1991)—for example when listening to

a specific sound, tasting wine or threading a needle. In this respect we can understand our whole body as a thinking thing as opposed to only our mind being a thinking thing (Noë, 2009). The mindful or knowing body is the position we argue from throughout this article.

Data collection and analysis process

We investigated the role of the body in material exploration by utilizing data gathered from the DEE course. The eight-week intensive course works as an educational experiment and research platform focusing on design students' personal creative process and their individual way of managing its phases (Kosonen & Mäkelä, 2012; Mäkelä & Löytönen, 2015). The students fill in consent forms regarding their participation in the research that is conducted in this platform.

Each year around 12 students participate in the course (figure 2). The course was designed especially for students that study in the Industrial and Strategic Design program, as in their curriculum studio-based practices were rare and individual design projects were often replaced by group work. However, it seems that the design students benefit from handling processes typical to fine art (see for example McDonnell 2011, p. 569).

During the course the students document their process in working diaries and share its phases in weekly and final reflections (figure 3). The final outcome of the process is an artefact that is presented in an exhibition (figure 4). The students first develop their concepts with the help of different types of drawings and representations. This is considered as a typical way for designers to approach design tasks (Goel, 1995; Rodgers et al., 2000, p. 451; Scrivener et al., 2000, p. 465). When the design is developed to a convincing stage, material exploration starts. In a few cases material exploration starts in a very early stage, letting the material agency affect the concept creation.

In this study, in order to see what themes were emerging from the data, we first made an initial analysis of all data gathered during DEE courses from two years, involving 19 students in total. Based on this initial analysis, we selected two cases that were closely linked with our specified theme for the research at hand, i.e. material exploration and, in particular, a connection with embodied cognition.

The data chosen for the deeper analysis consisted of the two students' own diary notes, drawings, photographs, weekly reflections and final reflections produced during the course, one case being from the year 2013 and the other from year 2014. As the focus was on the students' use of their body in knowledge creation during material exploration, we chose two students whose processes were rich in this type of data. Although their cases are similar, their processes are not, and so being they highlight different aspects of embodied knowledge in the design process. By presenting these processes



Figure 1. DEE course student's material exploration.
Photo by Camilla Groth.



Figure 2. DEE course students and teachers on an inspirational journey to Heinävesi.
Photo by Jaana Lönnros.



Figure 3. Examples of the weekly reflections, diaries and final reports produced during the DEE Course. Photo by Camilla Groth.



Figure 4. The DEE Course Exhibition opening at the end of the eight weeks long process.
Photo by Camilla Groth.

in a dual case study we are able to complement the image and show how the cases confirm each other.

As the students seldom reflect openly in their reports or diaries on their experiential knowledge or bodily interaction with the material, we also interviewed the two students. The questions were open questions followed by a directed question based on the themes of tactility/body and material/exploration. The students were not told what themes were searched for in their answers. The transcripts of the two interviews were analysed through a thematic content analysis (Fereday & Muir-Cochrane, 2006). Furthermore, when related drawings and visuals were available, they were utilized to give more depth to the content analysis. The quotes and transcripts of the interviews were translated from Finnish to English.

The combination of inductive and deductive coding enabled us to take the theoretical aspects of embodied cognition into account in our analysis process. The initial themes were searched for on the basis of our theoretical framing, that is the themes of tactility/body and material/exploration. Subsequently these were developed according to the themes that were emerging from the data.

The emerging themes from the analysis touched on the issues of how the students used their previous embodied knowledge in overcoming challenges when encountering a new and unfamiliar material. The artefacts made were found to carry with them embodied memories of felt experience from the time of making. The tactile aspect of the materials and the use of the touch sense was important on many levels, but especially in the process of deciding which materials to use. In encountering a new material, the two students referred to skills gained in other materials—thus utilizing their previous experiences and general embodied knowledge to overcome new material challenges. The felt experience of materials was also linked to emotions and shared social and ethical values. As noted previously, mental material exploration was detected to precede the physical material exploration.

Case description: Antti

The theme of the 2014 DEE course was Journey. Antti and his fellow students travelled to Lapland for five days to gather inspiration for their individual projects (figure 5a). As the course proceeded, Antti's project became 'a journey of material exploration' concerning the physical feel of a material and how we are fooled by our senses when one material is juxtaposed with another—leaving a feeling of the material to be somehow 'wrong'.

Antti has a craftsman's background: he is a metal smith by his first education. He was inspired by the Lappish craft (figure 5b), especially traditional leuku knife, a large and heavy knife used for light wood chopping and butchering, and he decided to make one just as a starting point for the course. Without much drawing or planning, Antti started his process by ap-



Figures 5a and 5b. Snowy landscape and one of the DEE students in Lapland, Finland (a) and local crafts (b). Photos by Antti.

proaching the material. Not having the appropriate material at hand though, he made the blade for his knife out of aluminium instead of steel, thinking that it was good enough for a mock up (figure 6a). Making the knife in parts, he only experienced the whole after he had assembled the parts, and was stirred in his senses when he picked up the knife from the working table:

I felt like ‘what on earth is this?’ It looked like a leuku, but when I picked it up it didn’t feel like a leuku at all. That weight is so confusing! You just know it is not real.

After this experience he decided to explore different materials (figure 6b) from the point of view of what they felt like in relation to their expected use and function: If the leuku knife were to be made of glass, or ceramics, what would it feel like to hold? What would it have left of its functionality? Would it be a tool, or reduced to a mere concept of a tool, or would it become an art object?



Figures 6a and 6b. The leuku blade being made in aluminium (a) and leuku knives in glass, steel, ceramics and aluminium, made by Antti (b). Photos by Antti (a) and by Camilla Groth (b).

Antti writes in his final report that he had known the difference between a real knife and a replica for the tourist industry since he was a child. He thought everyone knew the difference, but was surprised when meeting tourists who thought they had bought a real, functioning knife. He says that even if the knife looks real, you will immediately recognise it as a replica the moment you try to use it.

As Antti started designing the leuku knives in different materials, he was intrigued to use ceramics, a new material that he had not used before.

The difference between the imagined use of ceramics in his design and the actual making with clay took him by surprise. When confronted with this new material, he was confused at first due to the unexpected feel and behaviour of it. The uncontrolled material gave him a feeling of distrust in himself as a maker. In the interview he says that he had no help from previous knowledge of other materials as the clay was behaving in a completely unexpected way (figure 7).

I had practically zero experience of ceramics. I had no use of my mental skills toolbox in this case; the material was just behaving too differently to what I was used to.

In his working diary (figure 8) Antti draws an image of the skills he has accumulated during his life, naming them his 'toolbox'. In the interview Antti is referring to these as his 'mental toolbox' although they are very body-based practises. It is clear that he has many different kinds of skills and therefore also many skill-learning experiences in his life. During the interview he says that he is used to trying old 'tricks' and methods that have proven useful in previous situations when confronting new materials. He also considers new materials a positive challenge.

Although maintaining that the challenge of the new material, ceramics, took him by surprise and that he had no help from his previous skills, he is still clearly using working methods from his own field in tackling the material. When feeling helpless in front of the soft and plastic clay, he waited until the clay hardened a bit. In this way, he was able to carve the shape of his leuku knife handles (figure 9a) out of the clay, with a knife. He then smoothed the surface with sand paper, utilising the same method he would have used when making wooden knife handles.

In Antti's case, the end result of the course was a selection of leuku knives that create a mixed feeling in regards to the expected feel of the materials, playing on our general notion of embodied material knowledge (figure 6b). In the interview, Antti describes the feel of lifting the glass leuku (figure 9b):

It feels so strange. Like if it was only an idea of a leuku knife. This is like the construction of a knife made by someone who has never known what a knife is used for or who doesn't know what kind of entity uses one.

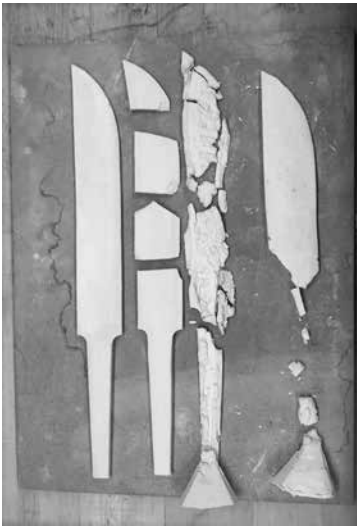


Figure 7. Ceramic material tests. Antti utilized his mould making skills for metal in the moulds for cast porcelain, but the clay is not behaving as molten metal. Photo by Antti.

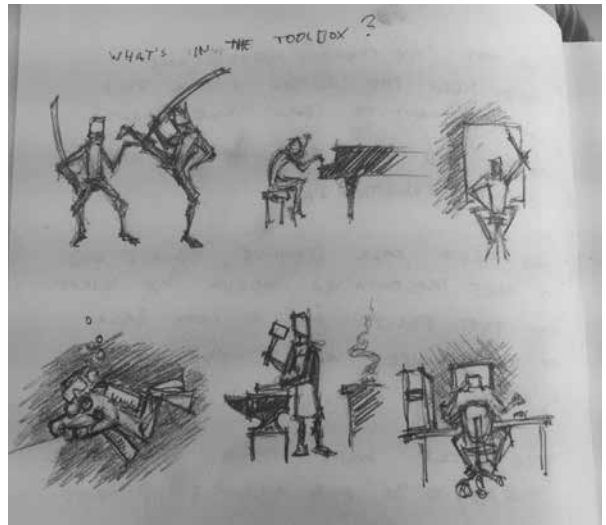


Figure 8. Antti's diary drawing depicting his skills 'toolbox'. Photo by Camilla Groth.

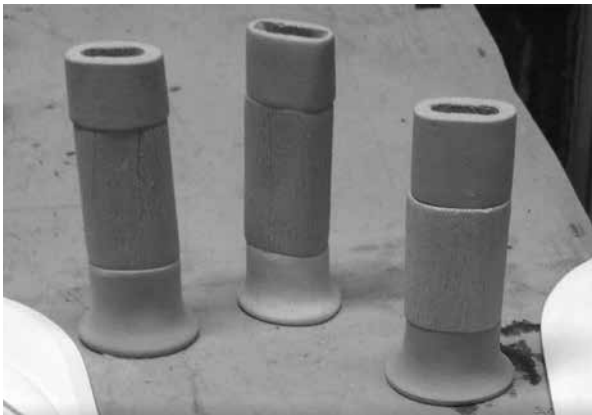


Figure 9a. Clay handles for the leuku. Photo by Antti.

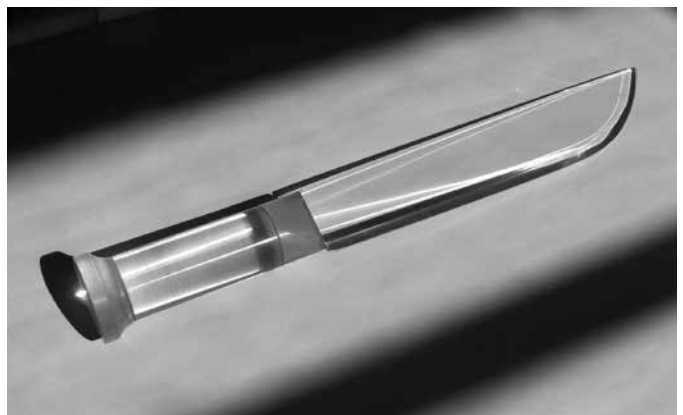


Figure 9b. Glass leuku knife made by Antti. Photo Camilla Groth.

Case description: Salla

Salla participated in the DEE course in 2013, when the theme of the course was Religion, Belief and Faith. The students travelled to Heinävesi, a site for Orthodox religion in the east of Finland. Salla felt her own position as a Lutheran Christian more determinedly in contrast to the orthodox traditions, that to her seemed overly artificial and materialistic.

During the course Salla worked on her concept of a non-God in response to what she experienced at the Orthodox convent in Heinävesi (figure 10). The work was based on the idea that the biggest religion in



Figure 10. A nun in the Lintula Convent, Heinävesi, Finland. Photo by Chien-Ting Hsu.

the world is money. She decided to make a natural-size golden pig for the worshippers of this money religion (figure 11a). The material choice for the pig was important and Salla went to great lengths to find the right ‘feel’ of material that would fit her purpose. The emotional feeling that the finished pig should awake in the audience is the feeling of disgust and meanness, but at the same time of wealth and luxury. In her working diary Salla set about her material exploration by listing materials that could be interesting and then striking out the ones that were not disgusting or luxurious enough. She then made four physical models (figure 11b), using the four remaining materials on her list.

In the interview she describes these tests as her most significant material tests, as through them, it was possible to compare the tactual experience of the materials:

It was important to make these four small pigs in different materials so that I could get to feel and see them; well most of all to feel them as in the end the way they look is not that different.

In her final reflection she explains that the small padded pigs helped to evaluate the emotional connotations of the materials—such as too kind, too cheap or too nice for her intentions. During the interview she adds that by making tactual pigs, she was also able to let her friends and fellow students feel and evaluate the materials, in this way confirming the social and ethical value and general understanding of the material:

And of course, since I had made those little pigs, I handed them to people and asked what they felt and what impressions they got from the material. Which one they found the most disgusting.

In her final reflection she lists the materials and the notions connected to them as a result of her own and her friends opinions. She found that the plastic pig was experienced as the most disgusting but since it was plastic it was also seen as a cheap material and thus not experienced as luxurious.



Figures 11a and 11b. Drawing of the golden pig by Salla in her working diary (a) and Salla's pig-shaped test pieces made out of velvet, satin, leather and plastic (b). Photos Camilla Groth.

Men thought the velvet was most disgusting while women liked it and thought it was comfortable. Leather was agreed to be the most disgusting, luxurious and mean material.

When Salla had made the decision to go for the leather material, she made a small model of the pig in play dough. She needed a body to model her leather pieces over, because she could not imagine what shape and size the joint leather pieces would have to be cut into. But the change

of prototyping material, method and mind-set from two dimensions to three dimensions was not uncomplicated. A dressmaker from her previous education, Salla was unfamiliar with moulding in play dough, she was surprised that the smallest changes in the moulding process changed the entire object from all sides. Finally a small model of the pig was made (figure 12a). Salla placed tracing paper over the pig (figure 12b) in order to simulate how the leather would be cut and constructed, and finally sewed into the shape of a pig.



Figure 12a. Salla's play dough pig model. Photo by Salla.



Figure 12b. The model with tracing paper showing the seams and shapes for the leather parts. Photo by Camilla Groth.

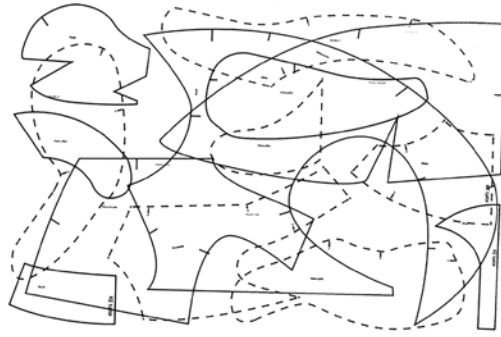


Figure 13. Design for cutting the leather parts for the pig. Vector image by Salla from her final report, 2013.

The tracing paper pieces were copied and converted into vector lines on a computer, then enlarged 700% (figure 13). The leather was then cut accordingly in 1:1 size. When the pieces were sewn together, a new material surprise lingered ahead. The massive amount of leather, eight leather jackets that went into making the pig, weighed tens of kilos. The plan to fill the pig with chicken net and cotton had to be revised and strengthened with a metal construction. The result is a natural size pig (figure 14).



Figure 14. The Golden Pig by Salla, photographed in the DEE course exhibition by Camilla Groth.

Discussion

Both Antti's and Salla's material exploration was about the felt experience and the feel of materials. The feel of the materials is connected to emotions evoked by the material, either when viewed or when touched directly. It is only with previous experiences of materials that there is a pre-knowledge to judge new experiences against. We connect these general understandings of a material to the embodied knowledge of these materials, which is revisited in the design process before actual physical manipulation. Both students were working with this type of embodied knowledge, and they based their work on the belief that the viewer shares their general understandings about the materials used.

Often a material has general connotations that may be utilized in the transfer of a certain feel through an artefact (Rompay & Ludden, 2013, p. 7). Some materials have use-areas that are commonly known and are attributed with expectations of a certain context. Other materials convey an emotion based on what the material feels like. The material feel links to feelings and emotions that work as motivators or as hindrances of the project. Both Salla and Antti were connecting feelings and emotions to the touch-feel of a material, using the same word, 'feeling', for both emotional feeling and physical touch related feeling. In Sallas' case the feeling is connected to atmospheres and images that the felt experience connects to. In Anttis' case it is a more personal feeling of contentedness, discomfort or confusion towards the right or wrong feel of a material. Even so Antti expects other people to have a similar expectance and experience as he has towards the material, and his artwork plays with exactly this notion.

Imaginary Material Exploration

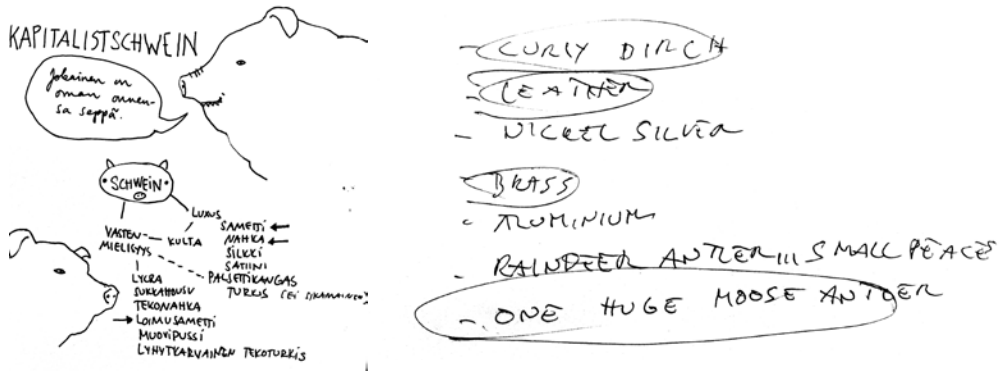
Before starting the physical material exploration for their final pieces, both Antti and Salla go through a sort of imaginary material exploration of potential materials. In the interview, Salla reports that she did most of her material exploration in her head:

I never really made that many material tests because I was imagining mostly in my mind what the different materials would look and feel like. That's how I reduced my choices.

She explains further that in this imaginary material exploration, she tried to imagine what the different materials were like. She brought to her mind objects that were made of these materials and their contexts that she had encountered previously:

I was thinking of objects that typically are made from those materials, and what images they brought to my mind. Even before I made the little pigs, I listed different materials and their properties.

Both Salla and Antti list materials in their diaries that they try out in their imagination before making a decision for which materials to include or exclude in their physical material exploration. In Salla's diary, the chosen materials are in the process of being indicated by arrows (figure 15a) while in Antti's diary, the chosen materials are circled (figure 15b).



Figures 15a and 15b. In Salla's diary material choices are indicated by arrows (a) and in Antti's diary by circling (b). Photos by Camilla Groth.

In our discussion Salla links the touch feel of the material with cultural and social connotations and contexts that are connected with the material generally:

It is not only the touch feel, but also the combination of memories and images linked to the materials and in what circumstances they have been seen or what kind of reputation they have generally. For example if it is connected to a bourgeois living room like velvet, a shiny BMW like leather or an evening dress like satin. Or then 'throw-away' culture as in plastic.

It is evident that the imaginary material exploration process is based on previous bodily encounters with the listed materials. The potential materials are not explored in drawing form, but they are listed in writing and then imagined. Both students hold the opinion that materials are too difficult to draw from memory and that a drawing describes a material's properties poorly. In the interview Salla says that drawing takes her to a certain point in designing, but to get to the next level she needs physical material exploration:

I see drawing more like searching for a shape and giving shape, the material is what brings it to the next level. Drawing or modelling on a computer is about what it looks like, and how it works. But the material is about what feelings it awakes. OK,

the material is also affecting the way it works but anyway it is the emotional side that is important. By drawing you can of course imitate materials but it is never at all the same.

In the interview, Antti describes the same problem:

How would I be able to draw a material? If I draw something that looks like glass on paper, I imagine what it looks like, how it reflects light and what I can see through it, but it still doesn't convey anything about the material. It is only imagination... The information that a drawing can convey is much more narrow compared to what the artefact conveys.

In both cases the selection of materials are imagined as lived experiences and applied mentally as the material of the new artefacts that are envisioned in their minds. In this process some materials are deemed not worth trying and others are considered for being tried out in physical form. Although availability and economical strains affected the material choice to some extent, the final decision of which material to take further is in Salla's case determined by touch. Only after physically confirming her imagined experience of the materials, she made the final decision to go with leather as her material. In the interview Salla reports:

What finally determined my choice was the way the material felt in my hands.
Because it confirmed my image of it and the connotations the material conveyed.

Touch thus played an important role in the decision making process as it confirmed the imagined image of the material. Salla goes on to explicitly say, that vision is giving only half of the perceptive view, and touch fills the missing part. Touching confirms what is expected, especially with familiar materials. If the materials are new, then one might have some expectations that can become different after actually touching them. It's like you get only half by looking and remembering and then holding it completes the impression. We link the phenomena of the imagined material exploration to the dual-space search investigated by Pirita Seitamaa-Hakkarainen (2000), who developed a model around the design process as relying on two design spaces. The first of these is the composition space, i.e. visual designing, including shapes, patterns and colour. The second is the construction space, i.e. technical designing, including materials, construction and technical details (ibid, p. 2). According to Seitamaa-Hakkarainen, the designer is performing a dual-space search back and forth between these two design spaces in order to solve design related problems, even before starting the physical material manipulation. The constraints of the material properties are also considered in this process, and experts have an advantage over novices due to their larger amount of domain-specific and experiential knowledge (Ibid, p. 2). Seitamaa-Hakkarainen draws on Anttila (1993) and

explains that the designer creates an internal image of the finished design and through testing redefines this image until the image meets the realized design when finished (see also Ahsen, 1984).

We suggest that the imaginary material exploration (that may also be described as part of a dual space search and refinement of an inner image of the finished design) is based on experiential knowledge gained through bodily interaction with materials over time. The choices and decisions on materials in the design phase are made based on previous bodily experiences and shared conceptual notions of the materials in question. Our case study proposes that in this space, between the imagined design and the material implementation, many students dwell for a considerable amount of time, before initiating physical material exploration.

The Lived Experience

When the physical material exploration is introduced, the design switches modality and enters our physical world of lived experiences. The object or prototype has many sides and surfaces, some of them are on the other side from us, allowing us to see the whole object only through interaction with it and by turning it in our hands or by walking around it. In line with phenomenology, our knowledge making process is thus subjective and linked to the kin-aesthetic ability of our bodies, as we gain knowledge by acting with our environment. We can detect these elements in our students' experiences of producing material artefacts or prototypes. For example, in her final course reflection, Salla describes her difficult process of transforming the two dimensional drawn idea into a three dimensional model:

From having drawn the pig several times I had a pretty good idea of what I was about to make, but the three-dimensional realization—expectedly—took it to a new level. The play dough moulding revealed challenges that I could not have imagined with my pen and paper. The smallest changes in the form made the pig look like a dog or a cow.

Taking the design into the lived experience, in the form of a prototype, may also help resolving spatial aspects unimaginable in two dimensions. Design researcher Kaiju Kangas (Kangas et al., 2013) describes how bodily interaction with a prototype aids in a problem-solving task. In her study, children were co-designing a lamp, but it was only when the children made the physical prototype that they were able to resolve the problem of the hanging construction that had puzzled them during the drawing process. The children used their bodies in measuring of distances and heights for the lamp and even climbed up the table to envision how the lamp would hang (Ibid., p. 39).

In a similar way, Salla was able to resolve the unimaginable aspects of her design by exploring them physically. Having made the play dough model of the pig, Salla fitted strips of paper over the model in order to envision how she needed to cut the leather material and where the seams might go (figure 12). In her final reflection she points out that this would simply not have been possible to do in two dimensions:

The assembling of tracing paper over the pig model was a useful way of extracting the complicated shape for the leather pieces. The shapes became very strange looking and my two dimensional working methods and imagination would never have been enough to create them.

Experiential Knowledge Builds on Previous Experiences

In her research, design researcher and teacher Biljana Fredriksen (2011) studied children's meaning-making processes during their experiences of working with materials. She found that previous bodily experiences played a part in the sense making of new experiences (Ibid., p. 65). In our case study, both students are using their previous experience and skills in combatting the challenges of a new material. Antti's previous sets of skills might not have been the right skills for the task at hand, but nevertheless the skill of learning new skills aided him in overcoming the unexpected challenges in the sense making of a new material. Antti says in the interview that: 'A person, who does not possess any kind of material knowledge at all, will take a long time to learn about any new material'. When Antti was pouring liquid clay into his plaster moulds, the clay got stuck to the sides of the mould and would not travel all the way to the base (figure 7). The mould was too narrow and the plaster dried the clay before it reached the base of the mould unlike the hot liquid metal that Antti was used to handle. Antti solved this problem by lifting the jug of liquid clay higher and in this way he got more weight and pressure in the pouring stream, pushing the liquid clay all the way down to the base. This was a general principle he found successful in both specific fields and he used this "trick" in the new material domain.

Also Salla referred to dressmaking skills as she pinned the tracing paper over the clay dough pig model, something that a novice designer might not come to think of in a similar situation. We link this notion of expertise to Pirita-Seitamaa Hakkarainen, who found in her research on the composition and construction techniques of novice and expert designers in weaving that the experts were able to consider both the visual elements and the technical constraints in a parallel way in their design process, and that this helped them to succeed in their material implementation at a later point

(Seitamaa-Hakkarainen 1997, pp. 153–154). Through this case study, we further believe that such domain-specific skills also help developing general design skills due to accumulated experiential knowledge—knowledge that may be used in a trial and error strategy.

In the group of 19 students whose work was initially analysed for this research, there were also cases where the material exploration was experienced as a real problem. For example, one of the students spent most of the time imagining different kinds of material solutions to his design, leaving the actual physical material implementation to the last few days with poor results. His ideas for a prototype were too complicated to be manufactured and every starting point had to be reversed or interrupted. In a video recording of a shared discussion on the students' intuitive making in material, the student said: 'My hands were not skilled enough to manipulate the material.' Later he also said: 'I could not make what I wanted to so I made something else instead.' Contrary to Antti and Salla, lack of previous material exploration and material skills deprived this student of any starting point for his material implementation, and the design was dwelling in an immaterial state until the very end.

Our findings are indicating the need to acknowledge the knowing body in design teaching. The implications of embodied cognition are now also getting attention in the general field of education. In line with this development, physicists Marcus Kiefer and Natalie M. Trumpp (2012) are pointing to the importance of real world material manipulation in education. According to them, appropriate sensory motor experiences are necessary for human cognition to develop at the highest level (Ibid., p. 19). They claim further that in line with embodied cognition studies it has been found that sensory-motor interaction with the environment during learning results in more enduring and richer knowledge (Ibid., p. 20). The important role of the environment and material manipulation in education has also been noted in another study in the context of the DEE course. In their study Maarit Mäkelä and Teija Löytönen (2015, p. 180) found out that matter can have an unanticipated or unexpected contribution to the learning process and proposes that materiality, in fact, has its own agency and thus teaches in its own way. (See also Malafouris, 2008).

As crafts persons and designers, we may understand learning a skill as training our mindful hands until they perform better. Our hands, in working with a material, slowly test, try, experience, fail, try again and in this way change us as makers towards becoming tuned in with the material. Enactivism and embodied cognition theory, as mentioned before, supports the idea that our interaction with the environment changes us and develops us (Hari & Kujala, 2009; Noë, 2004 & 2009; Varela et al., 1991). Through the perceptual feedback of our actions with the environment, or a material, we gain experiential knowledge that helps us recognise and judge future actions.

Drawing on Husserl's phenomenology, Merleau-Ponty sees sense perception as an original modality of consciousness, 'the primacy of perception'

(Merleau-Ponty 1964/2010, p. 12). This means that when learning through experience, we cannot know what something is like without perceiving it. When we touch a material, we immediately become aware of it. Also Varela et al. claim that there is not first sensing and then thinking, but a sense-reflection that is a singular event (Varela et al., 1991, p. 19). They suggest that the nature of reflection, instead of being an abstract and disembodied activity, is rather a form of experience in itself (Ibid., p. 27). Our mindful hands know the shape, temperature, orientation and surface structure of the material instantly, as if our hands could think.

Conclusion

In this article we have acknowledged the role of the body in knowledge creation within the field of design. As a result of our case study we consider material exploration an important part of the students development into a skill-full designer. Drawing and concepts are fundamental when determining the shape and the function, but does not come as close to the lived experience, as does the material prototype.

Materials have an important role in conveying felt experiences that affects the emotion of the user. Further, materials have general connotations as we share concepts and understandings about their nature, images and values. Tactile aspects are important in the evaluation of which materials to use, as well as in evaluating the finished product. During material exploration the student has a possibility to iterate his concepts based on the physical interaction with the material, and while doing so he makes important decisions for the continuation of the project.

Even before the student starts the physical material exploration, while performing a dual space search between the composition and construction design spaces, an imaginary material exploration takes place, one that is based on previous bodily experience of the imagined materials. When imagination reaches its limits, the physical material exploration and the resulting prototype takes the concept to the next level, that is the experiential level, where the design may be experienced bodily.

When encountered with new material challenges, previous skills and physical material explorations help in making sense of the new material and its behaviour. Physical material explorations thus strengthen the student's confidence in managing new materials, also in the design phase, giving the student a wider and deeper skills-toolbox to work with in the future.

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