To warm or to walk the clay? A pilot study for a tactile sensitivity experiment method in order to investigate the application of the craftsperson's perspective for studying skill in the ceramic chaîne opératoire

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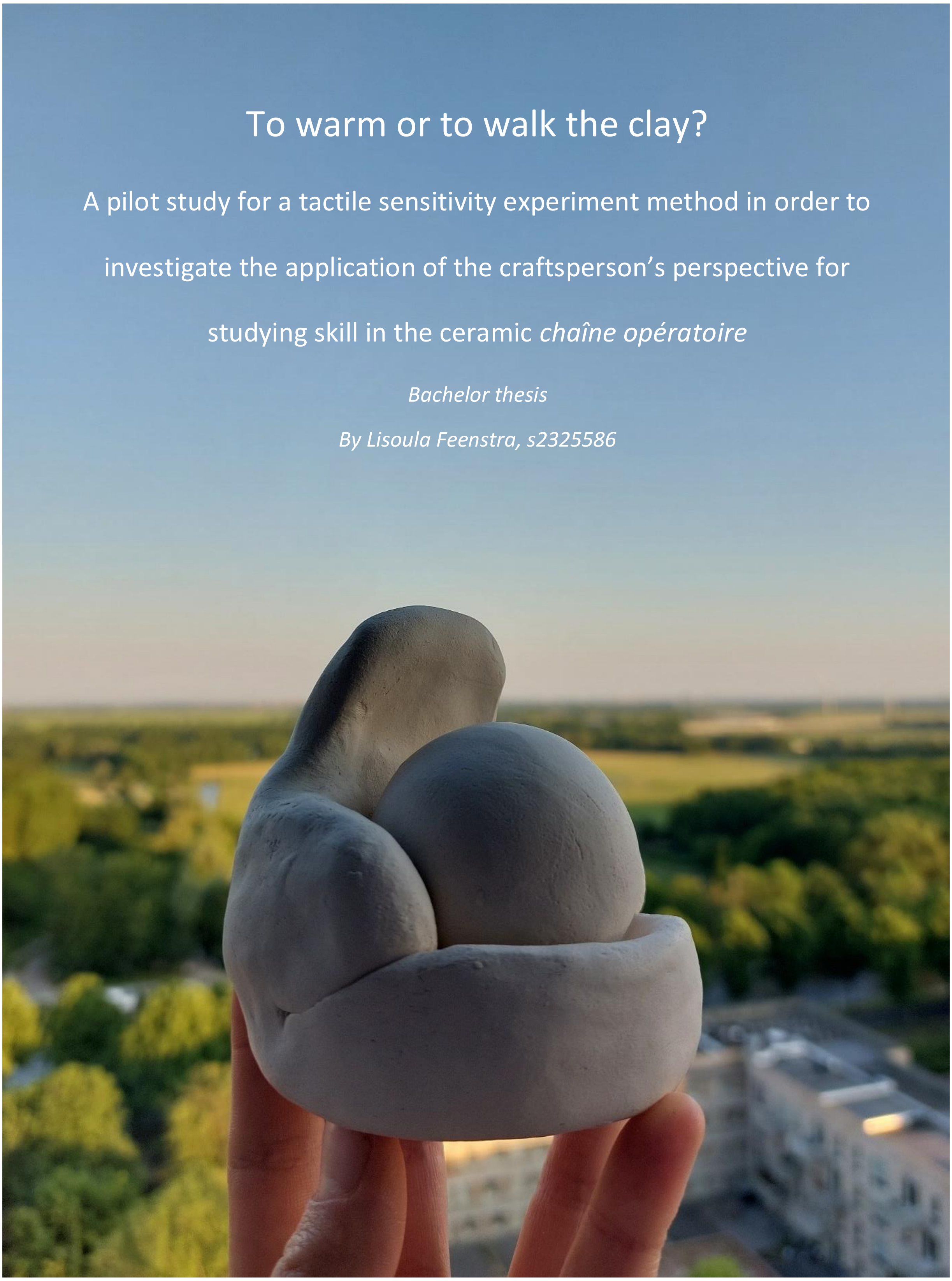
Bachelor thesis

By Lisoula Feenstra, s2325586



Picture 1: Front image. Picture of an abstract ceramic object made by the author, held against a (blurred) view of Rotterdam in the distance. The object represents a feeling of safety, shelter, and growth.

All pictures and figures are made by the author, unless stated otherwise.

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By Lisoula Feenstra, s2325586

Bachelor thesis in Archaeology

Under supervision of dr. M. Kuijpers

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“I thought clay must feel happy in the good potter’s hand.”

Janet Finch

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Also much deserving of thanks are my test people, in particular ceramist Nirdosh Petra van Heesbeen. Upon getting in touch with her, I was kindly invited into her house for two separate days of conducting experiments together and I am grateful for the insightful conversations with her. I would also like to thank my other test people, who I consider to be dear friends. Lastly, but certainly not least, I want to thank my music-loving friends for their support.

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1 Introduction

In studying the past, archaeology has always been heavily reliant on the study of hand-made objects. Inferences about the skill needed to produce such objects specifically have led to the development of larger theories about past societies and their (economic) organisation, for instance on specialisation (Kuijpers, 2008, 2015, 2017a, 2017b). Despite the importance of observations on skill for archaeology, a structured way of researching levels of skill does not yet exist and is scientifically challenging to create (Bamforth and Finlay, 2008; Kuijpers, 2017a; see Candy and Edmonds, 2018 for a proposal for practice-led research documentation and presentation).

In this thesis, I advocate for the application of Kuijpers' perceptive categories (Kuijpers, 2017a; 2018) on skill research in ceramic objects. Kuijpers devised this methodology for metalworking. Hence, this is a pilot study to explore the usefulness for the ceramics *chaîne opératoire,* using a newly designed method to obtain the data for a sensory categorisation in the ceramic production process.

Inferences about skill are typically made by archaeologists and/or material scientists. These researchers do not possess the large body of an intimate kind of knowledge (i.e. skill) that craftspeople possess. As a result, comments on the level of skill are largely based on subjective standards for what skill in these objects, or certain materials looks like. (Hurcombe, 2007; Kuijpers, 2017a, 2017b). This has led to theories that have remained largely unchanged for the last decades, even though the fundamental propositions for these theories appear questionable in the present discourse (see Kuijpers, 2008; 2015; 2017a; Almevik *et al.*, 2022).

Very useful insights come from so-called "practitioner-researchers", who use their own experiences with (learning) a craft to support their research (Groth, 2014; Feenstra, 2021; Westerlund *et al.,* 2022). Also drawing on the knowledge of craftspeople is Kuijpers, who has proposed a framework for studying skill based on sensory perception. He created an updated version of a well-established structure for describing production processes, the *chaîne opératoire*. This version visualises the production process in a way that is more aligned with how a craftsperson works with a material. Central to this perspective is the recognition of sensory perception as key in describing skill in craftspersonship (see also Feenstra, 2021; Groth, 2014). Even though he developed his framework for Bronze Age axes specifically, he advocates for using the idea of a sensorimotor framework for studying skill for other material groups alike (Kuijpers, 2017a).

I identified ceramics to be a promising material group for inquiries into skill. Ceramics preserve well and are abundant in the archaeological record. They have been used as archaeological indicators ever since the beginning of archaeological science (Tite, 2008, p.216) and technological actions in the production process can be retraced in the final product (Budden, 2018, p.2). To my knowledge, there is no structured way yet in archaeological ceramic analysis to research skill in the ceramic manufacturing process.

The idea of using ceramics for skill research led me to the following research question: **how can the craftsperson's perspective as designed by Maikel Kuijpers for the production process of metal objects be applied for establishing a craftsperson's perspective on the production process of ceramic objects?** Considering the scope of a bachelor thesis, I will focus only on one sensory aspect of the ceramic production process, which is temper/sand concentration in clay.

The word "temper" is a term commonly used in ceramic analysis and it refers to anything that can be added to the clay to enhance or diminish certain qualities of the clay and thus the final product. Examples of temper include sand, crushed shells, grog (crushed baked ceramics), straw, and hairs. For this thesis, my temper of choice was sand, because of easy availability and easy experiment reproduction possibilities. Temper concentration influences for instance baking conditions, porosity levels after baking, and subsequent use and value.

In this thesis, I aim to study how good people are in general at perceiving sand percentages in clay in both direct- and indirect-comparison situations. Direct comparison results will serve as an indication of level of sensory sensitivity in human fingertips, while indirect comparison tests the ability to accurately memorise certain stimuli ranges and stimuli differences. Additionally, I explore what differences in results can be seen when comparing sensory perception experiment results from a professional ceramist and students inexperienced with working with clay.

I expect to be able to identify the just noticeable difference in sensory stimulation for the human fingertips, and to visualise how well people can quantify sand percentages drawing from their own memory. For the second sub-question, I hypothesise that a professional ceramist has a heightened sensory perception compared to the student, as the senses of the ceramist will have become very much more attuned to the clay and its behaviour. This is due to the long period of time the ceramist spent working with clay, in contrast to inexperienced students. I expect to be able to recognise such an attunement through more accurate and precise perception of temper concentrations and differences therein.

In the second chapter, I will give background information on skill research in archaeology, the chaîne opératoire and Kuijpers' updated version of it, basic perception theory, and skill in ceramic research. I end this chapter with an introduction to the method I designed for this study. I elaborate on the application of this method in the third chapter. The fourth chapter contains the results. In the fifth chapter, I evaluate the performance of the method and my research practices. My conclusions are taken up in the sixth chapter. The appendix contains the worked-out response sheets for each test person (minus the comments) for the direct-comparison experiments and graphs per set per test person for the indirect-comparison experiments.

2 Background and Theory

2.1 Studying skill in archaeology

2.1.1 Defining skill in craftspersonship: Kuijpers

The concept of skill is much debated in a wide range of disciplines, leading to a broad variety of definitions. Distinct forms of knowledge can also be identified as conscious/declarative knowledge and unconscious/undeclarative or procedural (*tacit,* or implicit (Polanyi, 1959)) knowledge (Groth, 2022, p.49; Feenstra, 2021), or embodied (Ingold, 2000, 474; Malafouris, 2004). The discussion on skill, cognition and material engagement is lively and ongoing (see discussion in Malafouris, 2004).

For this thesis, I will stick to the definition of skill in craftspersonship as used by Kuijpers, which is geared towards usefulness in archaeology (2017a, p.37). Through this definition, he advocates for a "more complete embodiment of the craft than cognitive aspects alone" (Kuijpers 2017a, p.11):

"Skill is defined through four key points:

1) an engagement with material;

2) a fundamental dependence on the senses;

3) the involvement of the body as/and tool(s);

4) the drawing upon explicit and embodied knowledge."

2.1.2 How have we been studying skill in archaeology?

Prehistoric techniques are usually studied in two ways: from an exact, universal, material perspective, and/or from a contextual socio-cultural perspective. It goes beyond the scope of this thesis to present an overview of the literature on this subject, but it is safe to say that the body of literature on prehistoric technologies is extremely large. Technology is not the same as skill, however, and scientific judgements about technological advances can therefore not be directly translated to inferences about skilfulness of a maker. It continues to be difficult to bring together (approaches within) material science and the humanities needed to study. Many thinkers have concerned themselves with what skill exactly is, and what it is not. A particularly useful distinction to be made between techniques (*what* was done, *knowing-that*) and skill (*how* it was done, *knowing-how*) (Feenstra, 2021; Kuijpers, 2017a; Ryle, 1946).

Next to the material scientist's and the socio-cultural perspective, a third sensorimotor framework has been proposed (Kuijpers, 2017a, 2018), incorporating skill of the craftsperson and sensory perception. I will elaborate on Kuijpers' research later on in this chapter.

An academic discourse on skill research from a craft perspective has been gaining traction in Scandinavia since the 1990s. A special place here is reserved for so-called "practitioner-researchers" (Westerlund *et al*., 2022, p.6): those who let their research be supported by their own knowledge and skill of a crafts-based practice. Through their personal experiences with (learning) a craft, and sometimes ethnographic research, they are able to give a unique insider-perspective on craft-related methods, tools, and learning and teaching processes, which an outsider would easily miss. Their embodied knowledge enables the practitioner, especially one with an academic background, to relate to other practitioners through time and space, making their research highly valuable in all different kinds of research (Westerlund *et al,* 2022).

Nonetheless, the academic discourse on skill is lacking, specifically where the maker-material relationship, expressed through skill, is studied (Bamforth and Finlay, 2008, p.19; Kuijpers, 2017a). An important hurdle in further developing this discourse is in the very nature of experimental, practice-based, and/or experience-based research methods. This has made it challenging to reach a consensus on how to conduct this research (Candy and Edmonds, 2018), although the importance of such methods for exploring crafts has been stressed across many archaeological fields of study (see Adovasio, 1977; Bamforth and Finlay, 2008; Candy and Edmonds, 2018; Ferguson, 2010; Gandon *et al.,* 2011; Kuijpers, 2017a, 2018; Groth, 2014, 2017; Jeffra, 2014; Outram, 2008; Roux, 2016; Rye, 1981; Westerlund et al., 2022).

2.1.3 Why do we need a structured way to study skill in craftspersonship in archaeology?

Growing up in our modern-day society does not teach us about collection and production issues of traditionally used materials, nor do we develop a good sense of performance parameters of them (Hurcombe, 2007, p.537). Even material specialists are not equipped to accurately recognize small details in the way an object is made, let alone be able to correctly determine the degree to which certain aspects matter in the production process to achieve a certain end result. Such knowledge is only attained through dedicated working with a material over a longer period of time (Kuijpers, 2015; 2017a, see Feenstra, 2021).

This lack of knowledge becomes a problem only when it leads to uninformed (and likely incorrect) assumptions that are then used to base larger (archaeological) theories off. Kuijpers (2017a, 2017b) makes a convincing argument for exactly this issue in the case of long-prevailing views on metalworking in the Bronze Age. Here, the dominant assumption is that a displayed level of high technological metalworking skill (as interpreted by material scientists and/or archaeologists) signifies it being made by a specialist, which leads to specific interpretations of the Bronze Age economy and a high social position of the specialist metalworker therein. This idea is strengthened by the assumption that metalworking itself requires more (advanced) skills than preceding crafts (Kuijpers, 2017b, p.25-26).

2.1.4 A useful starting point: the chaîne opératoire

One way to structurally describe production processes is the *chaîne opératoire.* Coined by Leroi-Gourhan (1965), this approach was adopted by processual archaeology in the decades thereafter (Lemonnier, 1992, p.26; Pauketat, 2001, p.78; Van der Leeuw, 1993).

The chaîne opératoire is a methodological paradigm in which production processes for any object are described in the form of sequences of (optimised) technological actions. These steps follow the collecting and transformation of raw materials up until the final touches to the end product, allowing for both very general and more specific, layered descriptions of manufacturing techniques (Feder, 2005; Roux, 2016). Through close inspection of an object and knowledge of the behaviour of the material(s) at different stages in the production process, material traces and potential by-products are helpful sources in establishing a chaîne opératoire.

Lemonnier identifies five elements that tie into these technological actions: matter, energy, objects, gestures in sequence, and specific knowledge (1992, p.5-6). Specifically, the recognition of these last two elements in the technological actions that the chaîne opératoire strives to describe, make this approach suitable to start research into skill in production processes. Simply describing the actions, however, does not result in an accurate reflection of the way in which the production process was actually experienced by the craftsperson, nor does it give way to making acknowledgements on skill of the maker(s). A more qualitative approach is needed.

2.2 An updated chaîne opératoire approach: the intimate craftsperson-material relationship

2.2.1 Experiencing the production process: a craftsperson's view

To a craftsperson, the production process is not a clearly defined series of steps, but consists of actions that are fluidly connected to each other and which ideally are not viewed as separate within the scope of the total process (see also Ingold, 2000). This unity of the actions is only understood when looking back, from the insider perspective (O'Connor, 2005; Groth, 2014). Retracing, cutting out, or switching up steps does not necessarily have to negatively impact the quality of the final product; it can even be a socially mediated, stylistic indicator (Gosselain, 1998; Gosselain, 2000; Renfrew and Bahn, 2005, p.28; Roux, 2011, p.80; Rye, 1981).

Not only their order, but also the way the actions are carried out differ (slightly) at all times. The actions are always adapted to the situation, for example changes in the material, tool specifications, and knowledge and experience of the craftsperson (Lemonnier, 1992, p.8-9). A skilled craftsperson is able to construct a mental image in their mind of what happened to the material previously, how the material in the current state will react to further handling, and what actions need to be carried out in what way to reach the desired outcome (Groth, 2014).

The intimate relationship between a craftsperson and their material can be described as a continuous negotiation between the two, in which the craftsperson alters their next action(s) based on the feedback they get from the material after each action they perform on it (Feenstra, 2021; Gosselain, 2000; Kuijpers, 2017a, 2018). A (scientific) challenge lies in the fact that the craftsperson is not always actively aware of the differences in the material before, during, or after working it, nor can they accurately verbalise these and the ways in which they responded to them. These thinking processes largely make use of the previously mentioned unconscious (*tacit*) knowledge and have been described as *knowing-in-action* and *reflection-in-action* (Polanyi, 1959). The craftsperson, however, does not need to understand the exact scientific details of the behaviour of their material, as long as they can recognize these and accurately respond to them through their actions (Kuijpers, 2017a; 2018).

Important to keep in mind is that this feedback is perceived by the human senses. I will return to sensory perception later on in this chapter. For now, it is worth considering that the more skilled a craftsperson becomes, the more attuned their senses will become to small differences in the material, even if they are not actively aware of their existence. This also became apparent in conversations I had with professional ceramist Nirdosh Petra van Heesbeen in February and December of 2022, who has over fifty years of experience working as a ceramist full-time. She could quantify sand content in clay samples verbally, but my experiment set-up forced her to perceive differences therein more precise and mainly with greater awareness than she had done previously. This serves as a good example of Polanyi's tacit knowledge, or Malafouris' embodied knowledge.

Sensory perception is far from absolute accuracy and far from the highly detailed information on material properties we can attain using modern-day technology. It makes little sense to craftspeople to study skill or even production processes from the viewpoint of the exact sciences, as the strong reliance of craftspeople on their senses creates a different categorisation system for the reality of a responding material (Kuijpers, 2017a). Researchers such as Kuijpers (2017a, 2018) and Hurcombe (2007), and practitioner-researcher Groth (2014, 2017, 2022) therefore argue for letting sensory perception play a central role in skill research, but a firmly established research method on this topic does not (yet) exist.

Kuijpers has however laid a foundation for such a method, relying on the idea that skill shines through in (amongst others) the results of the negotiation process between the maker and the material, which is mediated by the maker's sensory perception. Before going into more detail on Kuijpers' method, I will briefly explain some useful concepts on sensory perception.

2.2.2 Theory: Weber's fractions, sensory thresholds, and the just noticeable difference

If we wish to quantify maker-material negotiations in order to study skill, it is necessary to be able to quantify and measure sensory perception, which can be done using the principle of Weber's fractions. The Weber fraction can be defined as follows (Colman, 2015, p.818): "In psychophysics, [the Weber fraction is] a ratio, differing from one type of sensory experience to another, representing the smallest increment in the magnitude of a stimulus that can be detected under ideal testing conditions, and that is a constant for each type of sensation according to Weber's law." This smallest increment in the magnitude of a stimulus that we can detect is called a sensory threshold, or the just noticeable difference (also: *jnd*).

2.2.3 Kuijpers' updated chaîne opératoire: technological pathway using perceptive categories

Kuijpers designed a structured research method to capture skill in craftspersonship of metalworkers in a way that is closer to the actual craftsperson's experience, making use of his own updated version of the well-established chaîne opératoire approach (2017a, 2018). He draws on the idea of skill being translated into sensory attunement of the craftsperson to their material (metal in his case), which enables and strengthens the (sub-)conscious maker-material negotiation process. Sensory attunement is seen as an enabling factor for, and a by-product of, becoming and being a skilled craftsperson. On the one hand, a heightened sensory perception of aspects that are relevant to a production process enables a craftsperson to register small but important details in the material, which helps them to adjust their following actions more precisely. On the other hand, working with a material very intimately trains senses to differentiate stimuli to an extent of which the craftsperson was not aware their senses had been trained to, such as the smell of a particular clay. Kuijpers framework offers researchers without this experience a practical, workable toolbox to quantify skill in craftspersonship.

Kuijpers proposes a chaîne opératoire with *perceptive categories* for important sensorial aspects in each step of the production process. He describes a perceptive category as "...a subjective, adjustable category through which we can set thresholds with regards to the categorisation and analyses of data, based on the human sensory modalities and the limitations thereof." (Kuijpers, 2017a, p.72). In a practical sense, the idea of a perceptive category is that it encompasses a certain range of stimulus intensities. The corresponding human sense of the craftsperson does not need to perceive the differences any further, or the craftsperson need not be actively aware of more precise differentiation, to be able to plan any alterations to subsequent production steps to reach a certain end goal. Thus, the categories are fuzzy and coarse. They are described verbally, contrary to the preference for a numerical quantification that characterises the approach of exact material scientists.

An important goal of Kuijpers' method is to apply this (verbal) categorisation on the (numerical) values used in material science, in order to better understand how the craftsperson might have experienced the production process and to what degree differences in the production steps might have been the result of differing levels of skill.

Complementary to a description of the actions carried out in the production process, the updated chaîne opératoire of Kuijpers adds a perceptive categorisation to each production step. He visualises this framework in Figure 2, with the steps displayed vertically and the corresponding perceptive categories on the horizontal axis:

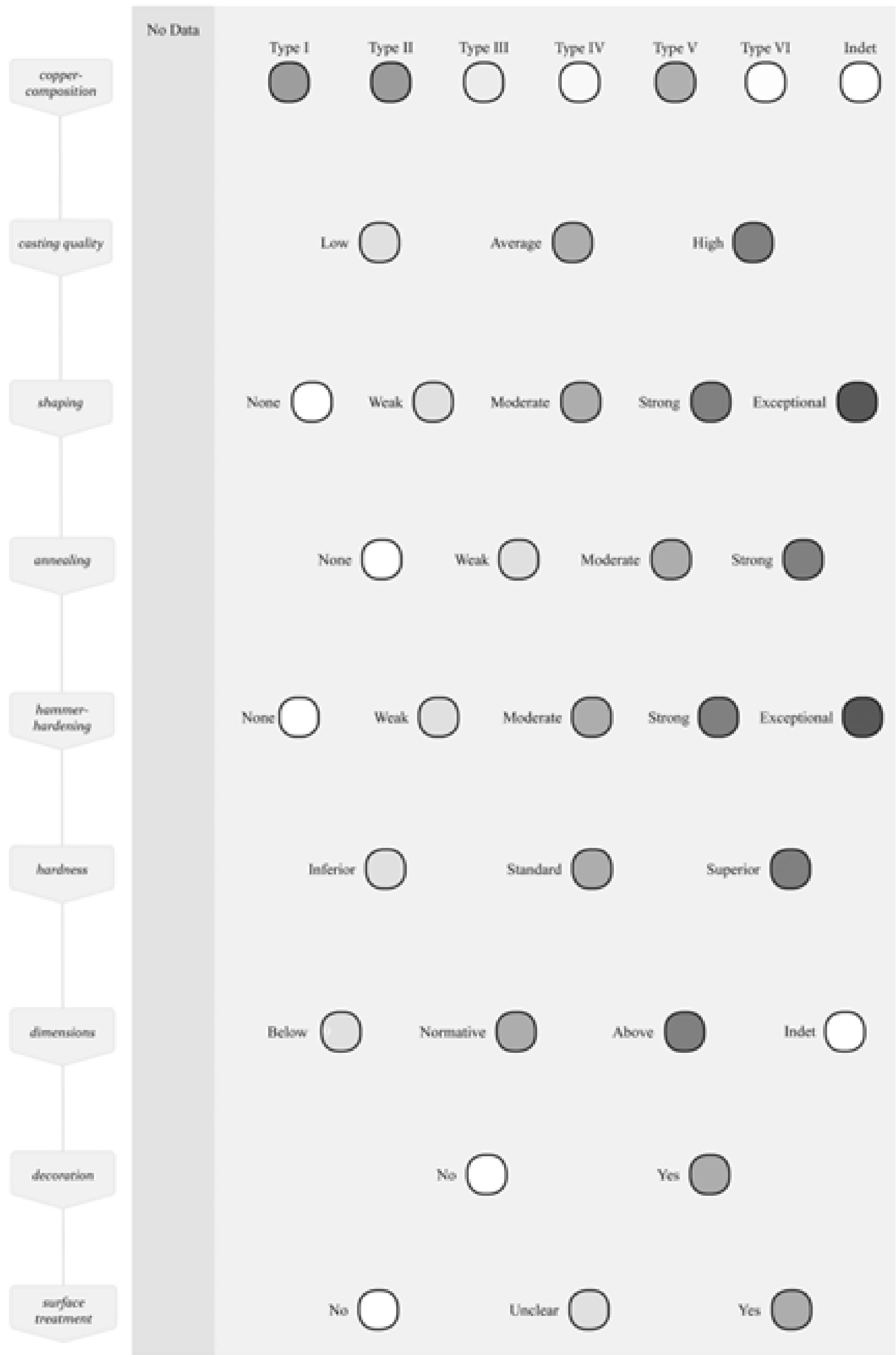

Figure 1: Visualisation of Kuijpers' updated chaîne opératoire (Kuijpers, 2017a, p.75) for metal production, including a corresponding perceptive categorisation for each production step. The steps are listed vertically; the categories horizontally per step.

Through scoring a metal object on one of each of these perceptive categories represented by the dots, and drawing a line between them, a technological pathway appears. If done for each object for a whole assemblage, a network of frequently and less-frequently taken production paths becomes visible. The spread and the way in which the technological pathways of a skilfully made assemblage go, will showcase different ways in which the craftsperson might have adjusted their next actions to attain a certain result based on the results of previous actions. This is fundamental to Kuijpers' idea of skill from a craftsperson's perspective.

2.2.4 Kuijpers' craftsperson's perspective approach within existing archaeological research

The practical implication of Kuijpers' framework is that there is now a tool that researchers can use to help them to better recognise and quantify skill in the production process behind an object, even though they lack the experiential knowledge a craftsperson has. Using this tool, the level of skill in the manufacturing of an object is no longer simply a subjective opinion of the researcher, but backed up scientifically through material science, yet in a way that is more in alignment with the actual craftsperson's experience.

In the case of Kuijpers' research, he uses his approach to place the supposed very high level of skill of a metalsmith into perspective. He argues that smiths should be viewed more as "regular" craftspeople, instead of attributing to them a far superior social rank, solely based on their chosen craft (2017a, p.3-4). Kuijpers' craftsperson's' perspective framework can nonetheless be highly useful for skill research for material studies in general, which led me to the idea of applying it to the study of ceramics.

2.3 Studying skill in ceramics

2.3.1 Suitability of ceramics for skill research

Due to their outstanding preservation and abundance in the archaeological record, ceramics have been widely used for archaeological interpretations. Even if only shards remain, they can still be very indicative of the original shape and manufacturing process. Ever since the development of archaeological science studies in the 1950s, ceramics have taken a central place in them (Tite, 2008, p.216). It must be noted however that preservation rate of materials does not correspond to evolutionary or sociocultural significance (Dobres, 2010, p.105).

Clay can be worked very precisely and in a controlled manner. Clay will, for instance, not fray or get (un)tangled (as in textile arts), not break or flip back (as in weaving with organic materials), does not require brute force (less controllable) or extreme heat (as in flint knapping, or as in smithing, although great precision can be reached here (for smithing, see Kitajima, 2015, 2016; for flint knapping, see Pelegrin, 1990)). It must be noted here that not every trace in the clay, however, can be accurately ascribed to a certain action due to the polysemic nature of clay (Roux, 2016, p.106). Concerning clay, this means that different actions or using different tools can leave similar traces. The exact results of the technological actions on clay, regardless of its polysemic nature, are permanently embedded in the object during the firing process, leaving behind "technological signatures of action" (Budden, 2018, p.370). As such, skill of the ceramist can be observed in all production steps. It is in these technological actions where skill becomes apparent, as the imprints of past choices in the manufacturing process that are informed by both explicit and embodied, sub-conscious knowledge. The actions and their technological signatures are furthermore a strong indicator of a close engagement with the clay with a strong reliance on sensory experience, involving the body as a tool, and making use of other optional tools. I defined skill to be just that at the beginning of my thesis.

In short, the reliance of archaeologists on ceramics, their abundance in the archaeological record, and the observable technological traces that can signal skilful manufacture make ceramics very well-suited for skill research.

2.3.2 Previous (skill) research in ceramics

Archaeological ceramic research has a long history, considering its abundance and recognisability in the archaeological record. Ceramics are produced in all kinds of different settings, touching upon almost all aspects of (past) life. Ceramic research is therefore as multifaceted as the material itself, ranging from inquiries into provenance (Holmqvist, 2017; Wiegand, 2017), dating (Blain & Hall, 2017; Bortolini, 2017), geochemistry (Degryse & Braekmans, 2017; Montana, 2016; Schneider, 2017; Waksman, 2017) and manufacturing techniques (Duistermaat, 2008; Arazi *et al*., 2010; Montana, 2016; Roux, 2016) to socio-cultural theories (Stark, 2003; Keegan, 2000) and economic models (Philip & Badreshany, 2020; Cohen *et al*., 2022). Considering the longstanding tradition of ceramics research, a vast body of "research-reflective" research has been produced concerning, for example, research practices (Ferguson, 2010; Whitbread, 2017) and data collection and analysis (Kuijpers, 2017a; Santacreu *et al*., 2017; Shirvalkar, 2017). Archaeological research into ceramic technology and experimental methods for this research have been gaining traction from around 1980 onward (Harry, 2010, p.14).

The topic of skill in ceramic research is less well-explored, however. It is nonetheless described in the social context of teaching, largely focusing on skill acquisition (Crown, 2014; Groth, 2014, Jeffra, 2014). Roux (1990) has attempted to quantify skill in wheel thrown ceramics through classifying ceramic forms in a techno-morphological taxonomy, based on which she scaled ceramic forms from easy to difficult to make. This research inspired research into measuring skill in dealing with issues due to mechanical constraints in ceramic shapes, demonstrating a learned implicit attunement of the potter to clay behaviour (Gandon et al., 2011). Interesting to note about these studies is their reliance on experimental research methods - in these cases, reproductions made by expert potters. These research examples follow a call made by multiple researchers (see Ferguson, 2010) to supplement existing ceramic analysis methods with experimental research, as this might help close crucial knowledge gaps. One of such gaps is skill (Groth, 2014; Rye, 1981). I have not been able to find a systematic research method or a theoretical framework in the literature on skill in archaeological ceramic production.

2.3.3 What could skill research in ceramics add to ceramics research?

Gandon et al. (2011, p.1088) stress the importance of including "the skill point of view" in ceramic analysis, which allows for interpretations of cultural perception of techniques. They argue that skill distribution analysis will contribute to our understanding of craft specialisation, socio-economic dynamics, and the status of objects requiring certain skills to produce.

It is my speculation that skill research in ceramics also holds great potential for shifting existing prevailing theories on, for instance, the social status and organisation of ceramists, and on our vision of household ceramic production. I would like to see a more wide-spread (re)appreciation in archaeology of the skill and knowledge necessary to produce, for example, rather mundane everyday household and transport ceramics, doing more justice to the insider view on skill and knowledge of craftspeople and practitioner-researchers alike. Such a re-evaluation of skill echoes, in part, the aim of Kuijpers' research (2017a, 2017b).

In a broader sense, skill research could lead to new insights in skill acquisition and development. These insights could not only be applied to technological advances in archaeological (material studies) research, but it could also add greatly to our understanding of cognitive and motor-sensorial aspects of (embodied) knowledge.

2.3.4 The ceramic chaîne opératoire

Pottery traditions are ever changing under the influence of available materials, cultural and technological developments, or individuals or local groups. Different parts of the ceramic chaîne opératoire specifically change to largely varying degrees. This phenomenon is linked to the technological fluidity of a step in the chaîne and the social interaction involved (Gosselain, 2000).

Rye (1991, p.3) differentiates steps in the ceramic production process into essential and non-essential operations. Essential operations include: sourcing materials (including extracting and transporting them), preparing them for use (forming, drying, and firing) and finally distribution, use and disposing of them. Non-essential operations would be any form of decoration, burnishing, or applying paint/slip/glaze. Following Roux (2016, p,105), the ceramic chaîne opératoire consists of pounding, hydrating, adding temper, wedging, forming, and firing. She identifies two levels in the ceramic chaîne opératoire with on the first level the consecutive main actions needed to transform natural resources into a finalised product. The second level concerns the productions processes for the separate production steps, which vary greatly depending on cultural and functional factors (Roux, 2016, p.103.

2.4 Introducing a new toolbox to study skill in ceramics (pilot study)

The larger aim of my research is to create a technological toolbox that will help researchers to quantify skill more accurately and in a structured way in craftspersonship in ceramic assemblages. This is very much in line with Kuijpers' aim, only I would like to attempt to adapt his toolbox into one suitable for ceramics production instead of metal production. This toolbox will encompass perceptive categories for (almost) all steps in the ceramic production process. I will be drawing on the craftsperson framework worked out by Kuijpers for metal production (2017a, 2018). This thesis will therefore take the shape of a so-called proof-of-method, as I will try to test the applicability of Kuijpers' approach on ceramic production. As one can imagine, the aim of this test is too large for the scope of a bachelor thesis. I will therefore focus on establishing just one perceptive category for now.

Following Kuijpers' concept of perceptive categories, a perceptive category needs to be identified using the following questions (Kuijpers, 2017a, p.77), which I have briefly answered in brackets and Italics for the perceptive category I will focus on in this research:

1) What qualities (of a material) are perceivable? (*Of clay being prepared for working: temper concentration, viscosity… etc.)*
2) Why would a specific quality be a matter of concern to the people/society in question? *(Temper concentration influences for instance necessary baking conditions, porosity level after baking, subsequent use and value, etc. (Harry, 2010, p.21))*
3) How is the quality recognised? Which senses are used and how does this relate to the type of information we are able to draw from the archaeological data? I.e. how do the properties we can measure translate into the perceivable quality? *(Senses used: vision, sense of touch, (hearing). Scientists make temper concentration estimates based on their own predominantly visual perception of the surface of a ceramic (and the inside surface of a ceramic shard).)*

4) Can the perceptive category be positively applied to the data and organise them sensibly? *(Yes; data on temper concentration is collected in standard ceramic analysis and already sub-divided into a categorisation.)*

I will attempt in this thesis to establish a perceptive categorisation of the human sense of touch in the hands for differing sand concentrations in clay. Through answering the questions above, I believe that this category can be used to indicate skill in the production step of mixing the bare clay with any temper materials before working it.

Such a perceptive categorisation tailored to (a step in) the ceramic production process does not yet exist, so I designed a method for creating one. As stressed by Harry (2010, p.27), experimental research (for archaeological ceramic research specifically) sometimes requires different runs to establish the correct parameters and even the correct methods, so I consider this research as a pilot study for my method. This method tests for the haptic ability to sense differences in temper percentages in clay samples, testing mostly the sense of touch in the tips of the thumbs. Improved touch perception can be seen as both a by-product and an enabling factor for an increased level of skill in ceramic manufacturing.

3 Methods

In order to establish perceptive categories that reflect the experience of a maker as closely as possible, I will need a specific dataset on sensory perception under certain circumstances. In this case, this will be direct and indirect comparison of sensory tactile stimuli. This chapter deals with explaining how the method that I created for this works, and how I used it for my research.

For the second sub-question, I will compare differences in perceptive category test results from a professional ceramist and a student inexperienced with working with clay. I will briefly explain my method for this question at the end of this chapter.

3.1 Sub-question 1: How good are people in general at perceiving sand percentages in clay?

3.1.1 Experiment aims

A series of sensory tests in an active touch setting will be conducted to answer the first sub-question. The goal of the first series of experiments, in a direct comparison setting, is to gain insight in how precise people can perceive differences in temper percentages in clay, and how well they can identify the sample containing more temper. In the second experiment series, in an indirect comparison setting, it is studied how well people can quantify temper percentages in clay using their own quantification system, which also tests their ability to memorise the available temper percentage range. The temper of choice is sand.

3.1.2 Experiment requirements

For the preparations for the experiments, the following items were used:

- River clay, no inclusions (standard industrial clay, available for study projects at the Faculty of Archaeology at Leiden University), at room temperature and moist enough for easy kneading;
- Cement sand (bought at GAMMA), dried, sieved twice using a 1-mm sieve;
- Small bowl with water;
- Cloth to dry hands after washing them;
- Plastic clay bags with corresponding percentage tags;
- Organiser box with corresponding percentage tags.

3.1.2.1 The samples: making and storage

From a larger block, smaller pieces of clay are taken and weighed with a measurement error of 0,05 grams. In weighing the clay pieces, the weight of the sand to be added later – per sample differing – is subtracted here. The sand also has a measurement error of 0,05 grams. The amount of sand added goes up in steps of 2,5 % with each following sample. I decided to make 2,5 % the smallest possible difference after a test round with the professional ceramist, in which she mentioned that she would probably also be able to perceive a difference smaller than the 5 % I tested with her (N. P. van Heesbeen, personal communication, February 10, 2022). This means that the first sample has a sand percentage of 0 %, the next of 2,5 %, followed by samples of 5 %, 7,5 %, etc. The last sample has a sand percentage of 42,5 %. A sand percentage of 42,5 % in a sample is very high, but up to this point, the clay will still stick together well enough for the experiment. The aim of the experiments is to test human sense of touch, not the most realistic or suitable temper percentage for the production of an actual ceramic object.

Each sample weighs a total of 100 grams, which I divide in two samples of 50 grams each for the experiment. This measurement allows for the test person to adequately feel the temper difference in the clay and to knead it comfortably in one hand. Having two samples of the same temper percentage enables me to carry out the same-percentage experiments.

A labelled organiser box containing the samples, lined with tin foil to prevent water loss of the samples and water damage to the box, enables swift retrieval of the correct samples (see Picture 2). Some water is added to increase kneadability and stickiness of the samples, to prepare the samples for each round of experiments. The samples are stored in an airtight plastic bag with the corresponding percentage tag (see Picture 2.1). The bags are put in another, larger plastic bag and put into another box lined with tin foil to prevent water loss.

Picture 3: Picture of the organiser box lined with tin foil, containing all samples in their accordingly labelled compartments. This picture was taken just prior to a round of experiments, so the samples have been taken out of their individual storage bags already and kneaded with a bit of water to make them easily kneadable again.

Picture 2: Picture of an accordingly labelled plastic bag containing the two samples with a sand percentage of 40 %.

3.1.2.1 The issue of water and sample preparation

The amount of water present in a sample greatly impacts the feel of the sample and its potential inclusions such as sand grains. This is due to the fact that in wetter clay, the clay particles roll over the finger more easily compared to drier clay, so that sand grains are noticed more readily in drier clay. When rolling a finger over a flattened surface of a wetter clay containing sand, the sand particles will be dragged along more easily. Such a movement creates a more clearly defined stimulation of the sense of touch and leaves behind visible striations in the clay. In drier clay, the clay-and-sand mass is more compact and sand grains will therefore less likely be dragged out of the clay matrix when rolling over them with a finger (N. P. van Heesbeen, personal communication, February 10, 2022). A significantly different wetness between the samples will therefore hinder making an accurate comparison.

The water content for the sand is constant as it has been dried beforehand. This turned out to be very impractical in the case of the clay. In theory, it would be possible to completely dehydrate the clay and to later add a very carefully measured amount of water under well-controlled conditions. The ideal water amount for each sample differs per temper percentage, since sand grains have a much lower surface-content ratio than clay particles. Samples with a higher temper percentage need less water to become easily kneadable, but might also need more water to stick together (N. P. van Heesbeen, personal communication, December 1, 2022).

Perceived 'similar wetness' for my samples is a state where the samples were easily kneadable and where the water was thoroughly and evenly distributed throughout the sample. The clay and sand also have to stick more readily to themselves than to my hands. Where there is overlap of these two requirements, a relatively small but workable window is created in which to compare kneadability of individual samples. I determine the absolute and relative wetness using my own senses as accurately as possible, following the following viewpoint on archaeological experiments of Skibo (1992, p.22): "...experimenters give up some control of the variables … to test hypotheses under more natural (i.e., behaviourally relevant) conditions".

3.1.3 Experiment series 1: direct comparison

3.1.3.1 Participants

Results are collected from three healthy volunteers. The try-out and the first experiment round are done with a professional (female) ceramist with fifty years of experience working as a ceramist. The second and third experiments are done with two (male) university students aged 22 and 26.

The test person is blindfolded during the experiment and receives no verbal clues, as my communication towards them during the experiment is structured and repetitive regardless of the correctness of their answers.

3.1.3.2 General procedure

The test person is presented with two samples with differing or the same predetermined temper percentages in pseudo-random order, one in each hand. The first sample that is presented is always placed in the left hand so as to limit any distractions in the presentation. The sample containing the most sand is placed in either the left or right hand based in a predetermined pseudo-random order. This person then feels and kneads both clay samples simultaneously, in a way that they feel enables them to perceive temper differences the best. The test person is then asked which sample contains more sand, or whether the sand percentage is the same. After each test, the test person washes their hands a bit and/or wipes off the excess sand and clay on the damp cloth.

3.1.3.3 Structuring individual tests, test sets, and interval sets

From this point onwards, I will describe a sand percentage difference between two samples [one of 20 % and the other of 25 %] as a [5 %] interval. An important focus for this research is how large the differences are that can still be perceived, which I want to study in a structured way and increasing in difficulty. I will first test all possible 15 % intervals (0-15 %; 2,5-17,5 %; 5-20 % etc.) in pseudo-random order. I refer to this collection of tests with the same interval as a [specific interval] set, in this case the 15 % interval set. If the test person performs well for a specific interval set, a set with smaller intervals will be tested. The possible interval sets are 15 %, 10 %, 7,5 %, 5 %, 2,5 %, and 0 %.

With a "test set", the collection of individual tests is meant where the intervals are equally large. Such a set may then be referred to as a specific interval set. Within every interval set, all possible fixed-range intervals in the range of 0 % up to 42,5 % are tested in semi-random order. Each set is tested completely before moving on to a set with a smaller fixed range of temper concentrations, unless stated otherwise. One "experiment round" refers to the collection of all interval sets that are tested in one day with a specific person.

The test person is told that any and all possible intervals can be tested at any time, even though the experiment is actually carried out per interval set. This allows me to repeat sets more easily before moving on to a set with smaller temper concentration differences, and to gradually increase the difficulty level.

3.1.3.4 Collecting results

The experiment results are tracked using a result sheet where I will mark the temper percentages I will present and in which hand, the given response, and whether this response is correct. I will also note down the knowledge the test person is given about potential temper differences. I furthermore note down any remarks the test person makes on difficulty and any doubts they have, wetness, stickiness, kneadability or personal energy level, and any distractions during the experiments.

I will make additional notes which are not relevant to the current research, but that could be used as inspiration for future research. These include notes on their dominant hand and on any hand-switching to double-check their thoughts. The complete response sheets have been included in the appendix.

3.1.4 Experiment series 2: indirect comparison

In many aspects, the first and second experiment series resemble each other. Any differences between them are described in this section.

3.1.4.1 Participants

Results are collected from four healthy (male) volunteers. Among them are three university students and one recent university graduate, aged 22, 24, 26, and 27. The students aged 22 and 26 are the same as in the first experiment series.

3.1.4.2 General procedure

Before starting the experiment, the blindfolded test person is made familiar with the available stimulus range. They will be presented with the clay samples containing no sand, the most sand, and the sample in between them, while being told what sample they are presented with. They are then asked to create their own quantification of sand content in the samples, for which a numerical quantification is the most suitable for making comparisons. After each test, the test person washes their hands a bit and/or wipes off the excess sand and clay on the damp cloth.

3.1.3.3 Structuring individual tests and tests sets

A set in the second experiment series refers to a collection of samples to be presented with all possible sample percentages, ranging from 0 % to 42,5 %. The set is randomized using an online randomizer tool. For an experiment round, a set is randomized ten times, yielding ten sample sets. These ten sample sets provide the test structure for all experiment rounds in the second experiment series. Differences in difficulty levels are unintentional.

3.1.3.4 Collecting results

On response sheets, I note down the quantification range each test person decides to use and how they quantify each sample on this range. I also make a remark of any breaks.

3.2 Sub-question 2: What differences in results can be seen when comparing sensory perception experiment results from a professional ceramist and students inexperienced with working with clay?

The collected pieces of information for the first sub-question will also enable me to answer my second sub-question. As the answer to this sub-question largely lies in the analysis of my results, I will only note down here the relevant factors I will keep track of during my experiments. These include the following: which intervals can still be accurately recognised and which are too small, and how large the error margin is when quantifying sand amounts, and how well the lower and upper end ranges of the possible sand percentage ranges are recognized in the quantification.

4 Results

For the first experiment series, a total of four active touch experiment rounds comparing temper percentages in clay were done with three people. The try-out and first round were done with a professional ceramist with fifty years of experience being a ceramist, whereas the second and third rounds were done with university students. The results of the try-out round will not be presented here, as these results were deemed highly unreliable due to a still too inadequate experiment set-up.

Results for the second experiment series were also collected in four active touch experiments. They were done with three university students and one recent university graduate. Due to the tight planning and having spent two days experimenting in her home already, I decided not to work with the ceramist again.

This chapter has been divided into two main parts. The first part starts with the quantitative results for the direct-comparison experiments and is followed by the quantitative results for the indirect-comparison experiments. The second part concerns the qualitative results of both experiment settings, which are mainly focused on the experiment conditions under which the method was tested, on issues inherent to this method and to the way it was applied, and issues inherent to working with people as test subjects.

4.1 Quantitative results

4.1.1 Direct comparison

In the direct-comparison experiment, the blindfolded test person is presented with two samples with differing or the same sand percentages simultaneously. They are asked whether there is a difference in sand content between the samples, and if so, which sample contains more sand. I also noted down whether they switched the samples between hands to double check their thoughts, as I thought that this might indicate levels of difficulty. Since these results do not add to the research question directly, they can be found included in the response sheets in the Appendix.

4.1.1.1 Difference perception and sample identification (all test people combined)

The quantitative results for difference perception per interval set have been visualised in Figures 2 and 2.1.

The percentages on the x-axis refer to the interval in sand percentages between the two samples, also called an interval set. As explained before, an interval set is the collection of tests where intervals of equal lengths are tested for difference perception. For example, a 15 % / 25 % test and a 22,5 % / 32,5 % test are both part of the 10 % interval set. The tested intervals are 15 %, 10 %, 7,5 %, 5 %, 2,5 %, and 0 %.

Figure 2 shows the percentage of tests where a difference between two presented samples was perceived, per interval set. Each dot represents the percentage of an interval set of one test person. In the description of the graphs, I will move from right to left, from easier to more difficult to recognize differences. It becomes visible that the 15 % and 10 % intervals are easily recognised. The 7,5 % interval is recognised well in most cases, too. A large spread in difference perception percentages becomes apparent for the 5 % interval, which has been repeated the most throughout these experiment rounds. The difference in the 2,5 % interval set is recognised less often overall than the 5 % interval. The same is true for the 0 % interval. Notably, one test person recognized a difference in 76,5 % of the tests where a 0 % interval was tested, despite there being no difference present.

It must be mentioned here that the baseline percentage for useful results is around 50 %. Only two responses are possible (yes/no difference), so there is a 50/50 chance of guessing the correct response.

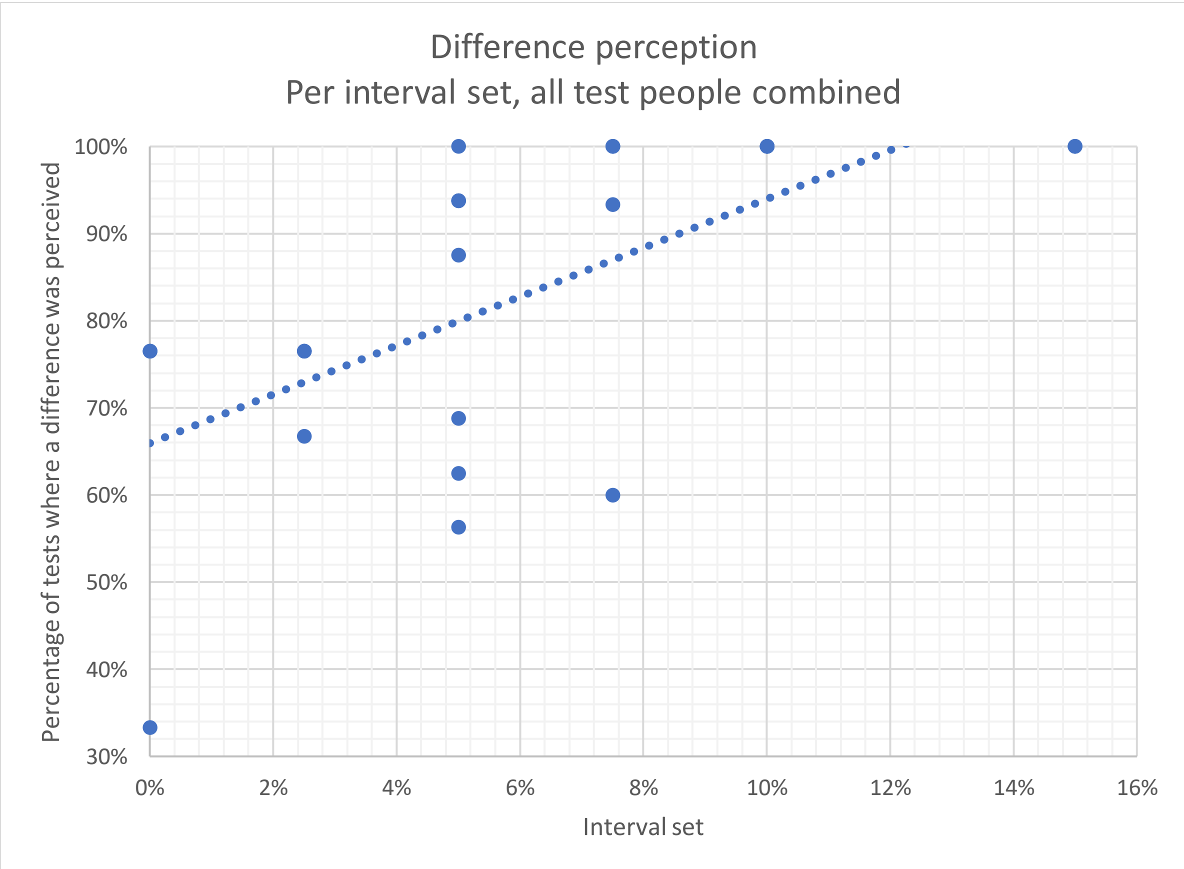

Figure 2: Graph showing the difference perception per interval set, all test people combined.

Since some dots overlap, the average percentage of perceived differences for each interval set across all test people has been visualised in Figure 2.1. A clear pattern appears where from the 10 % interval downward, a quite linear correlation exists between the decreases in intervals and accuracy in difference perception. Note that the value for the 0 % interval is surprisingly high, due to the lack of data points and the high outlier being one of the two.

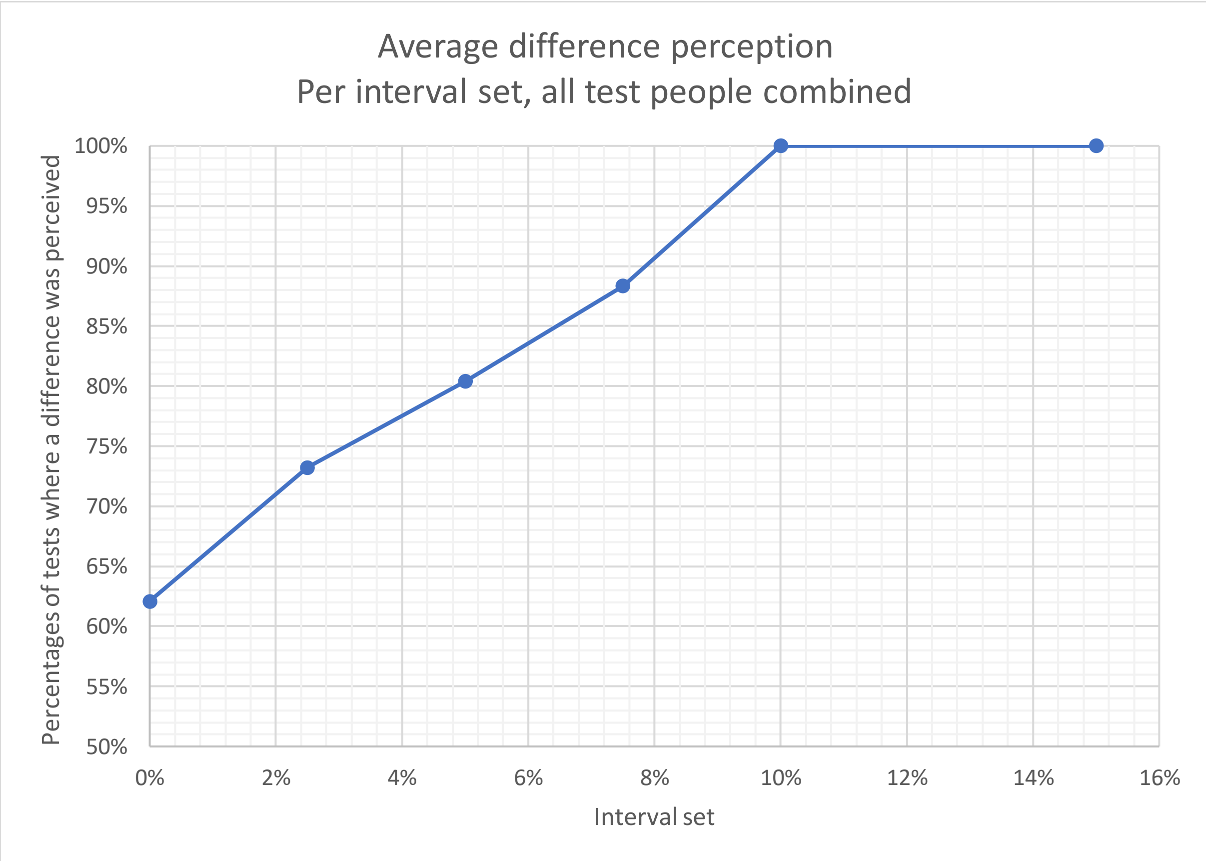

Figure 2.1: Graph showing the average difference perception per interval set, all test people combined.

The percentages of tests per interval set where both a difference was perceived, and the sample containing more sand was correctly identified, have been visualised in Figures 2.2 and 2.3. Both Figures show that the 15 % interval proved no real difficulty for the test people. This changes slightly for the 10 % interval, where not always the correct sample is identified [as containing more sand]. Just as for difference perception (see Figure 2), and not in the least due to this interval set being tested more frequently, there is a large spread in the 5 % interval for difference perception combined with correct identification.

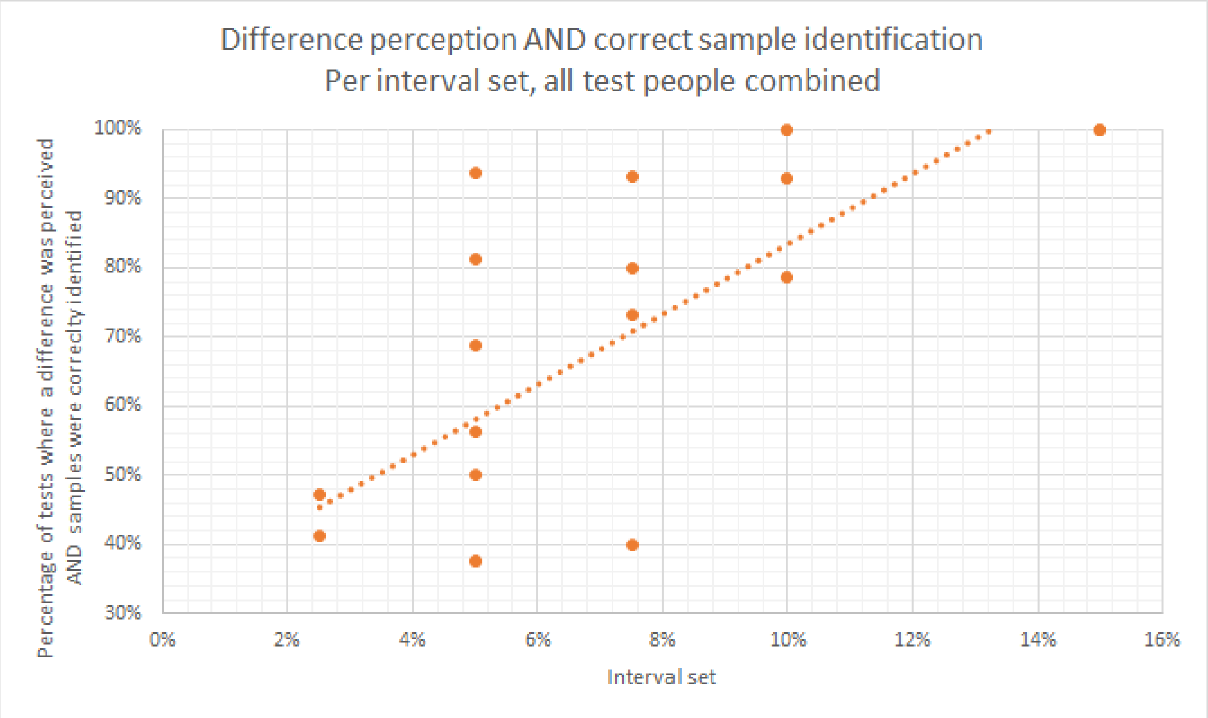

Figure 2.2: Graph showing the difference perception AND correct identification of the sample containing more sand per interval set, all test people combined.

Figure 2.3 depicts the average percentages of tests where both a difference was perceived and the correct sample was identified. A pattern becomes clear where in the case of each 2,5 % interval decrease, the accuracy of both difference perception and sample identification decreases rather linearly.

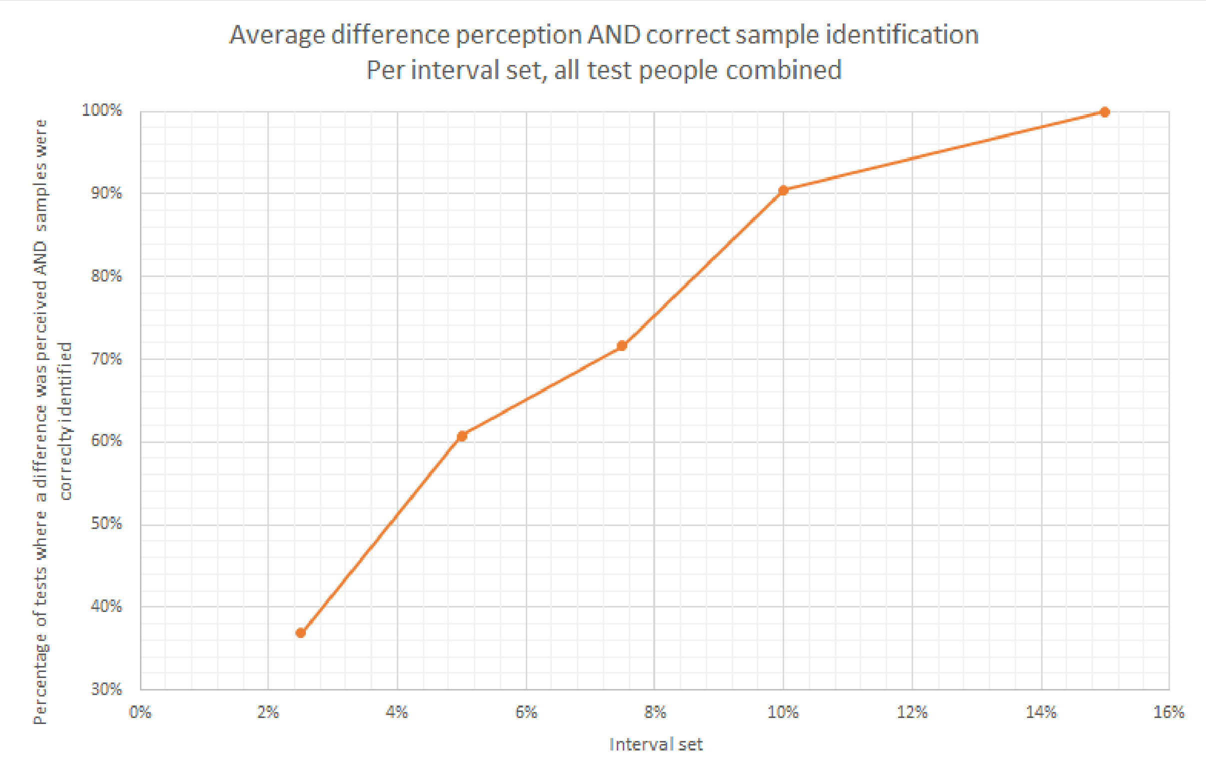

Figure 2.3: Graph showing the average difference perception AND correct identification of the sample containing more sand per interval set, all test people combined.

Figure 2.4 enables easy comparison of the average values of the direct-comparison experiments results. Two main things can be inferred from this figure. The first one is that even though a difference is perceived in every test in the 15 % and the 10 % interval set, mistakes in the identification of the sample containing more sand are made from the 10 % interval set onward. Secondly, it gets more difficult with each interval decrease for the test people to both perceive a difference and to identify the correct sample, than it is to only perceive a difference.

The previously mentioned 50 % chance guess mark needs to be adjusted in our analysis of the red line, symbolising both difference perception and sample identification. The guess mark of the red line value lies at 50 % of the blue line value, instead of at 100 %. Only when the test person has decided on there being a difference in perception, the 50/50 chance of which sample contains more sand becomes relevant. Only for the 2,5 % interval set, the average red value is (slightly) less than the average blue value.

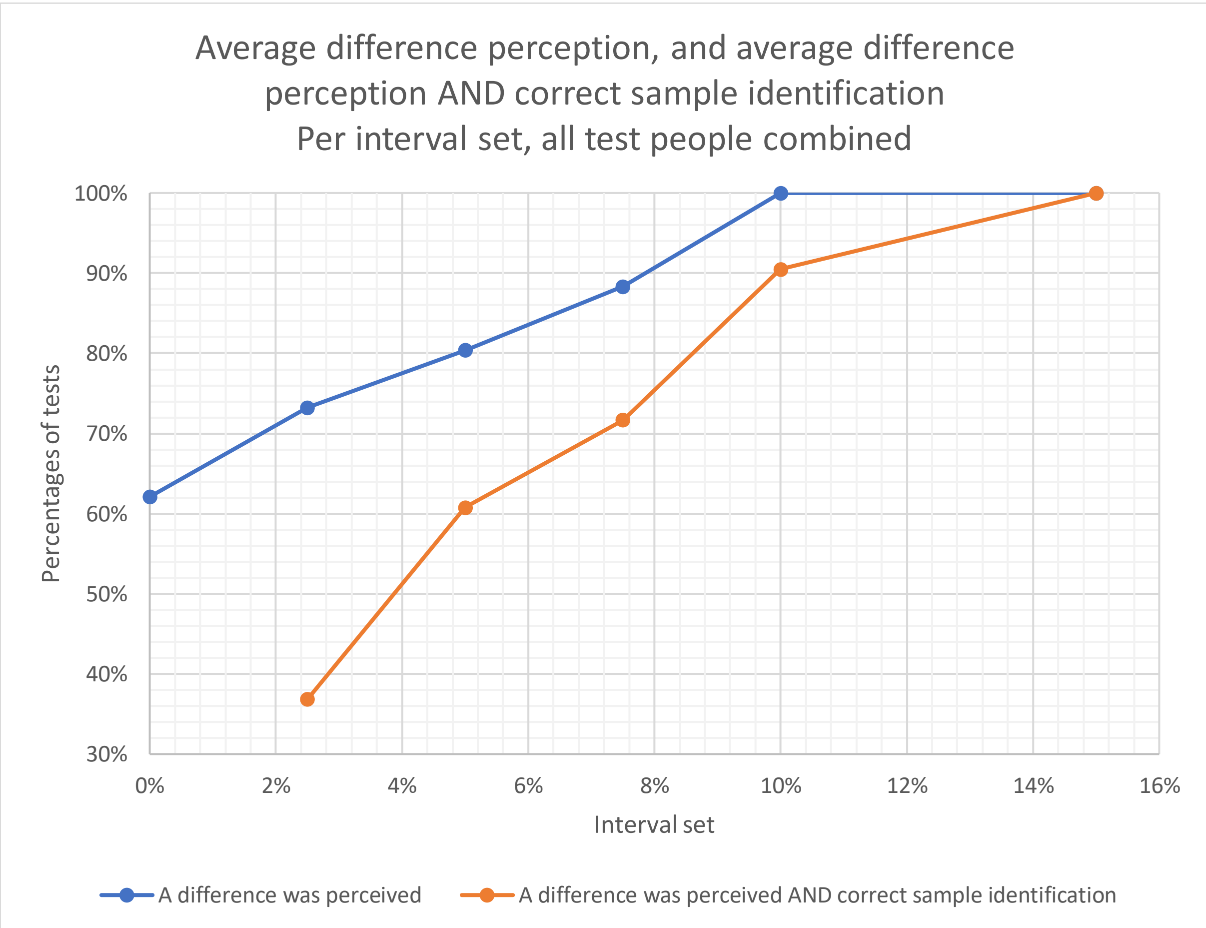

Figure 2.4: Graph showing in blue: average difference perception per interval set, all test people combined. In orange: average difference perception AND correct identification of the sample containing more sand per interval set, all test people combined.

4.1.2 Difference perception and sample identification (ceramist vs. students)

Figure 2.5 shows the average difference perception per interval set per test person in the filled lines. The dotted lines visualise the average difference perception in combination with correct sample identification per set per test person. These figures enable comparison of the results of the ceramist (test person 1) with those of the students (test person 2 and 3). They show that the ceramist scores lower in both categories, both perceiving differences less often and correctly identifying the samples less often. The average difference is perceived in all 10 % and 15 % interval sets by the ceramist and the students alike, but the ceramist performs relatively worse than the students at identifying the correct sample in the 10 % interval set. This trend is present for the smaller intervals, too, also when taking into account the higher difference perception scores of the students.

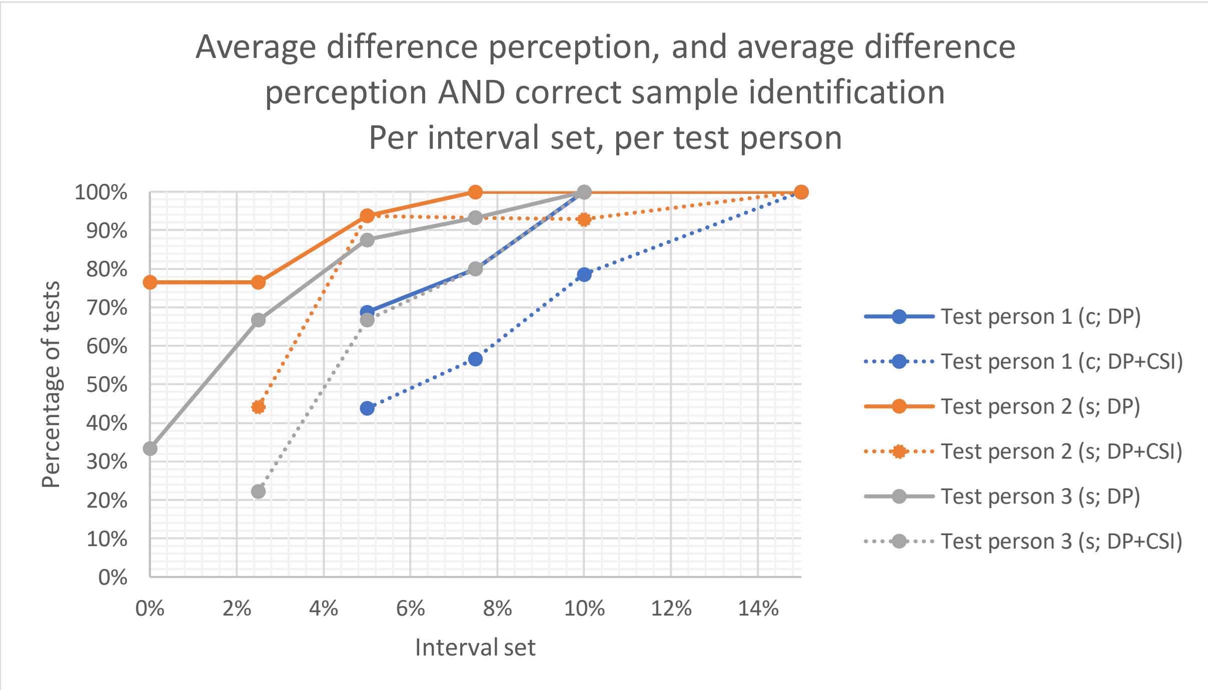

Figure 2.5: Graph showing in lines: average difference perception per interval set, per test person. In dotted lines: average difference perception AND correct identification of the sample containing more sand per interval set, per test person.

4.1.2 Indirect comparison

In the indirect-comparison experiment, the blindfolded test person is presented with the possible sand content range through a moment of familiarisation with the samples with 0 %, 20 %, and 42,5 % sand. The test person is asked to create their own quantification for the sand content, for which a numerical quantification is the most practical. The test person gets presented one sample at the time and is asked to score the sand content of the sample on this quantification range. The test people used the following quantifications, from second to fifth test person: 0-100, 1-5, 0-10, and 0-5. For easy comparison, I normalised them to the actual percentage values.

4.1.2.1 Single-sample perception (all test people combined)

The quantitative results for the indirect-comparison experiment set-up have been visualised in Figures 3 and 3.1. On the x-axis, the actual sand percentage is indicated. The y-axis shows the value that the test people gave to a sample, normalised after their own quantification of the sensory stimulus of sand content in the samples. The blue, dotted line is the trendline of the given responses, while the red line represents the actual values.

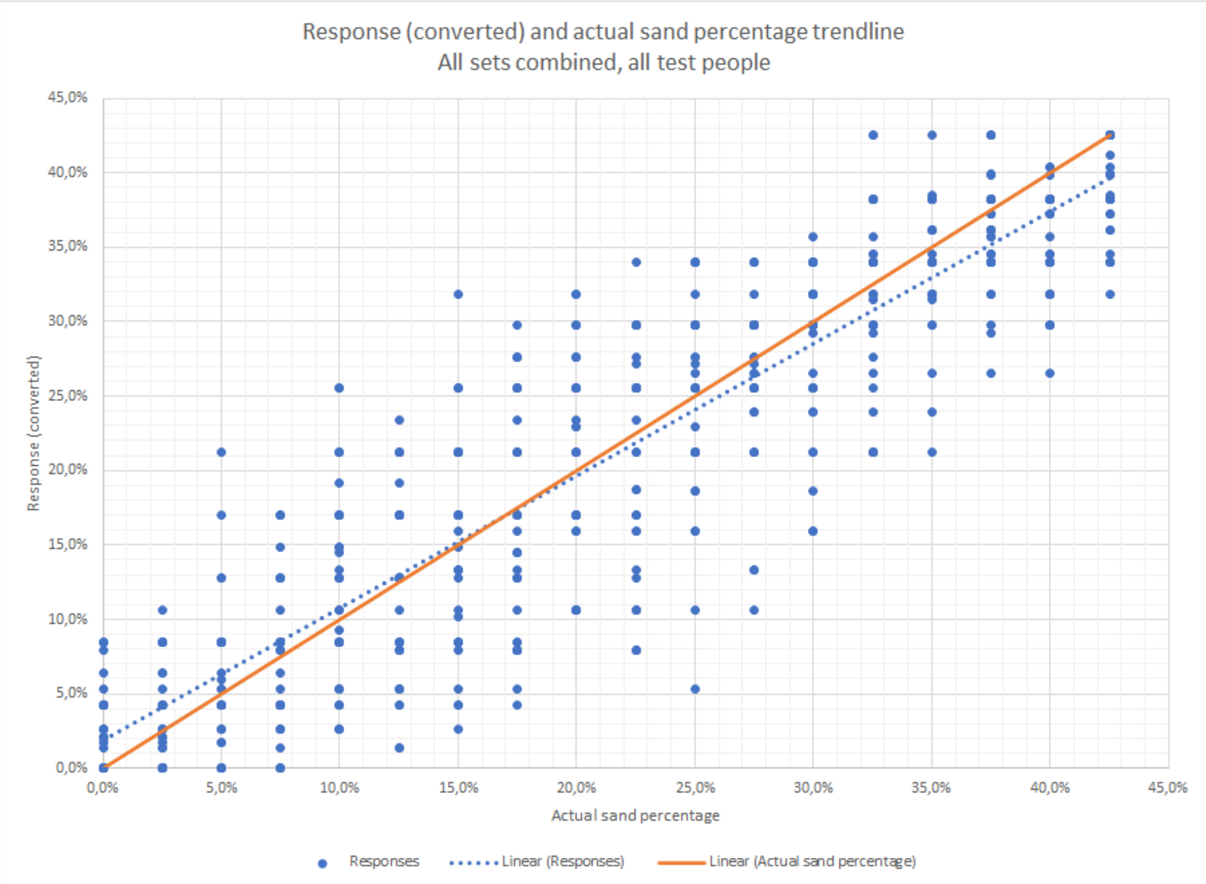

Figure 3: Graph showing the response (converted from the own quantification of the test person) of all sets, of all test people combined. The red line indicates the actual sand percentage trendline.

While Figures 3 and 3.1 both show that the spread of given responses is rather wide, Figure 3.1 specifically shows that the broad spread is most present in the (lower and middle) middle regions of the sand percentage range (mainly 10-25 %). This figure also contains the average responses, indicated with a blue dot at the border of the green (second) and yellow (third) quantiles. Despite the large spread of responses, the overall error in the average response of all test people combined is very low.

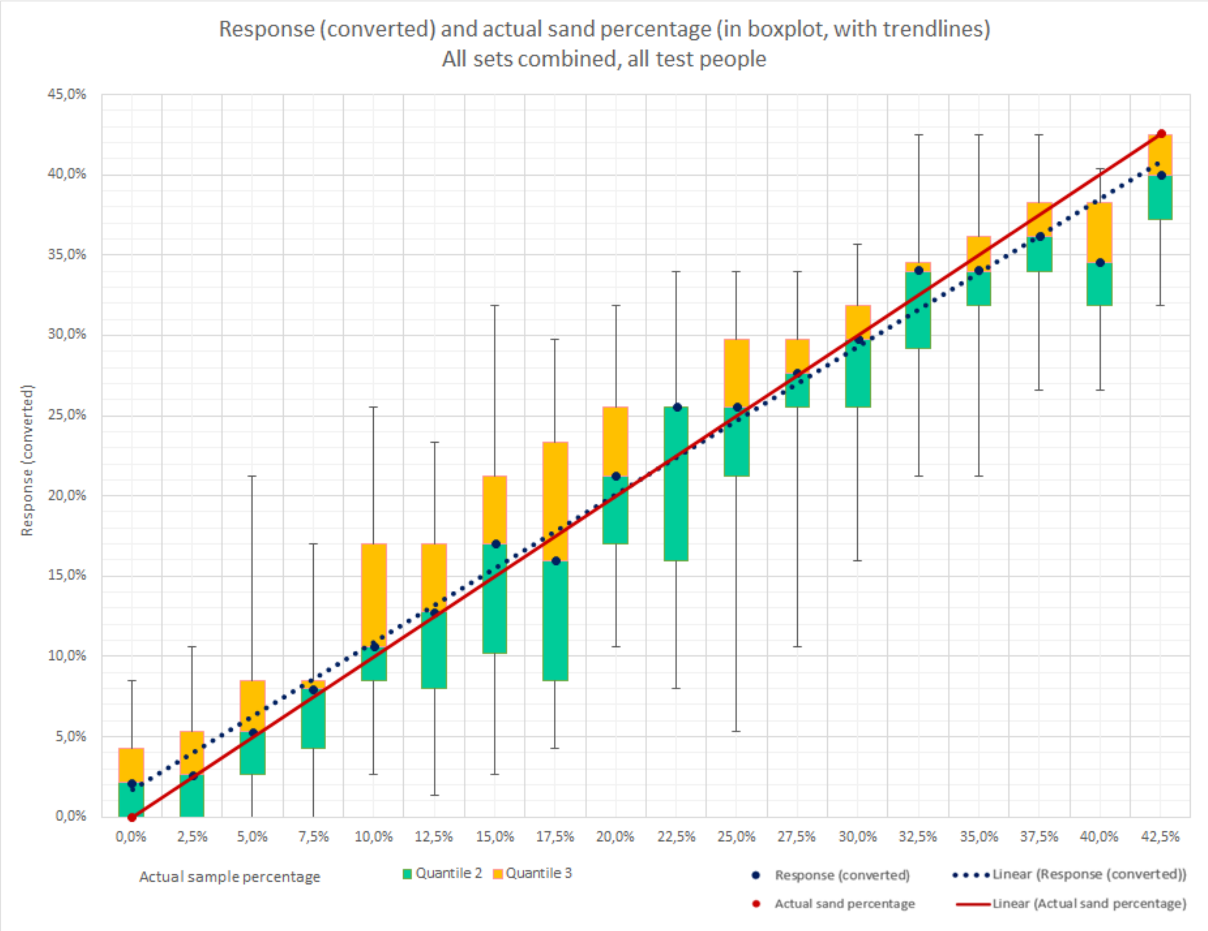

Figure 3.1: Graph showing the response (converted from the own quantification of the test person) and actual sand percentage in boxplot format. All sets of all test people combined. The blue, dotted line is the trendline of the average response for each interval set, while the red line indicates the actual sand percentage.

4.1.2.2 Single-sample perception (per test person)

Due to time constraints and having been in her house for two days already to do experiments, it was not possible to perform tests with the ceramist again. I am therefore unable to compare the results of the ceramist with those of the students inexperienced with working with clay. I still would like to showcase the differences in responses between the students (see Figure 3.2). Test person 1, the ceramist, lacks in this experiment. Test person 2 and 3 are the same test people as in the direct-comparison experiments.

This figure demonstrates that there are quite some differences in responses for each person. Test person 3 seems rather conservative in their responses, while test person 2 tends to overestimate all but the high sand percentages. The error of test people 4 and 5 is noticeably smaller for nearly all percentages. As became visible in the previous figures where results of all test people were combined, nearly all test people tended to consistently overestimate the lowest, and almost all tended to underestimate the highest percentages.

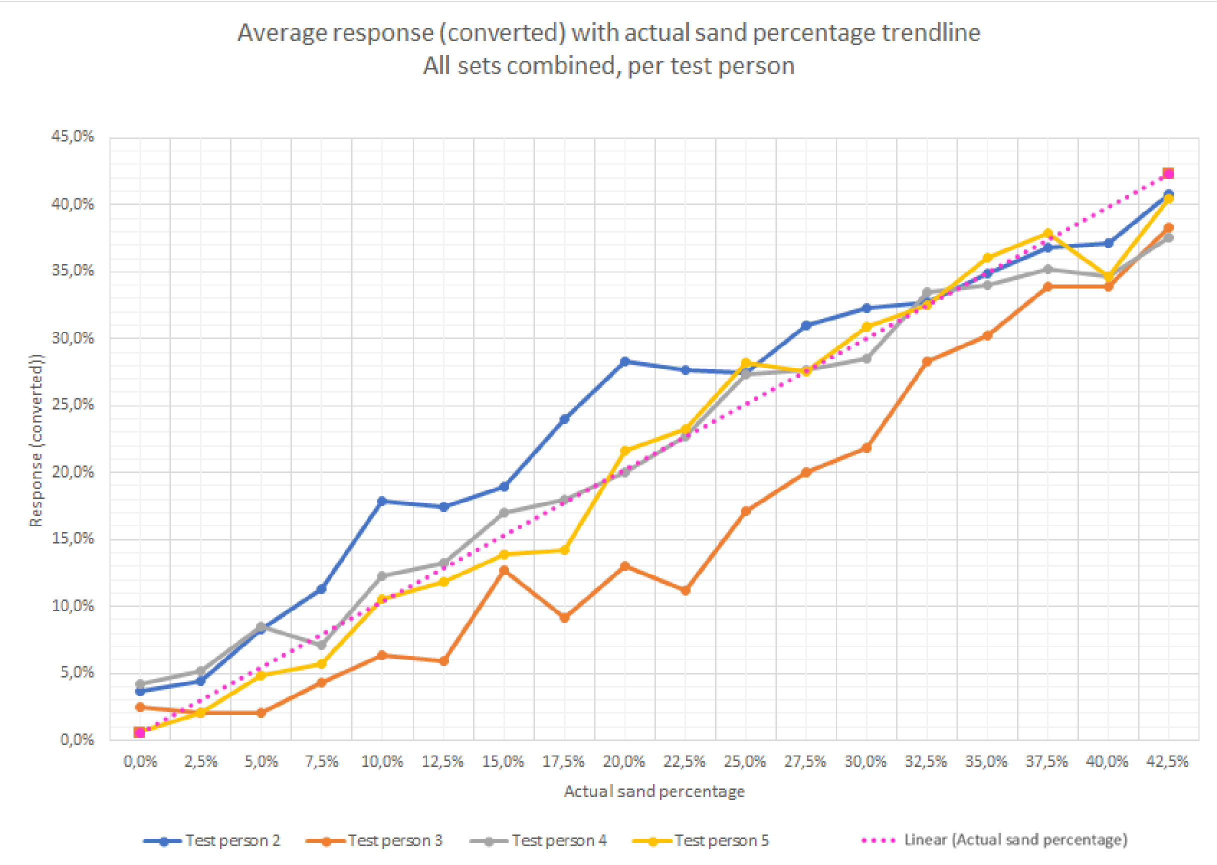

Figure 3.2: Graph showing the average response (converted) of all sets combined, per test person. The pink, dotted line indicates the actual sand percentage trendline.

Based on the errors for each sand percentage as visible in Figures 3 and 3.1, a perceptive categorisation could be identified. Keeping in mind that such a categorisation is fuzzy and coarse, I would propose the following: low, medium low, medium high, and high sand content. These categories would roughly cohere with the following actual sand percentages: low (0 % - 10 %), medium low (10 % - 15 %), medium high (15-25 %), and high (25 % - 42,5 %).

Aside from the quantitative analysis of the given responses compared to the actual values, it is also interesting to see how the experiment progressed through taking a look at the error in the subsequent sets. It can be expected that a certain learning curve becomes visible through subsequent, decreasingly lower error values, and/or a decrease in concentration levels visible in an error value increase.

Figure 3.2 displays the average error per set of all test people combined. The error is calculated through subtracting the true value from the given response for all tests. As we want to know how much the response deviated from the actual sand percentage, the absolute ("positive") value of the error calculated is calculated. Per set number, the average error is then calculated for all test people.

A virtually linear decrease in error value is visible between the first and the fourth set (see Figure 3.2). Between the fifth and the sixth set, a significant error increase exists, reaching around the percentage of the first set. After the eight set, the error value very rapidly declines again to the lowest values of the experiment. These seemingly odd results make more sense when considering the timing of the breaks and communication to the test person, to which I will return in the Discussion chapter. Note that the average error per set varies only between 3,44 % and 4,72 %.

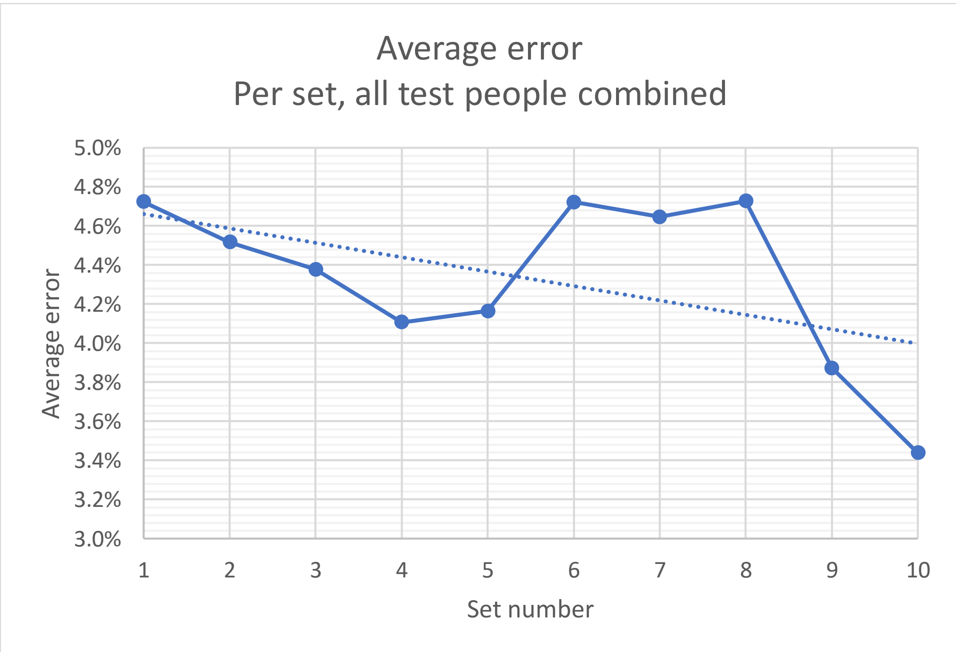

Figure 3.2: Graph showing the average error per set, all test people combined, with trendline.

To demonstrate that the average error per set, or potential learning curves and/or concentration levels differ greatly per person, I include here a figure demonstrating the average error per set per test person (see Figure 3.4). Further background information on how these error values might have been influenced can be found in the Discussion chapter.

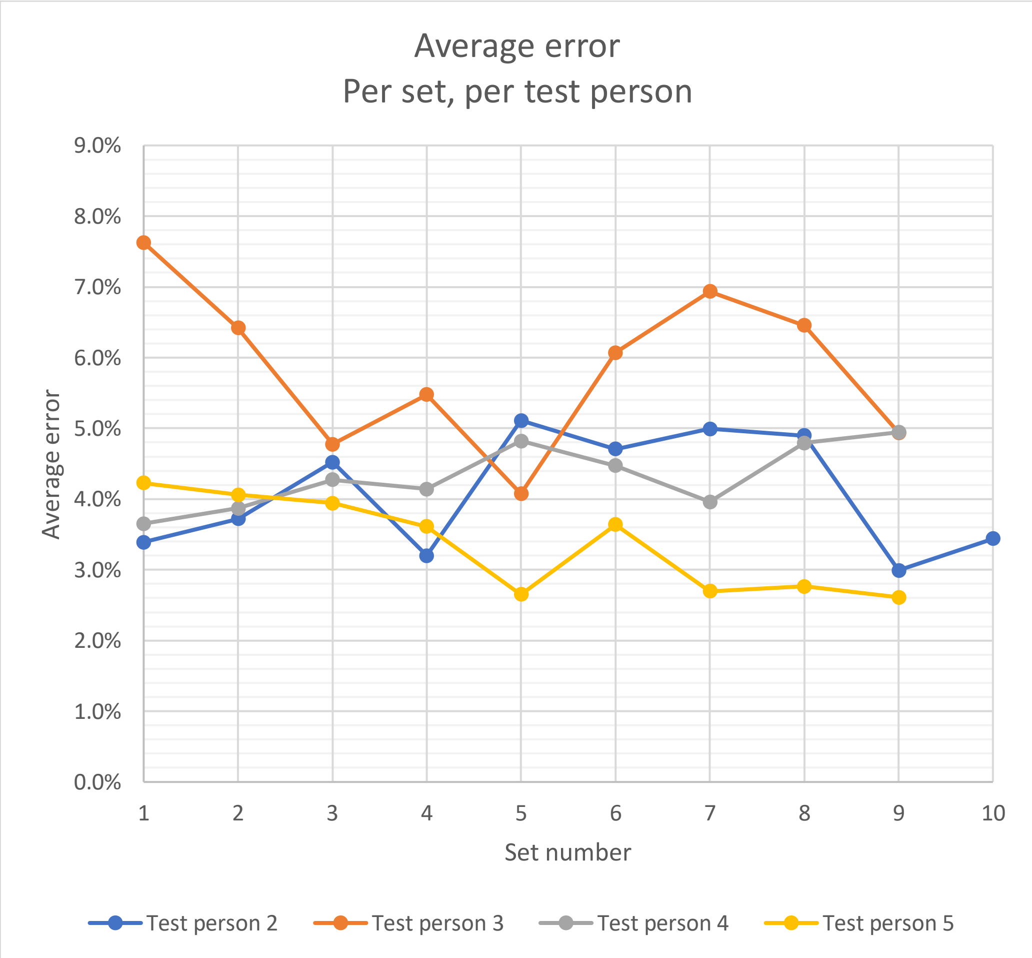

Figure 3.4: Graph showing the average error per set, per test person.

The average errors of all sets for each test person are, in order from the second to the fifth: 4,10 %, 5,86 %, 4,32 %, and 3,36 %, bringing the average error for all sets for all test people combined to 4,41 %.

4.2 Qualitative results

This thesis does not only focus on attempting to find a suitable way to quantify sensory perception to study skill, but also on developing a new method to establish a sensory categorisation for touch stimuli specifically. It presents a pilot study of this method, so still unexpected difficulties and interesting finds arose while conducting the experiments. I will give an overview of these factors in this chapter, and will further elaborate on them in my Discussion chapter.

4.2.1 Familiarisation with the material and kneading styles

What follows in this section are descriptions of how each of the test people approached the clay and their ideas on perceiving the clay. I decided to include these "results" because they briefly sketch the differences in communication between person and the material. For skilled craftspeople, this communication is described as a continuous negotiation, whereas this section shows that this is very different for the other test people.

First test person (ceramist)

The ceramist preferred softer, older clays to work with. She felt less comfortable working with the relatively young, industrial clay that was provided for the experiment, and the sometimes (very) high temper percentages. We noticed a communication difference, too. I asked her to familiarise herself with the material by "warming it up", to which she reacted with surprise and responded that ceramists "walk" the clay to prepare it for working it (quote in Dutch: "de klei walken"). This interaction demonstrated in a rather unexpected way how material scientists might be distanced from the actual craftsperson's experience.

The ceramist told me that she would now perform a routinised series of steps that she always performed when she started working with clay, to get an idea of what she was going to work with and to determine whether it needed further preparations. Without hesitation, she started kneading the samples, sometimes adding water to increase kneadability. She then made a small pinch pot in the palm of her hand using her thumb, rolled the clay back into a ball and started pulling a handle. She would curl up her pointing finger into her thumb and drag down an elongated clay piece, adding more water through wetting her fingers.

During most of the tests, she held the samples in her fists and prepared a flattened surface with her thumb. She then rolled her fingers back and forth over the surface to feel the sand grains. These grains would ideally drag over the surface, creating small grooves in the clay.

Second test person (student)

The second test person had noticeably larger hands and longer fingers than the ceramist and me, so the samples were rather small for him to hold them in his fist and comfortably roll over them with his thumb. After some experimenting, he found another way to feel. While also rubbing his thumb over the ball that he held in between his fingers, he relied more than the ceramist on pressing the clay between his pointing finger and thumb to feel the temper difference. It took a little bit of time to figure out how to feel in this case, as he also liked to squeeze the clay rather firmly. The material would stick to his hands, even though the samples were not too dry or wet, so the samples would diminish in size rather rapidly. Significantly less clay was lost when the test person found that squeezing more firmly was not necessary to make a good comparison between the two samples.

During the experiments, the test person preferred to hold the clay in all of his fingers instead of in the palm of his hand. Just like the ceramist, he would rub his thumb over the surface of the sample. He occasionally pinched a small piece between his pointing finger and thumb or reshaped the ball in the palm of his hand.

Third test person (student)

The third test person had smaller hands again, allowing him to comfortably knead the samples in the palm of his hand. He, too, initially squeezed the samples too firmly and much material was lost. This was not so much due to the squeezing itself, but more due to all samples containing (too) much water and being very easily kneadable. They were also quite sticky to the hands and this created a feeling barrier in terms of temper perception. I advised him to use less pressure to keep the clay from sticking too much.

For the experiments, he focused mostly on pressing the thumb into the sample laying in the palm of his hand. Where possible, this was followed by rubbing the thumb over the flattened surface.

Fourth test person (student)

The fourth test person had slightly larger hands and started a little cautious in his familiarisation. He tried to feel using mainly the tips of his fingers, sometimes taking a little bit of clay and squeezing it between his fingers. He sometimes also rubbed his thumb over a flattened clay surface or pressed his thumb into the ball to feel. He seemed not too keen on kneading the clay in his palms and he might have enjoyed touching the very sandy samples a little less than the other test people.

I advised him to use his palms nonetheless, which he started doing during the experiments. It took a little while of experimentation to find what actions needed to be taken when to keep his hands just moist enough.

Fifth test person (recent graduate)

The fifth test person had slightly smaller hands again and seemed to actually enjoy kneading the clay a bit. He kneaded the samples in his palms right away and took a little piece to squeeze between his fingertips. He would also sometimes rub his thumbs over a flattened surface of the clay or press the ball between his fingertips.

During the experiments, I more often squeezed out the water in the cloth the test people used to dry their hands after washing them after every test.

4.2.2 Perception in absolute measures

4.2.2.1 Water content of the samples

A movement used in almost all tests was to rub the thumb over a flattened sample surface so as to form a judgement based on the amount of sensory stimulation of small, hard particles present in the smooth clay. A slippery film will form on this surface in the case of a slightly wetter sample (surface) however, which alters the sensory perception of that surface. Too dry samples will have a rougher surface, giving more and again an altered sensory stimulation when they are being rubbed (N. P. van Heesbeen, personal communication, February 10, 2022). The second most used movement consisted of pressing the thumb into the sample. It is also in this case that water content influences sensory perception, namely through the way in which the clay particles change their orientation around the sand particles more easily in wetter than in drier clay.

4.2.2.2 Temperature of the samples upon presentation to the test person

I realised the impact of varying sample temperatures during the second experiment round in the first experiment series. Two specific samples for the 5 % interval set (37,5 %-42,5 %), in which the second test person performed very well, were relatively cold to the touch when I presented them to the test person. He doubted his response much more than in previous tests of the same interval set and finally concluded that they had the same temper percentage. I presented samples of the exact same percentages for the next test, making sure to knead and warm both samples a bit in my hand just prior to presentation. The (correct) response was given quickly and with certainty this time, so I took up the second response in my final results. We finished the interval set and then discussed the issue of sample temperature. The test person confirmed that he found it more difficult to respond with certainty when both samples were relatively cold or when there was a clearly noticeable temperature difference between them. I then proceeded to pay special attention to the sample temperatures for all following tests, kneading them a bit just prior to presentation if I thought them to be a little cold to the touch. I could not find any literature discussing varying perception of undangerously cold versus slightly warmer surfaces, so it remains a speculation of mine that surface temperature mediates tactile perception.

4.2.2.3 Dexterity

For the direct-comparison experiments, I kept track of whether the test people would switch the two samples between their hands. This did not add much to the final answers to my research questions, but I had started noting it down as a potential signal that the test person would feel the need to double-check their responses, indicating that a certain interval might be rather difficult. I came to know during these experiments that my test people were left-handed, ambidexter, and right-handed. Both the right- and left-handed test people switched samples frequently, while the ambidexter test person felt the need to do so only on very little occasions and only after I had reminder him that it was possible, should he want to do so. Dexterity indeed does affect tactile perception (Yalachkov *et al*., 2015). The results on hand-switching have been added in the Appendix (see Appendices 1.1, 1.2, and 1.3).

4.2.3 Information distribution

In the first experiment round of the direct-comparison experiments, the ceramist was made aware of the fact that the experiment was done in sets of fixed intervals during the 15 %, 10 % and the first set of 7,5 % interval sets. The 10 % interval set went well, and so did the 7,5 % interval set. She then mentioned that she felt pressured to pick a certain sample to contain more sand, even if she did not perceive any difference between the samples. I prepared some other things on my laptop and told her that from now on, the intervals would be randomised. They were not, in fact, randomised. I chose to repeat the 7,5 % interval set. The response of "the same" was frequently given here, as she now knew that that was an acceptable answer, too. In the second and third experiment round, the test person was told that all tested intervals were presented at random.

For the indirect-comparison experiments, the test people were told that samples would be presented in a completely random order. This was indeed the case, beside the structure of sets with each sample present once in each set. Naturally, the test people would get tired toward the end of the experiment. To increase their motivation for the last set in the indirect-comparison experiments, I would tell them that they only still had one set to go after the eight set.

The first time I performed the direct-comparison experiments was with test person 2, with whom I established that it was very difficult to remember the possible sand percentage range when resuming after the break. This led to overall rather overestimated responses after the break in set sixth, seventh and eighth set, as visible in Figure 3.4. Seeing how much the forgetting of the possible range negatively impacted the responses, I decided to refresh the memory of this test person after the eighth set. I presented them again with the 0 %, 42,5 %, and 20 % sample and indicating them as "the lowest", "the highest", and "the middle" samples, just like at the beginning of the experiment round. I repeated this memory refreshment for all test people thereafter and directly after their breaks.

For the second test person in the indirect-comparison experiments, the break was held after the first few tests of the sixth set. This test person was also the only one who did the tenth set; the other test people had lost most concentration after the ninth set. For the third test person, the break was held after the fifth set. For the fourth and fifth test people, the break came after the fourth set. It varied per test person how much the break affected their performance, as visible in Figure 3.4.

4.2.4 Test person influence

The test person had a certain amount of influence on the way I carried out the experiment. For example, the ceramist mentioned during the experiment try-out that she would like to try and see how well she could distinguish a 2,5 % interval if all the samples were more equally kneadable. This remark led me to creating a second sample batch and experiment structure including this interval. I would also, as mentioned before, let it be dependent on the results of the test person and a bit on their remarks, to repeat a certain interval set or to continue to a smaller interval set. For the indirect-comparison experiments, I used remarks and body language of the test person to decide if it was worth continuing with another set.

4.2.5 Person-focused experiment conditions

4.2.5.1 Attention span and energy level

I quickly realised during the experiments that I needed to make sure that the test person must feel at ease and remain concentrated and adequately energised, despite taking part in my usually three-hour experiment with limited knowledge and while being blindfolded, too.

Naturally, attention span peaks at different moments depending on a personal circadian rhythm. I took this into account a bit while planning the experiments. A difference in (re)gaining attention could also be noticed after a predicted of after an unpredicted disruption (e.g. lunch break or getting a phone call). Different test people needed different kinds of breaks at different moments during the experiment. In one instance, a very short break was held where the test person and I went outside for two minutes to check the mailbox, stepping out of the living room that was comfortably heated to 20 degrees Celsius and into 2 degrees Celsius outside. This test person looked and acted notably livelier and attentive after the short trip outside, and performed better for a while afterwards.

4.2.5.2 Sensory input

I furthermore noticed that certain other sensory stimulation, or lack thereof, could easily distract a person or help them regain their focus. This was the most evident for background noise. In the first experiment round in the direct-comparison experiments, there was no specific background noise, as the test person preferred relative silence around her. During all of the testing in the second experiment round, I chose to put on rather monotone and easy-listening music in the background with relatively constant sensory input levels. I noticed that this test person went into a trance-like, concentrated state at some point half-way during the experiments, and that he stayed there for multiple sets. The same music playlist provided the third test person with too little sensory background input. He had begun his experiment round with giving responses quite quickly, making virtually no mistakes, and he had started multiple, fast-paced conversations that distracted me sometimes in my experiment tasks. During the second interval set, he proposed to put on a certain classical music piece that he was going to start rehearsing soon. His attention was now focused on the music and the experiment simultaneously. Since the music gave considerably more variable and fast-paced auditory input, however, it started to distract me too much. We switched back to the playlist again. The test person, luckily for me, found himself occupied enough by the experiment soon thereafter when we moved on to smaller interval sets.

In the indirect-comparison, I chose slightly more upbeat, but still rather monotone music, which I put on an even lower volume than in the first experiment series and which seemed to be just enough sensory input for all test people.

4.2.5.3 Other systematic discussion points in the experiment set-up

Sticking to sets of fixed temper percentage intervals

The structure of interval sets in the direct-comparison experiments allowed me to track the general perceptive granularity level of the test person and to repeat interval sets at this level to gain more (reliable) results. I did however merge the 2,5 % and the 0 % interval set. The idea behind this was that, should the test person perceive the 2,5 % interval set very well, we would not move up to an interval set where the correct response would only be “the same”, which would become highly predictable. This level of perception precision was never reached, but I preferred to stick to the same test order for all experiment rounds and to therefore not change it.

4.3 Summary of results

4.3.1 Summary of quantitative results

The quantitative results of both the direct- and indirect-comparison experiments have been collected using a method designed and tested for this thesis, making the current thesis a pilot study.

For the direct-comparison experiment series, data was collected on difference perception and sample identification, and also information that was (not) given to the test person, comments of the test person related to the experiment, any breaks or disturbances and any switching between hands of the two samples.

For difference perception, it can be concluded from the results of these experiments that a 15 % and a 10 % interval in sand percentages in clay samples can be detected at all times. From the 7,5 % interval onwards (the 5 %, 2,5 %, and the 0 % interval), systematically less often a difference is perceived. One test person specifically perceived differences many times for the 0 % interval, even though there were none. Considering this, the just noticeable difference for sand percentages in clay is most likely to be between 2,5 % and 0 %.

Concerning difference perception and sample identification, samples are identified without mistake in a 15 % interval. From the 10 % interval downward, systematically less often samples are both identified as different and correctly identified. In the 2,5 % interval, the average percentage of tests where this is the case drops under the 50/50 chance mark of the percentage of tests where a difference is perceived in the first place (namely 36,8 % compared to 73,2 %).

In the indirect-comparison experiments, data was collected on the responses of the test people within their own quantification range, any comments they made, and breaks. On average, the test people quantified the sand content rather well, despite some test people systematically over- or underestimating it. On average, the test people consistently overestimated the lowest, and underestimated the highest percentages. The average error was the highest in the 10-25 % range. Based on this observation, I propose the following perceptive categorisation for sand content in clay samples: low (0-10 %), medium low (10-15 %), medium high (15-25 %), and high (25-42,5 %).

Error analysis per set showed a potential overall learning curve and diminishing concentration levels, although on a personal level, these trends might differ significantly. They are further elaborated on in the Discussion. The average error per set for all test people combined is 4,41 %, varying per person between 3,44 % and 4,72 %.

4.3.2 Summary of qualitative results

Several more- and less-expected issues and interesting finds arose while conducting the experiments, as this thesis concerns a pilot study of the method used. These include a difference for the test people in familiarisation with the samples and way of handling them, depending on differing levels of understanding of clay properties and hand size. In terms of perception in absolute measures, the water content of the samples heavily influenced how well their surface and in that, their temper percentage, could be perceived and accurately compared. A temperature difference of samples seemed to mediate perception processes, but this is highly speculative.

In order to capture most accurately sensory perception, the test people were not told about any structure in the interval sets in the direct-comparison experiments, and the available range for the indirect-comparison experiments was presented again after a break. Their results functioned as a guide for me as the tester to determine whether it was wiser to move on to the next interval set or repeat the previous one. For the indirect-comparison experiments, overall energy level and attention span were more important guides in determining whether to test again a randomised set of all individual samples.

The test people further had some influence on the experiment proceedings in the sense that their attention span and energy levels were important factors for the timing, duration and nature of breaks, and the presence and nature of background input (specifically music). Finally, dexterity is correlated to sensory perception sensitivity in the sense that being ambidexter can be correlated with (way) less hand-switching than being left- or right-handed.

5 Discussion

The first part of the Discussion chapter will cover relevant remarks regarding the experiment set-up of my method. The part will be concluded by a summary of these remarks.

The second part of this chapter will concern an evaluation of the suitability of my chosen research approach for collecting data for a perceptive categorisation and arriving at this categorisation.

5.1 Experiment method: perception in absolute measures

I will discuss notes on the perception in absolute measures, focussing on general sensory ability and cognitive decision-making within the limits of the experiment set-up. This will be followed by comments on perception of the test person, paying attention to aspects of the cognitive process of decision-making.

5.1.1 Sensory ability

5.1.1.1 Water content of the samples

Wetter samples will have more of a slippery film on their surface, while drier samples will have a rougher surface. Both circumstances significantly alter sensory perception (N. P. van Heesbeen, personal communication, February 10, 2022). I therefore tried to make sure that the samples were as equally wet and easily kneadable as possible. The test people also adjusted their feeling movements to the water content of the samples, predominantly through either rubbing their thumb over a flattened sample surface or pressing their thumb into the sample. Experimentation with feeling movements due to water content differences influenced perception, as test people commented during the experiments.

The samples were prepared by me under relatively controlled conditions, as described under Methods. Preparing the samples before each experiment round, however, was considerably less controlled. The samples would dry out and harden over time, despite them being stored in plastic bags in a box lined with other plastic bags. The tinfoil-lined box shown in the Methods chapter was in use from the first experiment round onwards and kept the samples softer for a longer amount of time.

Preparation of the samples meant kneading each sample, mixing in water if desired, until the sample felt pleasant and easy to knead without the material sticking to the hands too much. The most important aspect here was the amount of water added in combination with factors like time spent kneading, and the humidity and temperature in the room and that of the kneading hands. I considered calculating beforehand the amount of water I would need to add to each sample, for which I would rely on calculations using formulas from the field of Physics. I would then need to carefully weigh that amount, keeping in mind that varying clay-to-sand ratios would have different water needs to achieve similar kneadability and (non-)stickiness. Most samples needed only very little water and it would remain difficult to knead exactly the measured amount of water into each sample. This was not in the least due to differences in primary mixing time and in kneading time needed to evenly distribute the sand within the clay and the water within the samples. These varying kneading times also meant that the water content levels were not the same for each sample when I would start the preparation process. A lot of experimentation had to be done, too, to determine the ideal water amount for each sample and thus the exact remaining water requirements. If I would have succeeded in these tasks within acceptable error margins, I would also still have no feasible way of real-time checking the current water content of a sample other than letting it dehydrate completely.

An option to at least part of this problem could have been to precisely weigh the samples just before and after mixing and preparing them, and just before and after conducting each experiment. This is due to the fact that some material, not just water, will be both lost and added during handling. The water percentage can, however, still not be tracked with certainty, which is also not solved by using a highly accurate weighing scale. I thus decided not to calculate the amount of water I would add to each sample.

This meant that I had to rely on my own sense of touch to determine the relative wetness of the samples just prior to conducting the experiments in an attempt to get all samples equally kneadable and equally as non-sticky as possible. Skill of me as a researcher was needed for an accurate water content assessment, which became an important topic from the try-out experiment round of the direct-comparison experiments onwards. My initial lack of skill therein negatively impacted experiment results of mostly the try-out and first experiment round still. Clear improvements were made in preparations for the second round, when I came to realise better what 'similar wetness' across all samples felt like. I concluded during preparations for the third round that the water within the samples did not evaporate as quickly as I had in mind, but wanted to keep all samples as similar as possible. This caused almost the entire batch for the third round to be a bit too wet, negatively impacting experiment result, too. The preparations for the indirect-comparison experiments went much better, as I had improved my feeling of wetness of clay. Throughout the rounds of these experiments, the wetness of all samples was very similar at the start and end of the tests, as I was continuously checking the samples and adding water drops when necessary. This approach and my acquired wetness perception skills improved the experiment conditions greatly. The test people could now focus more on varying sand content.

5.1.1.2 Temperature of the samples upon presentation to the test person

I realised the impact of varying sample temperatures during the second experiment round of the direct-comparison experiments. Two specific samples for the 5 % interval set, in which the second test person performed very well, were relatively cold to the touch when I presented them to the test person. This test person doubted his response much more than in previous tests of the same interval set and finally concluded that they had the same temper percentage. I presented samples of the exact same percentages for the next test, making sure to knead and warm both samples a bit in my hand just prior to presentation. The (correct) response was given quickly and with certainty this time, so I took up the second response in my final results. We finished the interval set and then discussed the issue of sample temperature. The test person confirmed that they found it more difficult to respond with certainty when both samples were relatively cold or when there was a clearly noticeable temperature difference between them. I then proceeded to pay special attention to the sample temperatures for all following tests, also in the indirect-comparison experiments, kneading them a bit just prior to presentation if I thought them to be a little cold to the touch.

5.1.2 Cognitive decision-making

5.1.2.1 Repetition for reliability and learning curves

The experiment set-up for the direct-comparison experiments was not too focused on the development of learning curves, yet the repetition did allow for practice, nonetheless. Learning curves were best visible in repetitions of the same interval sets, with more correct responses and less hand-switching to double-check initial thoughts. They also took place when moving to sets of smaller intervals. The third 5 % interval set of the third test person serves as a good example for this, which was tested after trying the 2,5 % and 0 % interval. The results for this 5 % interval improved much more overall between the second and the third 5 % interval set than between the first and the second 5 % interval set (see Appendix 1.3).

Another factor keeping me from extensive experiment repetition here was the inevitable and unequal loss of material in each sample, due to the necessary washing of the hands of the test person after virtually each single test. Repeating the experiment more often meant that I would have needed to add clay, sand, and water to all samples in the correct (and small) measures, which is very susceptible to altering their ratios in the samples. I decided to do this in one case, just before the third experiment round, when a relatively large amount of material had been lost due to the clay being too wet and therefore too sticky, namely the 20 % temper percentage samples. I would recommend anyone replicating my research to mix larger batches for each sample beforehand for easy sample replenishment. I did however find that significantly less material was lost for the second batch I created for the indirect-comparison experiments. I think this to be due to maintaining an equal water level in the samples and increased attention for the moistness of the hands of the test people.

Doing lots of experiment repetition within each round also proved difficult. Several sets needed to be tested before I could determine at which interval set the test people would systematically fail to perceive differences and to identify the correct samples. An experiment round lasted about three hours of testing (minimum, including short breaks) and proved to be rather taxing mentally, mainly for the test person.

Due to the difficulty in experiment repetition, relatively few data points have been collected for the direct-comparison experiments. This slightly skewed the average value for difference perception in for instance the 2,5 % and the 0 % interval set in these experiments, as one would expect the percentage of perceived differences in the 0 % interval set to be (much) lower than 67,7 % (see Figure 2.1).

The indirect-comparison experiments provided better opportunities for development of a learning curve within an experiment round. Every set consisted of the exact same samples, randomised differently each time. The energy and concentration span of the test person would last nine to ten sets, resulting in nine to ten quantifications per sample per person. This repetition under more stable experiment conditions provided me with more reliable results than the direct-comparison experiments.

I also found that I had increased my skills in monitoring and stabilising the water content in the samples and moistness of the hands of the test person and me. Less sample material was lost in the indirect-comparison experiments as a result, so I could use the same sample batch multiple times without worrying about decreasing sample size.

5.1.2.2 Decision-making of the test person

5.1.2.2.1 Communication during the experiment

Test people must not be able to deduct any clues about the correctness of their responses from my language use, intonation, or movements. I tried to limit any variations in these as much as possible. Test people also must not be guided in their responses by any prior knowledge on temper intervals or the existence of fixed interval sets.

I started telling the test person that there were no fixed interval sets from a little into the first experiment round in the direct-comparison experiments onwards, as mentioned before. As mentioned before for the indirect-comparison experiments, I told the test people after set number eight that they still only had one set to go. The tenth set was only done by one test person who still had enough concentration and energy. Interestingly enough, the average error of all test people decreases significantly between the seventh and the eighth set (see Figure 3.3). This could be explained by the fact that the test people were motivated to perform (extra) well for their last set(s).

5.1.2.2.2 Dexterity

This section on dexterity only applies to the direct-comparison experiments, as my supervisor and me agreed that it might not add much to my test results. I did choose to mention the results I did collect on this topic (see Appendices 1.1, 1.2, and 1.3 for the results), to illustrate an interesting find that ties into perceived perception difficulty levels and which guided me in my decisions to start testing smaller intervals within an experiment round.

The first test person was left-handed, the second test person was ambidexter but used his right hand for writing, and the third test person was right-handed. The difference between being left- or right-handed and being ambidexter was striking in the difference between hand-switching. The left- or right-handed test people switched regularly and frequently, especially when starting on a smaller interval, in which case it was always indicative of doubt and double-checking, and thus of perceived difficulty. The ambidexter person did not feel the need at all to switch hands, so I had to rely on other factors to determine how much difficulty this test person had with a certain test. These factors included any comments they made, response time and response correctness.

I repeated the exact same experiment set-up with presentation in the same hands for all experiment rounds, except for the third 5 % interval set in the first experiment round. In this specific set at the end of the experiment round, I switched all presentation hands. Compared to the first and second 5 % interval set, the test person made slightly less mistakes, switched hands more frequently for the correct responses (and in similar measures for the incorrect ones), hand-switching took place more in temper percentage clusters instead of more spread-out, and they responded quicker overall. These findings could also be explained by a learning curve for the 5 % interval set (possibly combined with the energising promise of these being the last tests we were doing for that day), rather than having a somewhat “fresh” perception because presentation hands were switched.

5.1.2.2.3 Attention span and energy level

A bit more attention than perhaps strictly necessary will be given to the experiment conditions from a test person's perspective, due to the overall more qualitative rather than quantitative approach I have taken in this research. During the experiments, it is important that the test person be at ease, concentrated and energised, regardless of being blindfolded most of the time. Since doing these experiments is rather mentally taxing on the test person, it was beneficial for the results to pay attention to their personal circadian rhythm when planning the experiment rounds and the types of breaks the test people asked for during the rounds.

5.1.2.2.4 Background sensory input - music

Background sensory stimulation tended to influence the focus of a test person greatly. The most prominent one was background music. Depending on their personal preference, I tried to adjust it in as much as it enabled me to stay concentrated, too. For the direct-comparison experiments, successes therein varied a bit. Interestingly enough, background music seemed to be less of an issue for the indirect-comparison experiments. It is my speculation that the test people of the direct-comparison experiments were more used to the experiment setting this time and more at ease naturally as a result, and that the taste in background music of the two other test people aligned more with my own. I chose different background music this time, but still rather monotone, slightly more upbeat, and on a very low volume.

5.2 Method suitability for research questions

In this section, I evaluate how well my chosen research method applies to collecting data for a perceptive categorisation.

5.2.1 Chosen aspect and way of perception

As I have established in my Background chapter, temper/sand percentage is a very relevant factor in ceramic production and sand is commonly used as temper. This quality is also perceivable. Ceramists mainly recognise it through their tactile sense, but they are aided by their vision, too. Material scientists predominantly use their vision for estimations of temper percentages. They look at the surface of the ceramic object and the inside surface of a shard for this, as any surface treatments might make it difficult to recognise the temper. They, too, make estimations, as to my knowledge, there are no commonly used methods to precisely quantify sand percentages in clay other than human observations. In this sense, the chosen aspect of the ceramic production process (sand percentage in clay) is suitable for creating a perceptive categorisation.

I decided to focus on one way of sensory perception only, being touch, even though the craftsperson never relies on just one sense in their judgements, whether they are aware of the fact they are using multiple senses or not. Distinctions between separate senses might even be worth reconsidering in total, since it can be argued that the whole human body is one, large sense, which gets bombarded by all kinds of information at all times (see Feenstra (2016) for an insightful summary on this topic).

Despite zooming in on one sensory aspect of the production process in this thesis, which is not very true to the craftsperson's experience, it does make it easier to compare sensory attunement between ceramist and students. As I described previously, the level of sensory attunement is an important factor for skill of a person, as it is central to the continuous negotiation characterising the craftsperson-material relationship.

5.2.2 From experiment results to a perceptive categorisation

The test results of the direct-comparison experiments helped me to understand better the precision limits of the human tactile sense for sand content differences in clay. Very subtle differences could be perceived here. The results I collected here functioned as a difference perception baseline, from which a coarser categorisation could be made. At this point in the research process, I did not know how coarse such a categorisation would or could be to an actual ceramist when being in the flow of a production process, and I also did not understand for quite a while how to translate my results to such a coarse categorisation.

I then decided to do another round of experiments, where I wanted to gain insight in how well people could quantify temper differences in clay in a situation where they would have to memorise their reference range, without the luxury of direct feedback. This is also more in alignment with how a craftsperson works in a workplace or studio. It was my hope that I would be able to see this categorisation appear in their responses as clusters of the same or similar responses for different samples.

The next question presented itself in the quantification system I would use for this. Ceramists know which verbal quantifications make sense for them and for the subsequent production process. My test people and me, who were all inexperienced with working with clay, very quickly realised that we had no clue of useful categorisations for sand content in clay. I was curious to see how well people actually could perceive these without the hindrance of a rather coarse, fixed quantification system based on words. I was not very keen on wasting precious time and energy trying to create a verbal quantification system that would enable the test person to express their exact perception, leaving room for more precise perception for a potential learning curve.

I therefore granted the wish of the first of my test people for the indirect-comparison experiments to use a numerical quantification system. As it turned out, when given the freedom of numerical quantification, the test people were far better at quantifying sand percentage differences than I had imagined. The perceptive categorisation I identified in their average errors (low, medium low, medium high, high, roughly correlating to 0-10 %, 10-25 %, and 25-42,5 %) is much cruder than the ways in smaller differences matter for the final product.

I imagine to be able to identify more categories in results of professional ceramists, who would probably more naturally give verbal quantifications. In such a situation, the boundaries between the different categories would also become apparent more easily. I also expect them to be neater in their responses, especially if they were used to working with clay with more temper in it. This experience would give them the advantage of a pre-existing mental framework within which to place the sand contents presented in the experiments.

In the end, I arrived at a proposal for a perceptive categorisation through the error values per sample. I took the average number of options Kuijpers used for the different production steps in his toolbox for metallurgy as a reference, which is between two and five (see Figure 1). I figured that it might be useful to look at the error values as ways in which the test people experienced the different samples. This entailed more precise quantifications for the lowest and highest percentages, a slight loss of the reference frame in the medium low category, and a slight retrieval of this reference frame in the medium high category. I believe that a verbal quantification would have resulted in more categories. However, since I wanted to investigate the possible level of detail in perception, I wanted to offer experiment conditions in which the test people had full quantification freedom.

5.3 Discussion summary

5.3.1 Summary of factors to keep in mind regarding my method

The chosen research approach was set up as a pilot study. As a result, a number of factors during the preparation and the conducting of the experiments turned out to present some issues.

In absolute measures, the water content of the samples presented the greatest and most impactful difficulty in preparing stable and reliable experiment conditions. (Small) differences in wetness would drastically (and negatively) impact kneadability, surface texture, and sensory stimulation, and they sometimes demanded changes in kneading style (aside from differences in hand size). Ample thought given to ways to overcome this issue before and during the experiment yielded limited structural solutions, not in the least due to the impossibility of measuring the exact water content present in a sample at any given moment. This issue was mainly present in the direct-comparison experiments and was greatly improved upon in the indirect-comparison experiments through my own acquired wetness perception skills.

In the direct-comparison experiments, a learning curve was visible in the form of more correct responses and less hand-switching for the right- and left-handed test people. In the direct-comparison experiments, more repetition of experiment rounds proved difficult by much loss of sample material during the experiment, whereas more repetition of interval sets proved difficult due to the relatively long duration of one round to begin with. In the indirect-comparison experiments, more stable experiment conditions and the repetitive nature of all sets and the collected data enabled more a more reliable collection of more data points.

The most accurate test results were acquired using repetitive, straightforward communication from the tester concerning the tests and not explaining the structure of fixed intervals per set in the direct-comparison experiments to the test person. Higher levels of sand-switching were hypothesised to correlate to higher levels of doubt and were used as indicator to start on a smaller interval set in the direct-comparison experiments. The results seemed to demonstrate an academically proven correlation between dexterity and perception sensitivity. I also noticed that varying attention span, energy levels, and circadian rhythm of the test people required different background sensory input, specifically concerning music.

More accurate and clearer results in the direct-comparison experiments could be obtained using an interval-diversified approach and more stable experiment conditions. The indirect-comparison experiments did not have either of these issues due to the experiment structure and my improved wetness perception skill.

In short, the experiment set-up of this newly-designed method allows for qualitative research better than for quantitative research, and would function the best when the tester has developed a feeling for water content in the samples. The impossibility of perfectly quantifying water content in the preparations and throughout the experiments remains an present challenge.

5.2.3 Summary of method suitability for research questions

The sand/temper percentage in clay is a relevant, perceivable factor in the ceramic production process, mainly perceived through touch by ceramists and through vision by material scientists. This makes it suitable for creating a perceptive categorisation for the establishing of a craftsperson's perspective. For the sake of comparison, I decided to focus on one sensory aspect of the sand content in clay, being touch. A higher level of sensory attunement, inherent to being skilled in a craft, can be translated in a more precise perception of differing sand contents.

The direct-comparison experiment results gave a good idea of a baseline for the possible detail of tactile perception. These results could be grouped together into a coarser categorisation, but I did not see clearly how exactly. In indirect-comparison experiments, I tested sensory perception drawing on memory, which aligns more with the actual production process. I expected it to result in a coarser categorisation due to increased difficulty, but this was not the case. I decided to give the test people the freedom of a numerical quantification system over a more restrictive verbal one, which enabled much more precise quantifications than I had hypothesised.

6 Conclusion

The aim of this thesis was to see how the craftsperson's perspective as designed by Maikel Kuijpers for the production process of metal objects can be applied for establishing a craftsperson's perspective on the production process of ceramic objects. Considering the large scope of this aim for a bachelor thesis, this thesis focused on one aspect of the ceramic production process, being the human perception of temper (in this case: sand) percentages in clay samples. A pilot study was done for a method designed by me to firstly, investigate how good people are in general at perceiving sand percentages in clay, and secondly, in what way sensory perception experiment results from a professional ceramist differ from those of students inexperienced with working with clay. In this chapter, I will draw conclusions based on the results from direct- and indirect-comparison sensory perception experiments.

I hypothesised for the first sub-question that one would be able to identify the just noticeable difference in sensory stimulation for the human fingertips. Despite an unideal experiment set-up for the direct comparison setting, it can be concluded that differences in sand percentages of 15 % and 10 % can be perceived in all cases, and that even differences between 0 % and 2,5 % can be identified for the majority of the tests. In all cases of the 15 % interval set, the sample containing more sand was correctly identified, from which this rate decreased to the 50% chance guess mark at the 2,5 % interval set.

I further demonstrated that in an indirect comparison setting, on average, the test people were rather good at recognising the sand percentages using their own (numerical) quantification system of the available sand percentage range. The average error per test person varied between 5,86 % and 3,36 % with an average of 4,41 %, for a range of 0 % to 42,5 % sand in clay. Overall, the response spread was rather large. Based on trends therein, the following perceptive categorisation for sand content in clay is proposed: low (0-10 %), medium low (10-15 %), medium high (15-25 %), and high (25-42,5 %).

Average error analysis per set showed that possibly, learning curves and/or a decrease in concentration can be recognised throughout the sets. Again, trends therein varied substantially on an individual level.

My hypothesis for the second sub-question was that a craftsperson would be more attuned to stimuli differences than a person lacking this craftsperson's' experience. While all test people perceived the differences in the 10 % and 15 % perfectly, the ceramist performed relatively worse than the students at perceiving sand percentage differences and identifying the sample containing more sand from the 10 % interval set onwards. The main contributor to this unexpected result is likely the unideal experiment set-up for these experiments.

The indirect-comparison experiments have unfortunately not been done with the ceramist, so it was not possible to capture the correlation between sensory attunement and skill level.

This thesis took the shape of a pilot study for a specific newly designed method. Although arguably still needing improvements, it did enable the collection of useful data for the creation of a (rather crude) perceptive categorisation in sand content in clay. Seen the relevance of this aspect in ceramic manufacture, I propose sand content and/or temper content as a suitable aspect within a larger technological roadmap of the ceramic production process, following Kuijpers' method for establishing a craftsperson's perspective.

6.1 Possible future research

Regarding my method, improvements to the set-up could be made. My advice would be to consider quantification of water content and potentially sample temperature (or training the tester to make proper judgements therein prior to the experiment), stable storing conditions, repeatable and quantifiable sample preparation methods, equal information distribution for every test person, equal levels of (physical and/or mental) comfort for every test person which might be tailored to the test person's preference to optimise their concentration, choosing between a numerical and a verbal (temper) quantification system, and inviting (more) craftspeople to do experiments with. It might also be worth researching whether surface temperature mediates tactile sensitivity in some way.

I would encourage using my method as well as designing other methods to collect useful data for a sensory categorisation of those stimuli that guide craftspeople in their making process. I believe that the observations of craftspeople on their own craft should be leading in identifying these stimuli, and that their insights in their craft should be actively incorporated into the (experimental) academic discourse on skill.

The larger aim for the research I only ever so briefly touched upon in this thesis still remains. This is to create useful and functional perceptive categories for all steps in the ceramic production process with the help of experienced ceramists. It would then be possible to create a technological roadmap for ceramic production that can be used by archaeologists and material scientists to more accurately visualise and quantify skill of the maker through the objects they produce(d). A toolbox like that could then be used to re-evaluate existing ideas on craftspersonship (organisation), social structures, and the material reality of people in the past. Such larger aims could also be achieved through the creation and application of a skill-visualising toolbox for other material groups, creating new possibilities to challenge our perception of the past.

Abstract

Due to the largely ungraspable nature of skill, the academic discourse lacks a structured research method for it. Material scientists make inferences about skill in hand-made artefacts based on subjective judgements, despite missing the knowledge craftspeople possess. These sometimes rather unquantified inferences could lead to incorrect views on past societies and their socio-economic organisation. The craftsperson's perspective, recently proposed by Kuijpers (2018) provides a toolbox based on perceptive categorisation for more structured skill research for archaeometallurgy. Perceptive categorisations are made of different steps in the production process, which can be used to create a technological roadmap of an archaeometallurgical assemblage. This thesis concerns a pilot study for establishing a craftsperson's perspective for the ceramic chaîne opératoire. The focus lies on one suitable sensory aspect therein, being temper concentrations in clay. A newly devised method is introduced and tested. This method is used for investigating human tactile sensitivity for differing temper (sand) percentages in clay in direct- and indirect-comparison experiments. Through doing sensory experiments with people with different levels of experience with working with clay, it is hypothesised that a positive correlation can be demonstrated between an increased sensory attunement to a material and a higher level of skill. Conclusions about the relationship between skill and sensory attunement were not reached. However, it can be concluded that in direct comparison, sand content differences between 0 % and 2,5 % can mostly be recognised and that the sample containing more sand can be mostly correctly identified up to a 5 % difference. In indirect comparison, on average, temper (sand) percentages in clay can be perceived rather accurate. In both cases, large differences exist between individuals. Based on error analysis of indirect comparison, a perceptive categorisation for sand content in clay is proposed. The combination of such categorisations for all relevant sensory aspects of the ceramic chaîne opératoire could stand at the basis of the establishing of a craftsperson's perspective for ceramic analysis. This perspective could be applied to ceramic assemblages to develop new ideas, and challenge existing ones, on ceramics, craft, craft organisation, skill and specialisation, and socio-economic organisation, in past and present societies.

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Craftsperson consulted

Nirdosh Petra van Heesbeen, professional ceramist with over fifty years of experience working as a ceramist in the Netherlands and France. Conversations had on 10-02-2022 and 01-12-2022.

Appendix

Contents

1 Direct-comparison experiment results (difference perception, sample identification, and hand-switching)

1.1 Direct comparison results test person 1 (ceramist)

Bold = sample containing more sand
Underlined = sample presented in left hand
Green = sample containing more sand or the absense of a difference is correctly identified
Orange = sample containing more sand or the absence of a difference is incorrectly identified
[50,0%] = % of cases per set where an existing difference was perceived
[50,0%] = % of cases per set where a non-esiting difference was perceived
[50,0%] = % of cases per set where an existing difference was perceived AND the samples were correctly identified
S = switching of the samples between hands took place

15% interval

100,0%	0	15	Same	NOTE: test person was aware that there was a difference!
100,0%	2,5	17,5	Same	
	5	20	Same	
	7,5	22,5	Same	
	10	25	Same	
	12,5	27,5	Same	
	15	30	Same	
	17,5	32,5	Same	
	20	35	Same	
	22,5	37,5	Same	
	25	40	Same	
	27,5	42,5	Same	

10% interval

100,0%	0	10	Same		NOTE: test person was aware that there was a difference!
78,6%	2,5	12,5	Same	S	
	5	15	Same	S	
	7,5	17,5	Same		
	10	20	Same		
	12,5	22,5	Same	S	
	15	25	Same	S	
	17,5	27,5	Same		
	20	30	Same		
	22,5	32,5	Same	S	
	25	35	Same	S	
	27,5	37,5	Same		
	30	40	Same		
	32,5	42,5	Same		

7,5% interval

Set 1/2	0	7,5	Same	
100,0%	2,5	10	Same	S
73,3%	5	12,5	Same	S
	7,5	15	Same	S
	10	17,5	Same	
	12,5	20	Same	S
	15	22,5	Same	S
	17,5	25	Same	S
	20	27,5	Same	S
	22,5	30	Same	
	25	32,5	Same	
	27,5	35	Same	
	30	37,5	Same	
	32,5	40	Same	S
	35	42,5	Same	

7,5% interval

Set 2/2	0	7,5	Same	S
60,0%	2,5	10	Same	
40,0%	5	12,5	Same	S
	7,5	15	Same	S
	10	17,5	Same	
	12,5	20	Same	S
	15	22,5	Same	S
	17,5	25	Same	
	20	27,5	Same	S
	22,5	30	Same	S
	25	32,5	Same	S
	27,5	35	Same	
	30	37,5	Same	
	32,5	40	Same	
	35	42,5	Same	

5% interval

Set 1/3	0	5	Same	
62,5%	2,5	7,5	Same	S
37,5%	5	10	Same	
	7,5	12,5	Same	
	10	15	Same	S
	12,5	17,5	Same	
	15	20	Same	S
	17,5	22,5	Same	
	20	25	Same	
	22,5	27,5	Same	
	25	30	Same	
	27,5	32,5	Same	
	30	35	Same	S
	32,5	37,5	Same	S
	35	40	Same	S
	37,5	42,5	Same	

5% interval

Set 2/3	0	5	Same	
56,3%	2,5	7,5	Same	S
37,5%	5	10	Same	
	7,5	12,5	Same	
	10	15	Same	S
	12,5	17,5	Same	
	15	20	Same	
	17,5	22,5	Same	S
	20	25	Same	
	22,5	27,5	Same	S
	25	30	Same	S
	27,5	32,5	Same	
	30	35	Same	S
	32,5	37,5	Same	S
	35	40	Same	S
	37,5	42,5	Same	

5% interval

Set 3/3	0	5	Same	
87,5%	2,5	7,5	Same	
56,3%	5	10	Same	
	7,5	12,5	Same	
	10	15	Same	S
	12,5	17,5	Same	S
	15	20	Same	S
	17,5	22,5	Same	
	20	25	Same	
	22,5	27,5	Same	
	25	30	Same	
	27,5	32,5	Same	S
	30	35	Same	S
	32,5	37,5	Same	S
	35	40	Same	
	37,5	42,5	Same	S

1.2 Direct comparison results test person 2 (student)

Bold = sample containing more sand
Underlined = sample presented in left hand
Green = sample containing more sand or the absense of a difference is correctly identified
Orange = sample containing more sand or the absense of a difference is incorrectly identified
[50,0%] = % of cases per set where an existing difference was perceived
[50,0%] = % of cases per set where a non-esiting difference was perceived
[50,0%] = % of cases per set where an existing difference was perceived AND the samples were correctly identified
S = switching of the samples between hands took place

15% interval			
100,0%	0	15	Same
100,0%	2,5	17,5	Same
	5	20	Same
	7,5	22,5	Same
	10	25	Same
	12,5	27,5	Same
	15	30	Same
	17,5	32,5	Same
	20	35	Same
	22,5	37,5	Same
	25	40	Same
	27,5	42,5	Same

10% interval			
100,0%	0	10	Same
92,9%	2,5	12,5	Same
	5	15	Same
	7,5	17,5	Same
	10	20	Same
	12,5	22,5	Same
	15	25	Same
	17,5	27,5	Same
	20	30	Same
	22,5	32,5	Same
	25	35	Same
	27,5	37,5	Same
	30	40	Same
	32,5	42,5	Same

7,5% interval			
100,0%	0	7,5	Same
93,3%	2,5	10	Same
	5	12,5	Same
	7,5	15	Same
	10	17,5	Same
	12,5	20	Same
	15	22,5	Same
	17,5	25	Same
	20	27,5	Same
	22,5	30	Same
	25	32,5	Same
	27,5	35	Same
	30	37,5	Same
	32,5	40	Same
	35	42,5	Same

5% interval			
93,8%	0	5	Same
93,8%	2,5	7,5	Same
	5	10	Same
	7,5	12,5	Same
	10	15	Same
	12,5	17,5	Same
	15	20	Same
	17,5	22,5	Same
	20	25	Same
	22,5	27,5	Same
	25	30	Same
	27,5	32,5	Same
	30	35	Same
	32,5	37,5	Same
	35	40	Same
	37,5	42,5	Same

2,5% interval				
Set 1/1	0	2,5	Same	
76,5%	2,5	5	Same	
47,1%	5	7,5	Same	
	7,5	10	Same	
	10	12,5	Same	
	12,5	15	Same	
	15	17,5	Same	
	17,5	20	Same	
	20	22,5	Same	
	22,5	25	Same	
	25	27,5	Same	
	27,5	30	Same	
	30	32,5	Same	
	32,5	35	Same	
	35	37,5	Same	
	37,5	40	Same	
	40	42,5	Same	

2,5% interval				
Set 2/2	0	2,5	Same	
76,5%	2,5	5	Same	
41,2%	5	7,5	Same	
	7,5	10	Same	
	10	12,5	Same	
	12,5	15	Same	
	15	17,5	Same	
	17,5	20	Same	
	20	22,5	Same	
	22,5	25	Same	
	25	27,5	Same	
	27,5	30	Same	
	30	32,5	Same	
	32,5	35	Same	
	35	37,5	Same	
	37,5	40	Same	
	40	42,5	Same	S

0% interval				
Set 1/2	0	0	Same	
76,5%	2,5	2,5	Same	
	5	5	Same	
	7,5	7,5	Same	
	10	10	Same	
	12,5	12,5	Same	
	15	15	Same	
	17,5	17,5	Same	
	20	20	Same	
	22,5	22,5	Same	
	25	25	Same	
	27,5	27,5	Same	S
	30	30	Same	
	32,5	32,5	Same	
	35	35	Same	
	37,5	37,5	Same	
	40	40	Same	
	42,5	42,5	Same	

0% interval				
Set 2/2	0	0	Same	
76,5%	2,5	2,5	Same	
	5	5	Same	
	7,5	7,5	Same	
	10	10	Same	
	12,5	12,5	Same	
	15	15	Same	
	17,5	17,5	Same	
	20	20	Same	
	22,5	22,5	Same	
	25	25	Same	
	27,5	27,5	Same	
	30	30	Same	S
	32,5	32,5	Same	S
	35	35	Same	
	37,5	37,5	Same	
	40	40	Same	
	42,5	42,5	Same	

1.3 Direct comparison results test person 3 (student)

Bold = sample containing more sand

Underlined = sample presented in left hand

Green = sample containing more sand or the absense of a difference is correctly identified

Orange = sample containing more sand or the absense of a difference is incorrectly identified

[50,0%] = % of cases per set where an existing difference was perceived

[50,0%] = % of cases per set where a non-esiting difference was perceived

[50,0%] = % of cases per set where an existing difference was perceived AND the samples were correctly identified

S = switching of the samples between hands took place

10% interval

100,0%	0	**10**	Same	
100,0%	2,5	**12,5**	Same	
	5	**15**	Same	
	7,5	**17,5**	Same	
	10	**20**	Same	
	12,5	**22,5**	Same	
	15	**25**	Same	
	17,5	**27,5**	Same	
	15	**25**	Same	
	20	**30**	Same	
	22,5	**32,5**	Same	
	25	**35**	Same	
	27,5	**37,5**	Same	
	30	**40**	Same	
	32,5	**42,5**	Same	

7,5% interval

93,3%	0	**7,5**	Same	S
80,0%	2,5	**10**	Same	
	5	**12,5**	Same	
	7,5	**15**	Same	S
	10	**17,5**	Same	
	12,5	**20**	Same	
	15	**22,5**	Same	
	17,5	**25**	Same	S
	20	**27,5**	Same	
	22,5	**30**	Same	
	25	**32,5**	Same	S
	27,5	**35**	Same	
	30	**37,5**	Same	
	32,5	**40**	Same	
	35	**42,5**	Same	

5% interval					5% interval					5% interval				
Set 1/3	0	**5**	Same	S	Set 2/3	0	**5**	Same		Set 3/3	0	**5**	Same	
68,8%	2,5	**7,5**	Same	S	100,0%	2,5	**7,5**	Same	S	93,8%	2,5	**7,5**	Same	
50,0%	5	**10**	Same		68,8%	5	**10**	Same		81,3%	5	**10**	Same	
	7,5	**12,5**	Same	S		7,5	**12,5**	Same	S		7,5	**12,5**	Same	
	10	**15**	Same			10	**15**	Same	S		10	**15**	Same	
	12,5	**17,5**	Same	S		12,5	**17,5**	Same			12,5	**17,5**	Same	
	15	**20**	Same			15	**20**	Same			15	**20**	Same	
	17,5	**22,5**	Same	S		17,5	**22,5**	Same	S		17,5	**22,5**	Same	S
	20	**25**	Same	S		20	**25**	Same			20	**25**	Same	
	22,5	**27,5**	Same			22,5	**27,5**	Same	S		22,5	**27,5**	Same	
	25	**30**	Same			25	**30**	Same			25	**30**	Same	
	27,5	**32,5**	Same	S		27,5	**32,5**	Same			27,5	**32,5**	Same	
	30	**35**	Same	S		30	**35**	Same	S		30	**35**	Same	
	32,5	**37,5**	Same	S		32,5	**37,5**	Same			32,5	**37,5**	Same	S
	35	**40**	Same			35	**40**	Same	S		35	**40**	Same	
	37,5	**42,5**	Same	S		37,5	**42,5**	Same	S		37,5	**42,5**	Same	S

2,5% interval

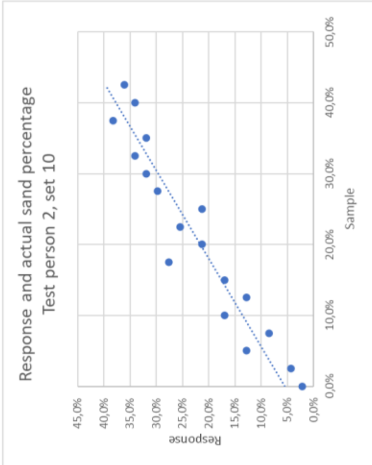
66,7%	2,5	**5**	Same	
22,2%	5	**7,5**	Same	S
	10	12,5	Same	S
	15	**17,5**	Same	S
	25	**27,5**	Same	
	30	**32,5**	Same	S
	32,5	**35**	Same	
	35	**37,5**	Same	S
	40	**42,5**	Same	S

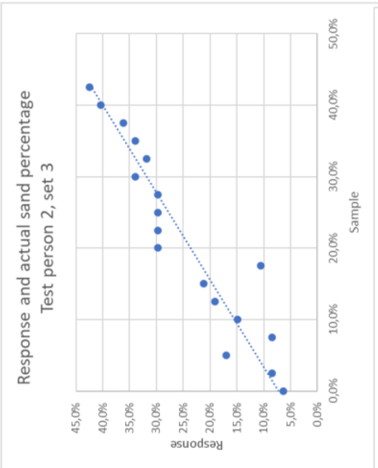
0% interval

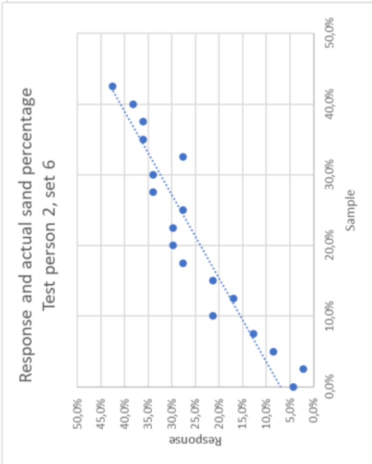
33,3%	2,5	**2,5**	Gelijk	
	12,5	**12,5**	Same	
	20	**20**	Same	
	22,5	**22,5**	Same	
	32,5	**32,5**	Same	
	42,5	**42,5**	Gelijk	

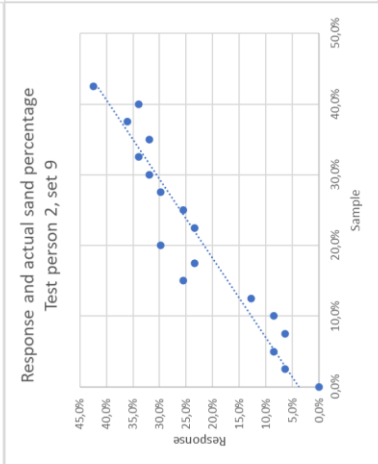
2 Indirect-comparison experiment results (quantification)

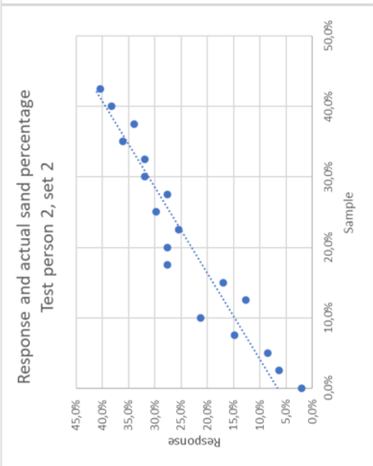
2.1 Indirect-comparison experiment test person 2 (student)

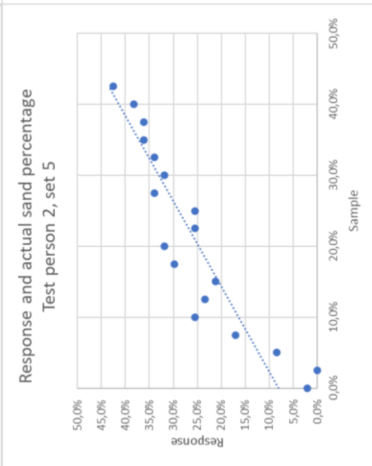


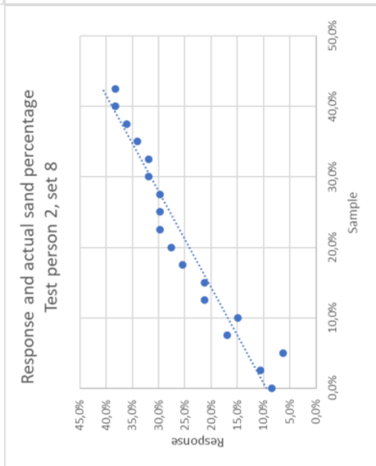


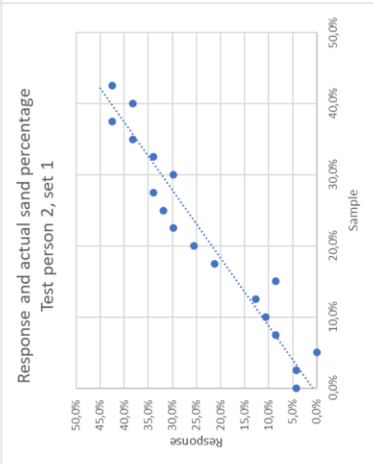


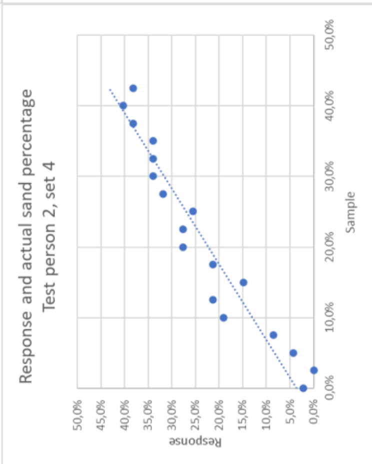


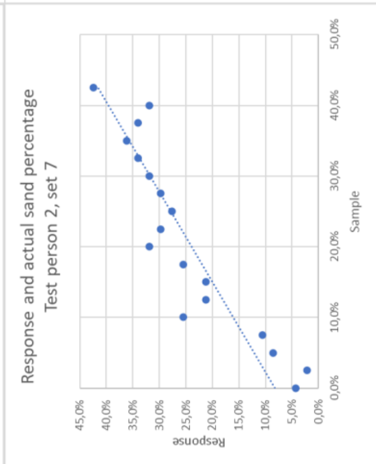




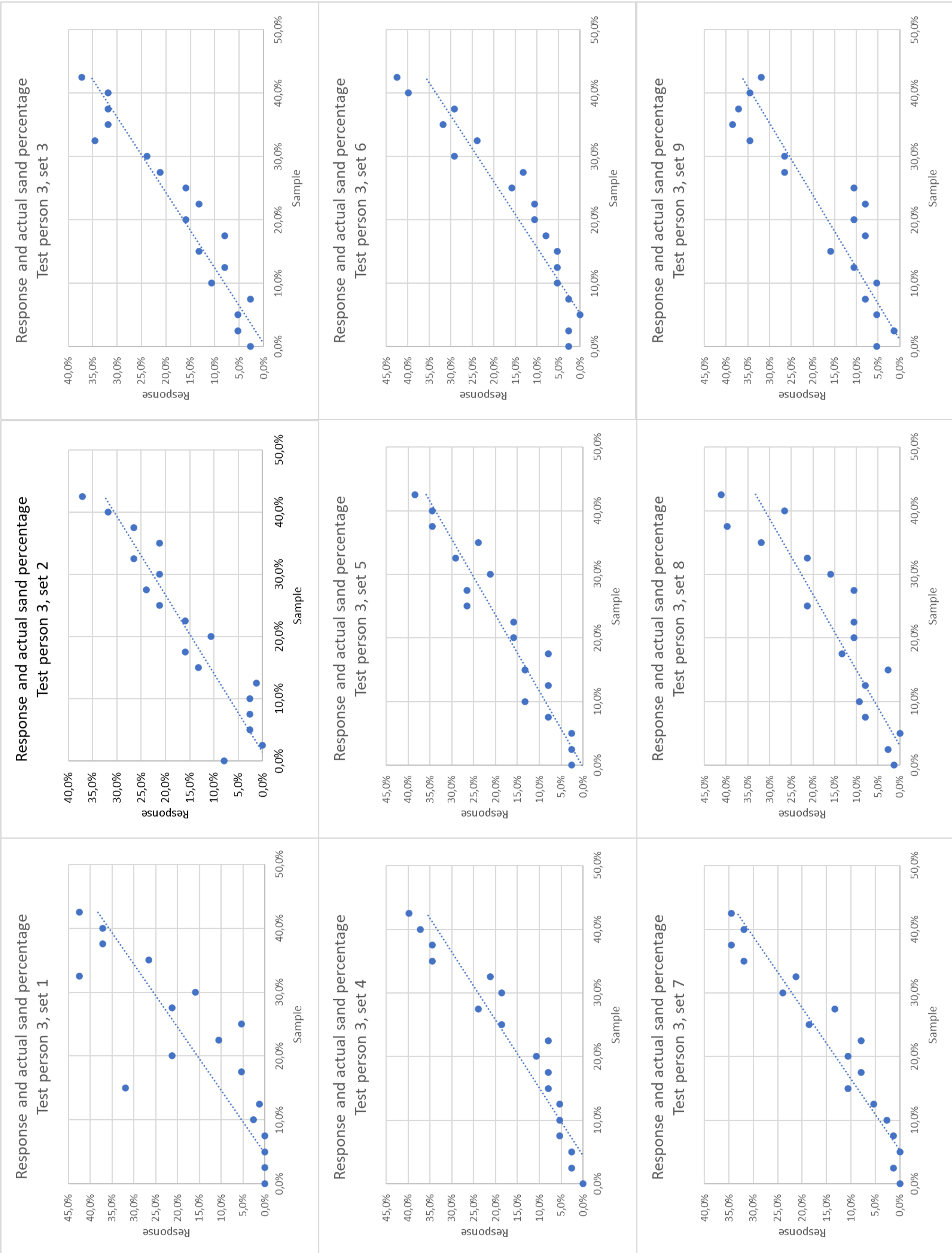




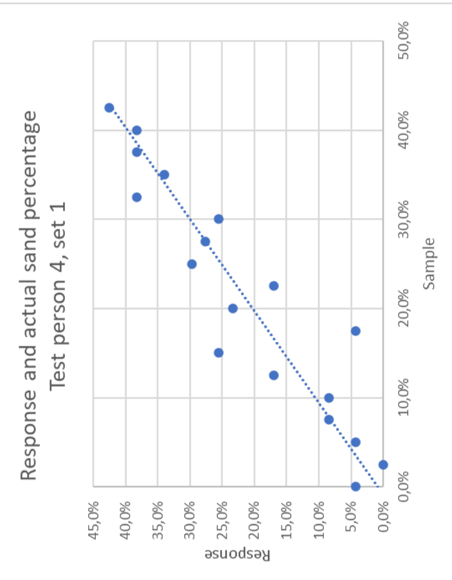


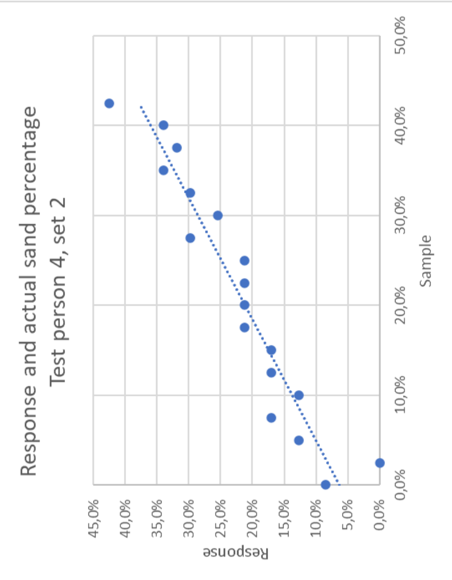


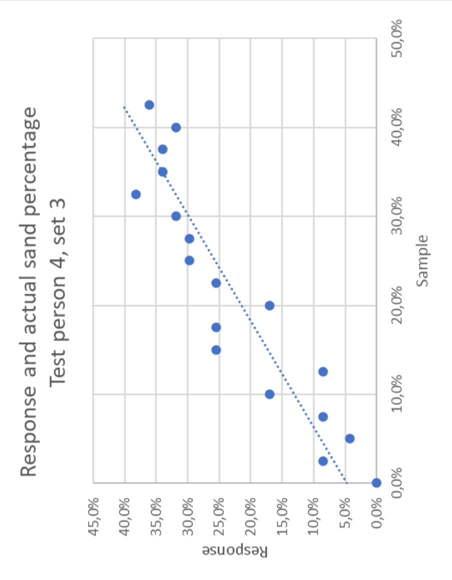
2.2 Indirect-comparison experiment test person 3 (student)

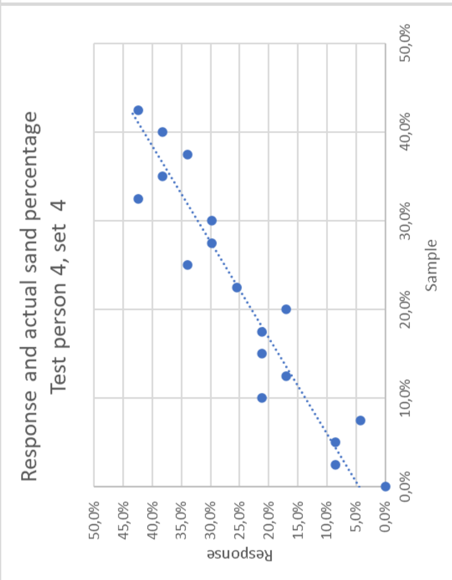


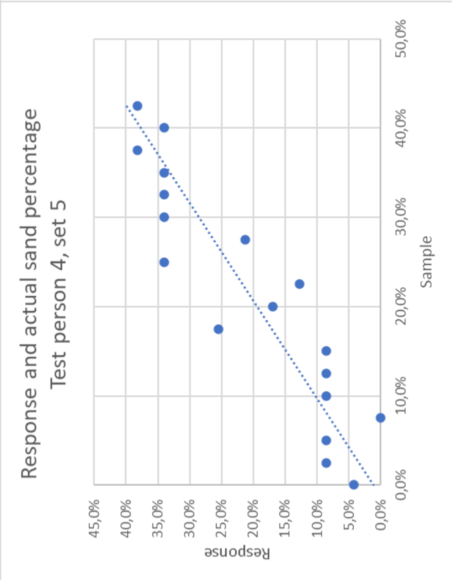
2.3 Indirect-comparison experiment test person 4 (student)

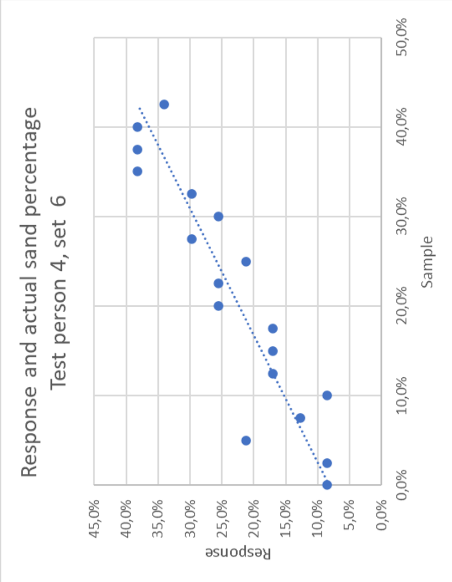


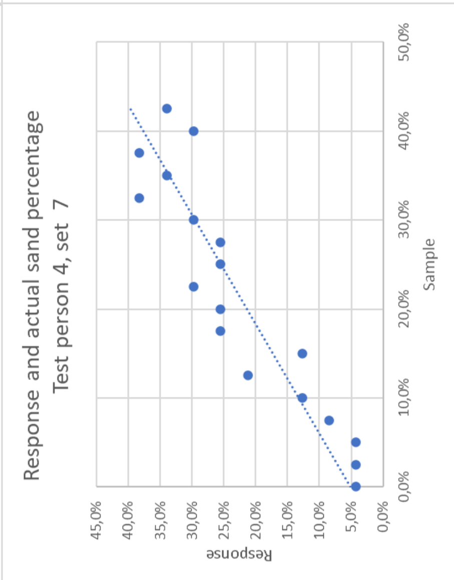


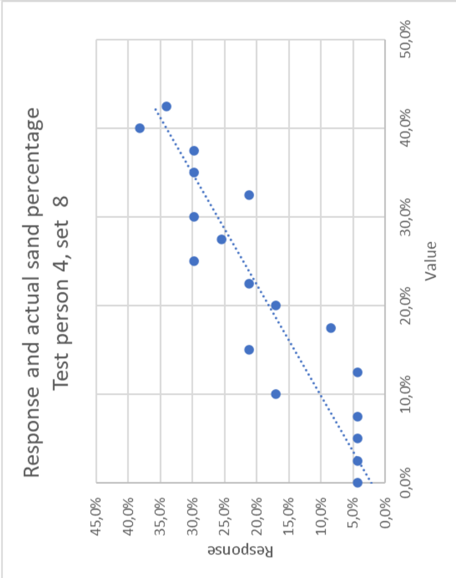


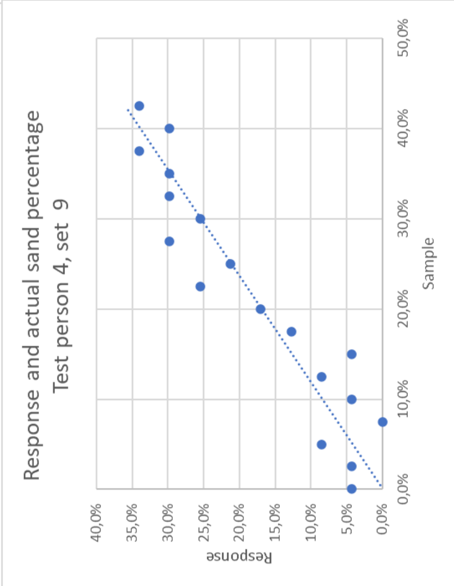












2.5 Indirect-comparison experiment test person 5 (student)