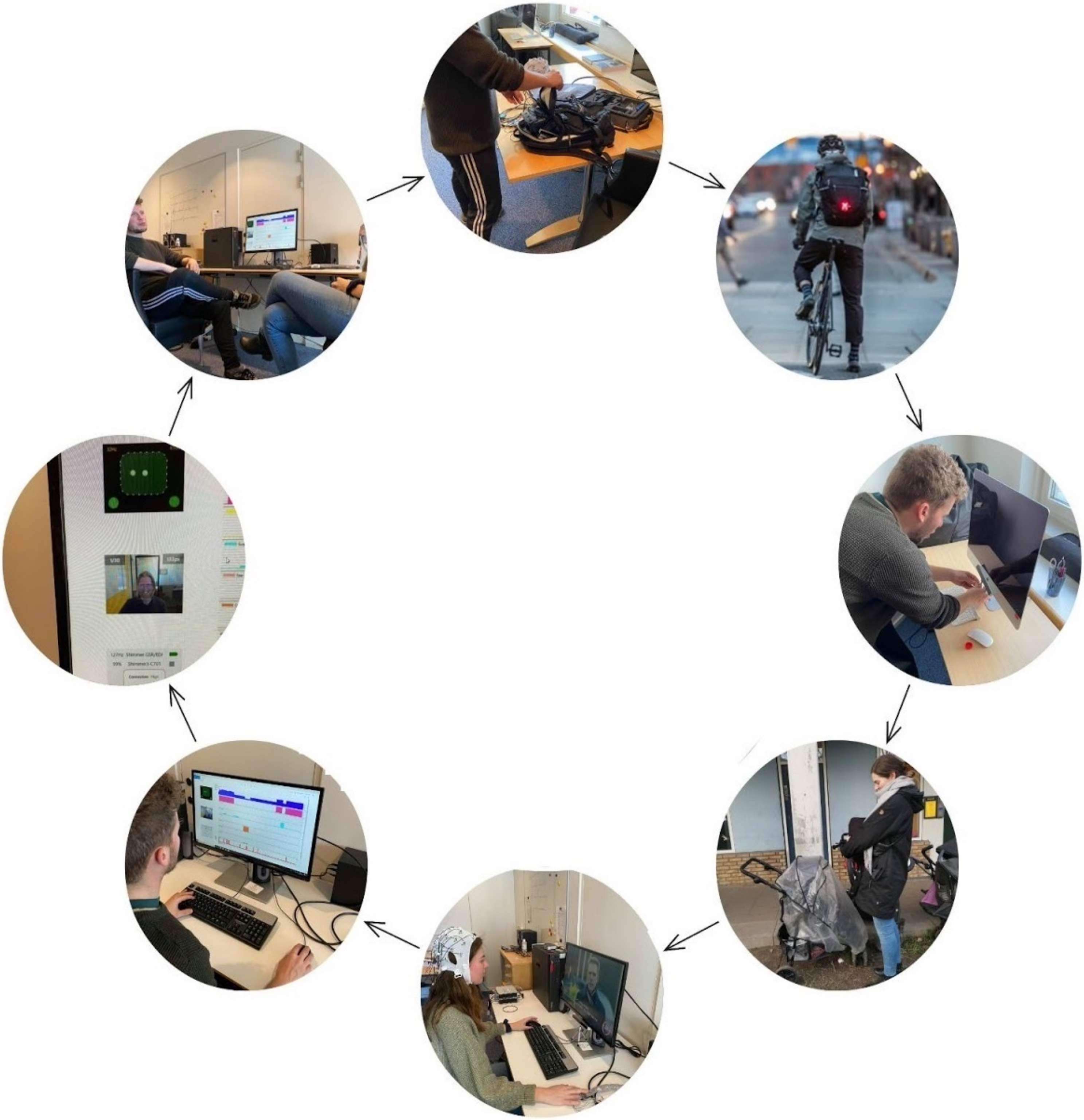
The constitution of biometric research at Danish universities



THE CONSTITUTION OF BIOMETRIC RESEARCH AT DANISH UNIVERSITIES

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ABSTRACT

English:

Over recent years biometric tools and methods have become more common within different areas. Thanks to the rapid development in technology, biometry has enjoyed a growing interest and is today applied in many parts of the global society. In 2005, the software company iMotions lunched a technology, which makes it possible to synchronize different biometric sensors in one platform. Since then, the amount of scientific articles using biometric research has increased significantly.

This master's thesis takes a closer look at, how Danish universities apply biometric research and which challenges they face. Beyond the university itself, this master's thesis also investigates closer the challenges researchers themselves face and how they view the potential of biometry. In addition, a closer look is also taken on the private sector, that is using academic approach, and how biometric research is applied here. Again, challenges are identified and future perspectives are presented. Finally, an overall overview is presented, which sheds light on the practical challenges biometric research faces and how these can be handled going forward.

The research method behind this master's thesis is qualitative, as most of the empirical work is based on field interviews. The interviews are carefully selected such that a variety of different users of biometry are included. A total amount of eleven interviews have included. In order to get a comprehensive overview of how biometric research is applied, we are using the Actor-Network Theory (ANT) by Bruno Latour as the theoretical framework.

Dansk:

Igennem de seneste år er biometriske værktøjer og metoder blevet mere almindelige inden for forskellige områder. Takket være den hurtige teknologiudvikling har biometri haft en voksende interesse og anvendes i dag i mange dele af det globale samfund. I 2005 lancerede softwarefirmaet iMotions en teknologi, der gør det muligt at synkronisere forskellige biometriske sensorer i en platform. Siden da er mængden af videnskabelige artikler, der bruger biometrisk forskning, steget markant.

Følgende kandidatspeciale ser nærmere på, hvordan danske universiteter anvender biometrisk forskning, og hvilke udfordringer de står over for. Udover at anskue selve universiteterne, så undersøger dette kandidaspeciale også nærmere de udfordringer, forskerne selv står over for, og hvordan de ser potentialet i den biometriske forskning. Derudover bliver der også set nærmere på den private sektor der går til værks med en akademisk tilgang, og hvordan biometrisk forskning anvendes inden for dette miljø. Efterfølgende identificeres udfordringer, og fremtidsperspektiver præsenteres. Endelig præsenteres en samlet oversigt, der

belyser de praktiske udfordringer, som biometrisk forskning står over for, og hvordan disse kan gribes an fremover.

Forskningsmetoden der er bag dette kandidatspeciale er en kvalitativ tilgang, da det meste af det empiriske arbejde er baseret på feltinterviews. Interviewene er nøje udvalgte, således at en række forskellige interessenter af biometri er inkluderet. I alt er elleve interviews er inkluderet. For at få et omfattende overblik over, hvordan biometrisk forskning anvendes, bruger vi Aktør-netværksteorien (ANT) af Bruno Latour som et teoretisk rammeværk.

ACKNOWLEDGEMENTS

Tak til iMotions og deres eksperter, professorer på CBS og KU samt studerende på KU og AAU. Derudover vil vi rette en tak til dem som gør brug af biometrisk teknologi uden for universitetererne og som har været interesseret i at give os et indblik i deres syn på biometrisk. Kæmpe tak til vores vejleder Anders Kristian Munk, for den ekstraordinære støtte og vejledning i løbet af processen til udarbejdelsen af vores speciale. Til sidst, tak til alle, som har vist interesse og bidraget til dette speciale i løbet af dets udarbejdelse. Det er vores intention med dette speciale, at det kan bidrage som en grundforståelse af de nødvendige samt anbefalet praktiske og teoretiske elementer af biometrisk forskning, som man skal gøre sig bekendt med. Det samme gælder de omkringliggende faktorer, der i sin helhed kan bidrage til udviklingen og udbredelsen af biometrisk forskning på universiteter.

Thanks to iMotions and their experts, the professors at CBS and UCPH, and the people who gave us an insight into their perspective on the use and potential of biometric research. A huge gratitude is directed at Anders Kristian Munk, who has been an extraordinary support as a supervisor during the compilation of our thesis. It is our goal with this thesis, to create a foundation of the necessary and recommended both practical and theoretical elements of biometric research. As well as, the external factors that hopefully can contribute to the development and extend of its wider use at Danish universities.

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1 INTRODUCTION

Biometrics has become an intensely debated topic in recent years, especially following iMotions releasing its software platform in 2005. The platform enabled multiple sensors to automatically synchronise their data live, revolutionising sensor usage and creating a catalysator for more praxis-oriented applications across different parts of society, especially parts that are, arguably, intrinsic to the lives of millennials. Biometric data is derived from the study of subconscious signals expressed by the body, allowing insights regarding cognition, attention, physiological, and emotional arousal.

Consequently, many countries have embraced technology to the extent that its presence is unnoticed. Mobile phones scan fingerprints, voices, or faces to open applications filled with sensitive data, such as apps for government services, Nemid, mobile banking and e-boks. In areas of substantial human traffic – for example, airports, shopping streets, and country borders – cameras monitor people and help identify potential terrorists, an identifying process supported by an algorithm that automatically sends a signal to the authorities when it recognises a suspect. However, in a world where mixed ethnicities are more common than distinct ethnicities, an algorithm can be prejudiced against certain traits, including particular skin colours, body compositions and facial hairstyles. Governments and organisations also use biometrics to monitor staff through recording and scanning the face, fingerprints, finger veins, palm veins, irises, and voice patterns of employees, allowing them to precisely measure the number of hours worked (Trader, 2020).

China, meanwhile, has provoked ethical debates through the new level of control represented by the government's 'social credit system'. The system controls the citizen behaviour by assigning and retracting points for positive and negative actions. Citizen behaviour is judged by an AI whose algorithm recognises people while monitoring their activities. For example, if a person buys nappies, the system ascribes points for taking care of others; in contrast, procuring alcohol for a social gathering is considered a precursor to alcoholism, resulting in points being deducted (dr.dk/horisont, 2019). An individual's score dictates their freedom in a variety of ways; for instance, whether they can travel, where they are permitted to live, and what private loans are available to them. The program has been criticised for the lack of transparency surrounding how the information is collected and how it is utilised by both governmental and commercial players (Egeskov, 2019). Nonetheless, China is just one example of biometric technology's infiltration of society; as it has been increasingly adopted by all kinds of public and private businesses and organisations, biometrics have produced ethical dilemmas surrounding its broad use and usage of the information it collects and how it is collected..

However, it should also be mentioned that the sensors participate in scientific discoveries, by forming part of the theories and methods enabling development in society. Especially, when science's responsibility is to utilise scientific information to develop practical solutions and this is often bound to technology and engineering (Bird, 2014). Thus, to map the proper use of biometric technology and accommodate ethical debates, researchers have needed to use it in their practice and study its use. Unfortunately, has the use of biometric equipment been kept constant at a bare minimum. Furthermore, considering our years at both the Technical University of Denmark and Aalborg University (AAU), we have undertaken 5 years of education, during which we have seldom debated biometric technology, whether in lectures, group work, or the professor's office. Biometric research is not specifically studied and seems driven by personal interest.erswt

For this Master's thesis, we have used comprehensive ethnographic fieldwork to consider two experiments, one at a university and one at the Danish headquarters of iMotions. In this context, biometric research can be perceived as a case study highlighting challenges and differences and enabling a discussion of the experience of working with biometric technology from the scientist's perspective. We have also investigated how biometric research is accommodated by danish university researchers, allowing mapping of relevant Danish actors inside and outside of the experiments.

2 Problem field

Optimisation and innovation of society and research are endeavours that have always benefitted from technology. However, technology tends to create challenges, which vary according to the technology and the context and are often left to science to solve. Unfortunately, the problems biometric technology has created still exist, and there remains an absence of research substantiating proper use of the technology. This might be due to the ideological change implied by science's shift from ´pure science´ to ´applied science´. Pure science refers to research for its own sake, through deductions based on demonstrated truths that are not restrained by practical applications in the forms of policy, economy, acknowledgement and preferential treatment (Børsen & Botin, 2016:135–136). In contrast, applied science is the introduction of existing scientific knowledge into praxis; this describes inventions or technology. However, applied science incorporates economic and bureaucratic complexities into the research design, as are the particular researcher's specific interests and competencies and the broader public interest. These elements all impact the success rate and interest in biometric research, for both the university and the researcher (Børsen & Botin, 2016:135–136).

Against this backdrop, we consider it worth investigating biometric research in an academic context. Considering the general awareness of the debate surrounding uses of biometrics, we, as techno-anthropologist students, were first formally introduced to this type of research during our 8th semester, during a visit to the aforementioned iMotions headquarters. As techno-anthropologists, we are interested in the study of human interactions with technology; in this case, we were surprised that we had not yet been introduced sooner to a technology appealing to the core of our study and society.

Our desktop research revealed that the medialogy study program at AAU in Copenhagen had biometric equipment in its department. There, we conversed with many students and found that only one study group was familiar with biometric research as a methodology. That group had once utilised facial expression recognition analysis, eye-tracking and galvanic skin response for a project during a semester. When we asked one of the group members about her experience with biometric research, she answered:

“It was the first time we used biometric research in our project assignments. I do not understand why we had not done it before. We had one or two lessons where the method has been presented. That is all. Since I happened to get acquainted with biometric research, I will definitely include it in my Master’s thesis”. (9th-semester AAU medialogy student, Copenhagen, 2019)

It became more apparent that it was not mandatory to be acquainted with biometric research at AAU, even for students of the program with the equipment. Nonetheless, it became clear that researchers could utilise the potential of biometric research to explore the human mind in new ways and investigate practical solutions for societal challenges. Reality showed how researchers with access to the equipment, had neither acquainted or awareness of its use and presence. It was difficult to even locate the faculty who owned the equipment and the professor in charge. This diminished our faith in Denmark’s Ministry of higher education and science, who positions Denmark as a knowledge society with high quality educations that provides students with the opportunities and motivation to acquire new competencies (The ministry of higher education and science, 2020). An impression enhanced when looking at the publication rate.

The total number of publications in Denmark which have used biometric research has grown from 26 in 1996 (0.16% of the total number of published articles) to 73 (0.21%) in 2004, the year before the release of the iMotions platform. In 2019, 250 articles were published, 0.48% of the total, an insignificant change considering how widespread biometric technology has become between 1996 and 2020.

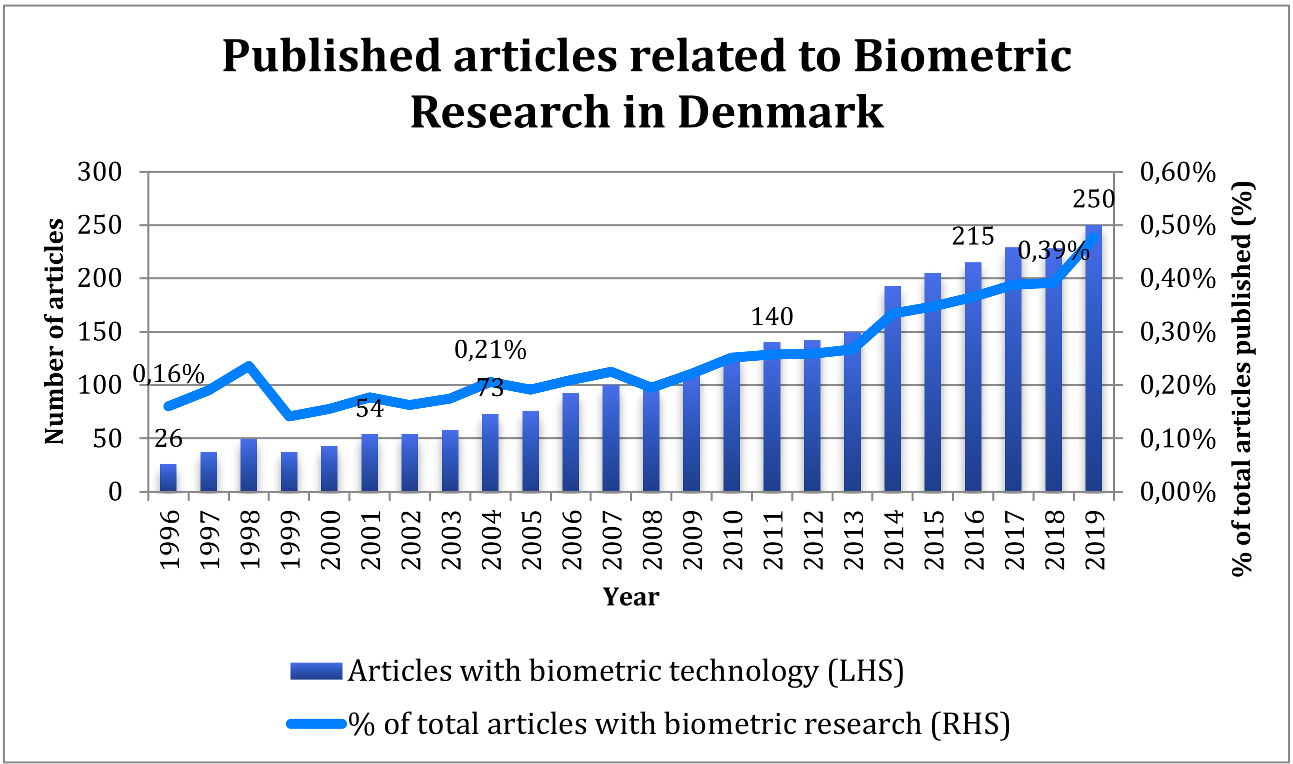


Figure 1 Public articles related to biometric research in Denmark

Source: Scopus

This Master´s thesis seeks to understand why biometric research is not more widespread at Danish universities given the responsibilities of science, its potential to innovate and optimise research, the statement of the Denmark's Ministry of Education, and the extent of its incorporation into society. Of the many ways of approaching the broad inquiry, this paper takes the form of a journey departing from an exploration of the general and specific challenges faced by researchers, especially as these are defined by the nature of the project and the researcher's academic background. This leads us to understand the considerations researchers take when shaping an experiment, individual professors' willingness to change their approach, and how the absence of specific competencies can constitute restraints.

Using the input of several researchers, this work takes a qualitative approach to reaching a conclusion regarding the considerations and challenges that emerge when conducting a project using biometric research.

2.1 Problem statement

The research questions of this master´s thesis goes as:

1. Which challenges do researchers at Danish universities face when researching within the methods of biometric research?
2. What opportunities and barriers are involved with the introduction of this method?
3. How are these scientific facts being constructed?

3 BIOMETRIC RESEARCH IN DENMARK AND AT DANISH UNIVERSITIES

Biometric data has been utilised to record many aspect of human life, almost since humans started tracing history (Anil, K. Ross, A. Nandakumar, K., 2016). Initially, it was used mainly in science and for medical treatment. It later became more widespread, being used to, for example, settle business transactions and distinguish children from one other (The National Science and Technology Council).

In recent decades, technology has automated many of the manual procedures around biometric data capture and analysis, innovating research and society both online and offline by making data collected more universal and consistent. Before iMotions, biometric methods were primarily the realm of experts; thus, easier access to the equipment and the automatization have resulted in growing interest in its use, but the expertise required to utilise the technology in methodologies has not changed as drastically. In addition to its revelations for research, biometric technology has shaped society and the lives of individual people. Organisations and governments use it to secure investments, surveil citizens and provide access to accounts; in many ways, it has become a part of society and probably without everyone's awareness. Using iMotions software platform enables various sensors (eye-tracking, facial expression analysis, galvanic skin response, electroencephalography, electromyography and electrocardiography) to synchronise simultaneously in realtime and present the biometrics on a monitor. This has promoted a deeper understanding of human behavioural and cognitive processes in response to different stimuli. The platform also enables the sensors to complement each other, increasing the validity of the data. According to Michael Polanyi's theory of tacit knowledge, which considers the mechanisms associated with the physical and mental reactions to stimuli. The embedded behaviour is normally expressed unconsciously, but can be expressed verbally according to a person's capability of recalling the memory relating to the behaviour (Polanyi, 1969C:144). This means that the sensor(s) measure a person's embedded behaviour, which, after being analysed by an algorithm, is visualised on a monitor.

An example of biometric research contributing to science is found in studies by lead by Paul Kruszka, which improved the procedure and precision of diagnosing Asian, African, and Latin-American children suffering from velocardiofacial syndrome (Krusczka et al., 2017:879–888). Using facial recognition to locate the corporal defects associated with the syndrome, it has generated a database based on numerous cases around the world. The database accommodates the challenges of diagnosing the syndrome in diverse populations due to the disease's different manifestations (ibid.). A more well-known application of biometric technology is using electroencephalography, electromyography and electrocardiography to diagnose a patient's mental and physical condition. In education, biometric research has improved learning outcomes using eye-tracking and facial analysis. The sensor(s) provide insight into student orientation and response to pictures, illustrations, formulations and test formats. In neuromarketing and food studies, biometric data have been directly applicable in the activities of different organisations, for example, such data can aid the design of a label for a product that will compare favourably to the labels of other choices.

In the context of commercial and governmental relations with the individual, biometric sensors are used, for example, to regulate access to physical and virtual spaces, services and information, including at border crossings (Pato et al., 2010:2). However, in striving for optimised security, there have been compromises of the safety of citizens, data, surveillance equipment and law enforcement. As aforementioned is China's 'social credit system' giving citizens a score according to their behaviour, with their score dictating the extent of each citizen's individual freedoms. However, the algorithm does not consider the context for the activities resulting in accumulations or deductions of points (dr.dk/horisont, 2019). Another example derives from a 2009 US Supreme Court case against a company collecting sensitive data without a clear goal; according to one justice,

"The Illinois Supreme Court issued an important decision in late January rejecting attempts to gut the state's landmark law that bars companies from collecting people's biometric identifiers — including face recognition scans, fingerprints, and iris scans — without providing a written explanation of what they plan to do with the data and obtaining consent" (Wessler, 2019)

This example and the general development of technology for online and offline data collection necessitated general data protection regulations being implemented globally in 2018. These regulations attempted to give control back to individuals by enabling them to choose the type and quantity of data organisations can collect. This range of possibilities of biometric technology indicates that thorough research of its beneficial and detrimental potential is needed by researchers to ensure that data is valid, individualistic, persistent, universal, and collected transparently. Meaning, that, the choice and use of different sensors continue to be of great significance to the one using it (Scherer 2005:84).

4 LITERATURE REVIEW

This chapter positions the thesis in comparison to other scenarios in the field of studies on biometric technology improvements in a world where economy, acknowledgement and disciplines are antipoles in the use of biometric research. The information has primarily been accessed through the Aalborg University database, with a focus on peer-reviewed academic articles and book compilations relevant to the subject and its influential actors.

4.1 An anthropologist visits the laboratory

In another study, the anthropologists Bruno Latour and Steve Woolgar, from Salk Institute, California, investigated how scientific facts are social constructions rather than objective truths. The study was published in the second chapter of their book ´Laboratory Life: The Construction of Scientific Facts´ and recognises the construction of a result after its stabilisation, the result of a series of hybrid processes involving technical, natural and social elements which are difficult to track after stabilisation (Jensen et al. 2007, p. 63). A pioneering work, the study indicated a spatial division of unclear roles. For example, it distinguished the relationship between ´office´ and ´bench´ space. That is, the technicians (bench) bring documents to the office at the end of every day. Then, the secretaries (office) post papers falling into one of two document categories: printed external publications and those produced within the laboratory. One iteration was literary inscriptions, describing the efficient operation of inscription devices and the production of articles.

A fixation on inscriptions – reading, coding, marking and use devices and writing – were prevalent activities in this research, which took the form of a lengthy series of experiments – including machine reading, extractions and outputs – attempting to create graphs and curves to describe the findings. As the research progressed, the focus shifted to new devices creating new products, resulting in figures ready for analysis. The term ´machine´ described the transformation of matter between stages, while the term \`inscription device´ described the final transformation of matter into a written document with a direct relationship to the original substance. Next, the researchers explored the culture of the laboratory to understand the substance of reading and writing, using articles about neuroendocrinology as their focus. Mythologies or frames of reference between activities and practices was described from the anthropologist's point of view not as the ´culture´, but as a ´paradigm´.

Here, the researchers were referring to the set of self-reinforcing arguments and beliefs which constitute a framework of legitimacy . All inscription devices comprise a mixture of technicians, machines and pieces of apparatus, which generates a curve which collaborates with external literature to generate articles.

Next, the researchers consider the ´phenomenon technique´, which applies theories of literary inscription to apparatus. An important characteristic of inscription devices is the absence of all intermediary steps upon achieving the end result. The central importance of inscriptions is that, while the phenomena discussed with participants could not exist without them, there are consequences. When material processes are relegated to the realm of the technical, inscriptions are indicators of the substance under study, meaning inscriptions are confirmation for or against the ideas or theories. According to Latour and Woolgar, apparatus are 'reified theory', and the availability of an apparatus is not crucial, but the arrangement of apparatus is. The phenomenon technique manufactures the artificial reality researchers use to describe objective entities constructed using inscription devices. Elaborating on this, Latour and Woolgar recognised that the impact of an article depends on both the literary inscription and readers, which enable different types of statements. That is, ´facts´ are essentially congruent with a successful literary inscription. Table 1 presents the five types of statements delineated.

Statement no.	Statement
1	Conjecture or speculation about relationship; End of paper, private discussion
2	Claim, rather than established fact; modalities highlight generality of available evidence; “normal” papers or drafts
3	Statement about other statements using modalities; removal of modality converts to type 4; modalities - use reference to merti, authority; review articles
4	Prototypical scientific assertion; textbooks
5	Taken-for-granted facts; not justified or mentioned explicitly

Table 1 Latour and Woolgar´s five statements used according to the information mediated and discussed both private or public. Source: An anthropologist visits the laboratory

Finally, Latour and Woolgar described the transformation of statement types. They realised that lab activities transformed statements from one type to another, typically aiming for type 4 while ensuring equilibrium with regard to the use of modalities. To achieve this, two related operations are necessary: first, the alteration of the existing modality to increase or decrease facticity; the use of existing statement types to increase or decrease facticity. As such, they used a network of texts containing a multitude of statements, which implied a series of operations on and between statements. Lab members were convinced of an inscription´s relation to a substance if similar inscriptions exist and statements were easily recognised if a similar statement could be found. Latour and Woolgar recognised that the subjectivity of a statement disappeared with the accumulation of similar statements. The 'object' state could be achieved through the superimposition of a particular number of documents relating to something beyond the reader or author's subjectivity. In this case, modalities served as 'weights'; that is, the addition or subtraction of documents altered the weight of a statement.

This paper, thus, is positioned within the theoretical tradition of Latour and Woolgar, sympathetic to their scepticism towards the radical separation of natural and social sciences. Latour and Woolgar realised that scientific work's production of knowledge is crucially constituted by and dependent on the daily routines of the office and the laboratory bench (Jensen et al. 2007, p. 64). Beneficially for this research, the ethnographic approach does not require acquaintance with a particular culture´s rituals, beliefs or terminology in the manner of becoming a full participant or member (ibid.). Latour and Woolgar also focused on the inscriptions within the researcher's literary obsession, represented by the journals, protocols and figures that form the foundation of their research. This information, provided by the many devices of already established order enable the discussion; for example, in the context of interpreting a graph, assuming that the inscription devices used to correspond with the original research (Olesen and Kroustrup 2007, p. 70). However, scientific processes and a laboratory's intrinsic routines include more procedures than those expressed in any given article. Thus, according to Latour and Woolgar, the 'inscription devices' used – the actions, text and devices – must be scrutinised (ibid.).

4.2 Domestication of the scallops and the fishermen of St Brieuc Bay

The study examined how the systematical exploitation of scallops in Saint-Brieuc had progressively dwindled the stock and how the reconstitution of scientific knowledge had precipitated new social relationships. Michael Callon's study investigated the elements of a sociology of translation and is particularly well suited for the analytical framework, as it considers the roles played by biometric technology, science and society in structuring power relations. The study began by examining the development of social relationships on the basis of 'scientific knowledge', expounding upon the generally fallacious approach a sociologist takes when entering scientific fields within society. Callon's introduction addressed three principles underpinning the economy and scientific controversy surrounding the decline in the population of scallops in Saint-Brieuc Bay: generalised symmetry (the commitment to explaining all viewpoints in the same terms), free alliances (the surrender of all a priori distinctions between the social and the natural) and agnosticism (impartiality of actors involved in a controversy). The paper critiques the way the dichotomy between society and nature strips actors of the capacity to freely discuss society and its constituents given the scientific and technical context of the controversy.

The principle of general symmetry ensures that society and nature are acknowledged to be a mixture of considerations concerning both aspects. That is, fishermen, scallops, larvae, nets, anchors and the scientific community were recognised as equal in ´size´ and the conflicts and arguments in a technological, sociological or scientific controversy are discussed in the same terms. The second principle, free association, discards all *a priori* difference between social and natural events and mobilises the categories and the relations between them as topics for discussion. This aligns with this paper's attempt to identify how different elements of biometric technology are defined and associated by their interdisciplinary and economic positioning, enabling an explanation of the world of a Danish university researcher. The third principle, agnosticism, frames the impartiality of the observer within technical and scientific arguments expressed by the protagonists of the controversy, while also incorporating the social sciences. Doing so abstains from censoring actors from discussing their social environment.

The discussion was clustered around the adoption of a Japanese method for cultivating the scallops, a lack of information regarding the mechanics of scallop cultivation in the area, and the intensive level of fishing that had caused the dwindling stock. Four 'moments' of translation were discerned in the attempt to impose a definition of the situation in the context of the research:

1. Problematisation: Researchers seek to become indispensable in the tension between actors, helping them define the identities and problems of those actors (in this case, fishermen, scientists and scallops) and propose solutions. These steps can establish and solve these problems by negotiating the program's ´obligatory passage point´; according to Callon (1986, p. 2), that passage point involves 'the possibility of increasing the production of scallops by controlling the cultivation of these crustaceans'.
2. Interessement: The group of actions imposed by an entity (in this case, the three researchers) to stabilise the identity of the actors defined through problematisation. For example, although the researchers were inspired by the Japanese technique of preserving scallops, interessement is founded on the interpretation of the desires of actors and the associated entities. The ´device of

interessement´ is used to attract other actors to create a balance of power: For the scallops, this involved using a Japanese-style towline to collect and protect; for the scientists, conferences and conversations were used to garner interest.

3. Enrolment: This is the process of describing groups in terms of the multilateral negotiations which accompany all interessements and whose strength dictates success. In Callon's paper, three actors were enrolled; the fishermen were enrolled without any resistance, the scallops with towline, while the predators were enrolled through physical violencen.
4. Mobilisation: This is the researcher's assurance that the proper spokesman for relevant collectivities are present and able to represent those collectivities without being betrayed.

5 METHODOLOGY

This section illustrates the methodological framework of this thesis, which is based on the qualitative approach illustrated in Figure 2. The approach was chosen because the bulk of our research was grounded in the experiences of individual actors and their subjective opinions, which helped to recognise the research problem formulated by this study. Initially, initial data collection techniques took the form of desktop research (Step 2.0), which included an extensive, systematic literature review. Step 2.1 involved initial semi-structured interviews, which helped develop Step 2.2's semi-structured interviews, at which point we also used data collection approaches such as participant observation and written field notes. In our approach, all methods were carefully selected for mutual validation (Step 2.3). The following sections analyse how each step's execution contributed to answering the research questions.

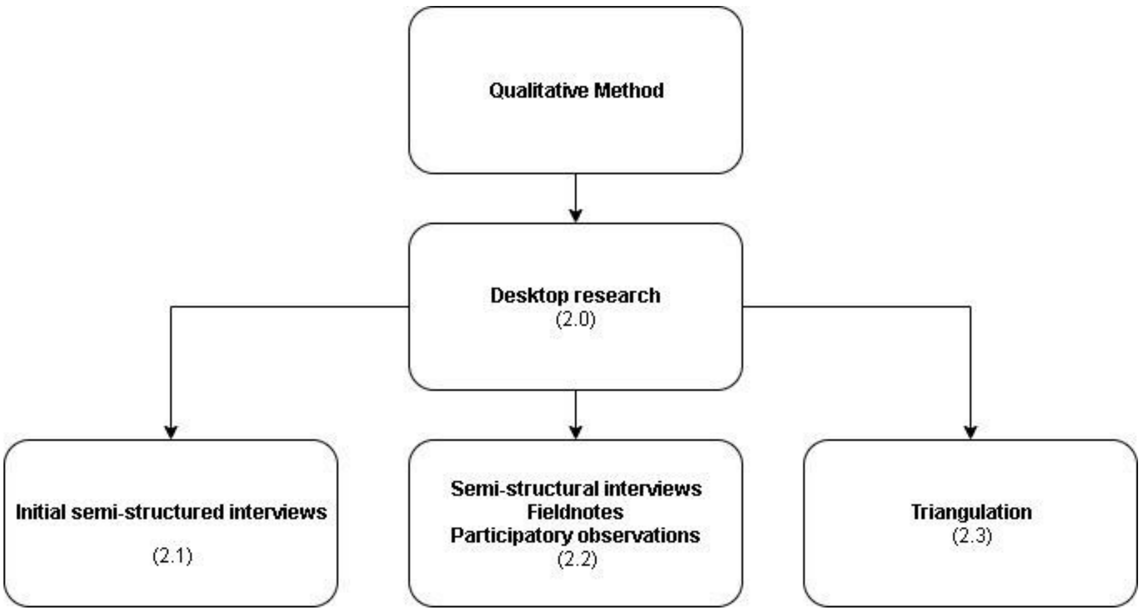


Figure 2 illustration of this thesis data collection

Scouce: Own

5.1 Getting a grasp of the situation

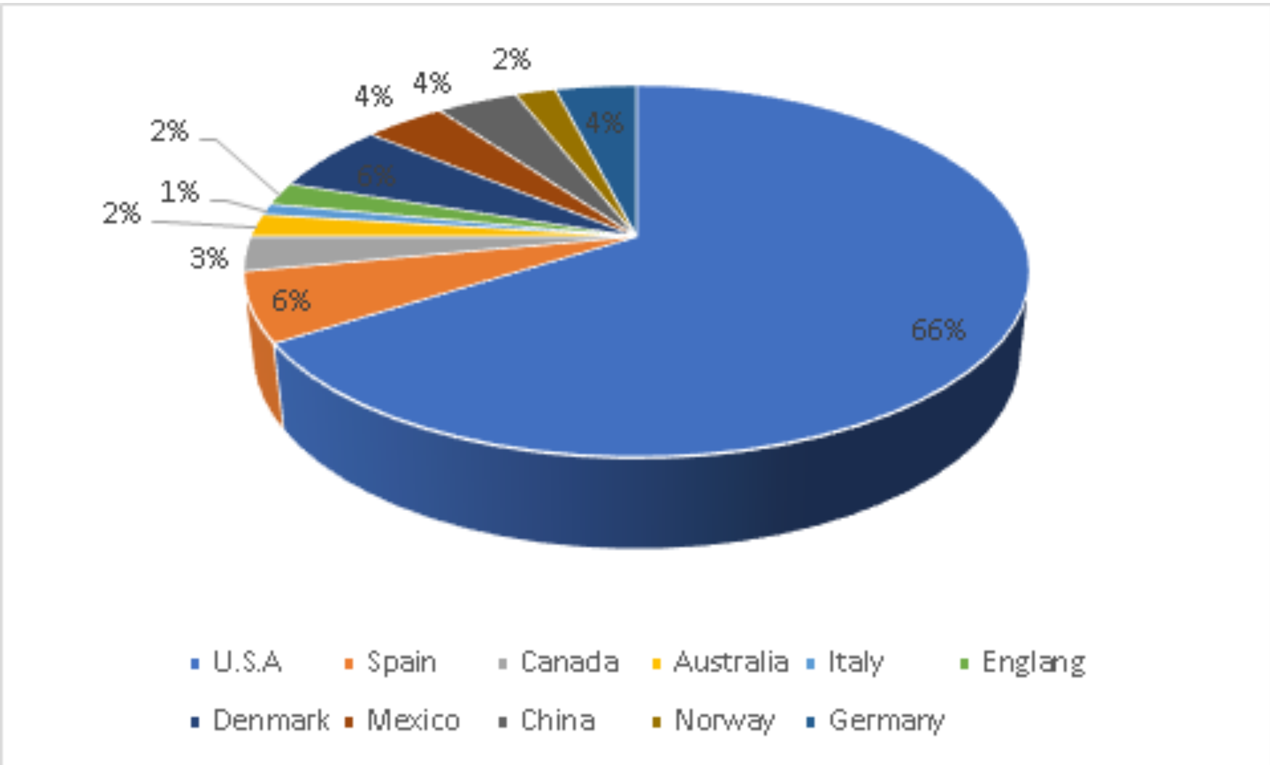
To paint a broad picture of biometric research and the considerations surrounding its use, it is essential to investigate the preference and competencies of individuals researchers and the scientific community, in addition to the guidelines and expectations outsourced by journals and the danish government; all of these components constitute the interdisciplinary, competencies, and technical know-how associated with biometric research. For this research, we utilised a contact at iMotions, a fellow student who was able to open the gate for us. His insider knowledge, which included practical and technical insight from acquaintances at the company, allowed the following series of questions to be answered before we immersed ourselves:

- Which actors have access to biometric research methods?
- Which scientific disciplines are represented?
- How represented are they?
- With whom are they collaborating?
- Why are these scientific disciplines working together?
- What are the general and practical issues?
- What are the technological capabilities and limitations of biometric technology?
- How are universities and professional scientific bodies responding to this technology?

The answers reflected our contact's dual position as both a student and an iMotions employee. Although his knowledge and acquaintance with research life did not provide all-encompassing responses, especially given his attachment to a specific community, his responses helped us to prepare certain topics that might emerge during interviews. As such, we have been able to use iMotions as a mediator between us and their experts and clients. Furthermore, the database on the iMotions homepage served as a point of departure for mapping a holistic picture of published projects, authors involved, scientific disciplines, and countries using biometric technology in research.

5.2 Preliminary fieldwork

Scrutinising the iMotions database, we became aware that the database might be influenced by their interests. For instance, it was possible that only successful studies are presented, while unsuccessful studies are ignored (survival bias). This might omit articles filling gaps in the field of biometric research. Especially, when mentioning how insightful a project on their database was, it focused on the challenges and limitations of biometric research (Nichlas fieldnotes, 2019:1-2) The statement was a test, but showed how iMotions quickly changed focus into locating the project, because such a study should not be in their database (ibid). Also, projects might be using iMotions software without the company's awareness; subsequently, these would not be included in the database. To create an overview, a list of the most familiar countries using biometric research is represented by figure 3, which clearly indicates that the US is the frontrunner and is followed by Denmark and Spain. Nonetheless, it would be misleading to label Denmark as a frontrunner because the chart is merely an indicator that Denmark is acquainted with biometric research. Given the complexity of comparing researchers from Denmark and the US – which would require us to also compare how universities, culture, politics, economy, and life as a researcher differ – a transcription into a Danish context was considered too



extensive.

Figure 3 Top 11 countries who have published articles involving biometric research as a data collection method or theme, Source: Scopus

Digging deeper a bit deeper, we began to isolate all the authors, and the field they represent associated with the project, as seen in figure 4. Psychology, neuromarketing, IT management, Computer Science, and food science are the disciplines most represented. An arguably reason may stem from either the interest in the human mind and behavior or the validation and implementation of the technology. With the graph, we can locate the university researchers who are acquainted with biometric research. Before contacting the authors, we cross checked the reliability of the data from iMotions with the Scopus database. Scopus is the abstraction and citation database of Elsevier. Scopus is from an objectively viewpoint more trustworthy compared to iMotions, but nevertheless will the design of our search criteria, and, the discourse of biometric research include and exclude relevant and irrelevant papers. Finally, Scopus has a filter sort the articles by country, which makes the comparison more precise.

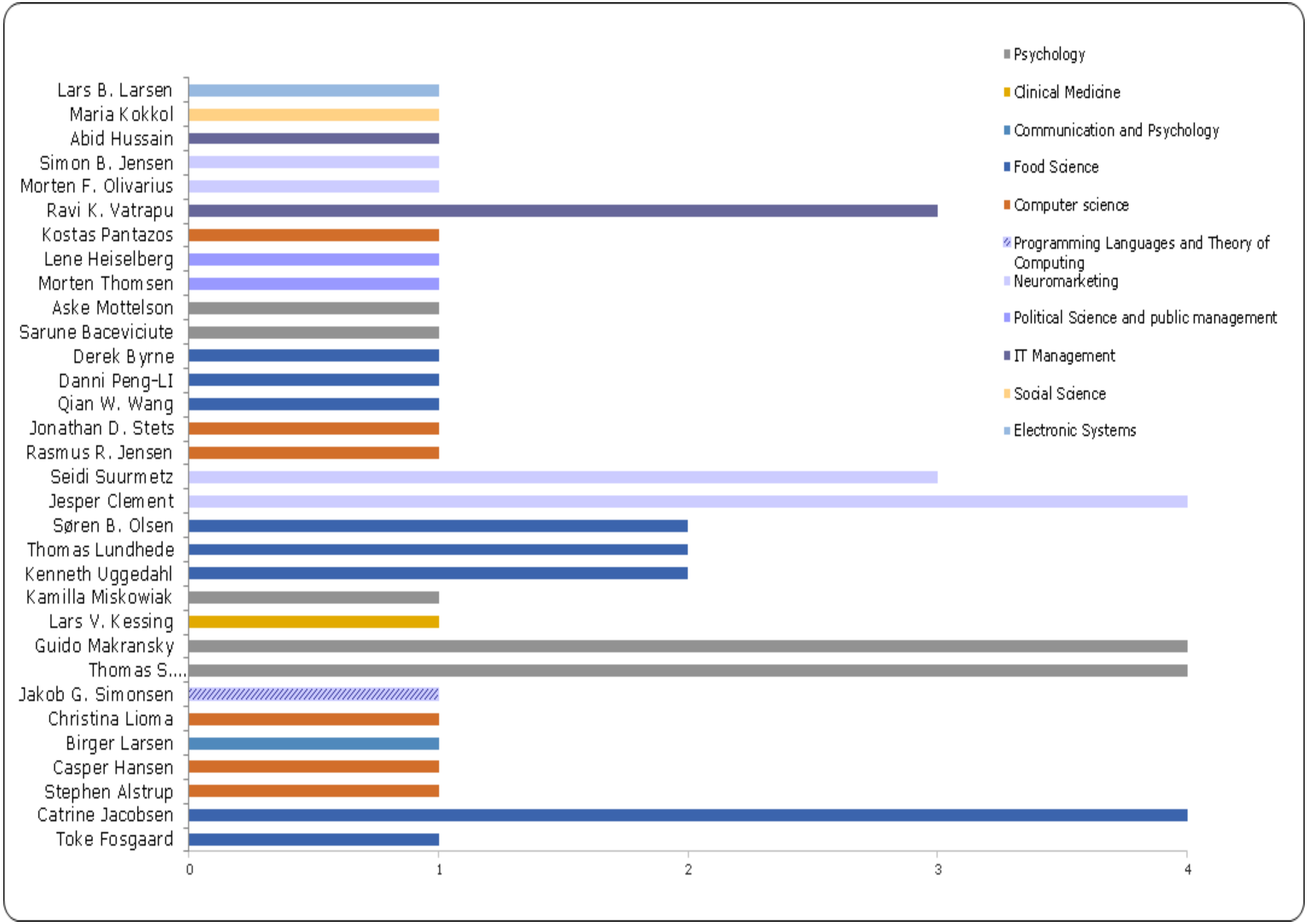


Figure 4 Top 10 authors who have published articles using biometric research with a table showing their discipline

In the following sections, we indicate how Steps 2.0, 2.1, 2.2 and 2.3 were applied and combined to shape this thesis, beginning with the literature review component of our desktop research.

5.2.1 Searching for materials

The data extracted corresponded to intricate research on lexemes and synonyms for the broad topic of 'biometric research'. This strategy was adopted due to the distinct terminologies and individual interpretations. For instance, the description of biometric research may vary between researchers and disciplines and even between projects. In such cases, the optimal choice was including search criteria that considered these variations. Table 1 shows this in practice; our searches used the following syntax, which incorporated Boolean operators: ['Biometric research' OR 'Biometric-research'] (Search 1), ['Galvanic skin response' OR 'Eye-tracking' OR 'Facial analysis' OR 'Electroencephalography' OR 'Electrocardiogram' OR 'Electromyographic'] (Search 2), and ['Biometric sensor' OR 'Biometric sensors' OR 'Biometric-sensor' OR 'Biometric-sensors'] (Search 3).

Search no.	Index	Top discipline and number of published papers	Focus
1	“Biometric research” OR “Biometric-research”	Computer Science (134) Engineering (54) Mathematics (44)	Optimizing the sensors and software
2	"Galvanic skin response" OR "Eye tracking" OR "Facial analysis" OR "Electroencephalography" OR "Electrocardiogram" OR "Electromyographic"	Medicine (122.791) Neuromarketing (50.690) Computer Science (29.518)	Used in medicine as treatment or research related interest and in neuromarketing to explore human behaviour and consumer´s interest
3	"Biometric sensor" OR "Biometric sensors" OR "Biometric-sensor" OR "Biometric-sensors"	Computer Science (233) Engineering (145) Mathematics (60)	Optimizing the sensors and software

Table 2 Overview of search index used on Scopus

Source: Scopus

The results are papers published between 2005 and 2020, with 2005 chosen because the platform was released in 2005. Although moving the start year from 2014 (the first year represented by the iMotions database) to 2005 creates a different dataset, to validate the iMotions database, it is necessary to ensure data from the iMotions database properly represents the most prevalent disciplines and countries using biometrics. Results were retrieved from Scopus database based on the paper’s title and abstract and the author´s keywords. The dataset comprised 197,795 papers, each representing an unique article. Before juxtaposing the Scopus and iMotions datasets, we conducted and compared the results of three separate searches. Search 1 returned 215 papers, Search 2 returned 197,339 papers, and Search 3 returned 311 papers. After combining the searches and removing duplicates, the total was 197,795 papers spread across 160 different journals and 28 disciplines, authored by more than 170 different researchers. The results indicate that 456 papers use a lexeme of ‘biometric research’ or ‘biometric-sensor’ without referring to a specific sensor and 31 papers do not speak of biometric research or a particular sensor but refer to biometric sensors. This indicates that different discourses exist within the field of biometric research, which defines our research as an overview rather than a holistic picture of biometric research. Figures 5 and 6 show the most prominent disciplines and countries in the field, with Figure 6 locating Denmark in a cluster of countries separated by only a few published articles. Although Denmark is not the most publishing country, the concordance of this data with the iMotions data confirms that researchers in Denmark are sufficiently acquainted with biometric research and contact with the Figure 4 authors would be valuable to this research.

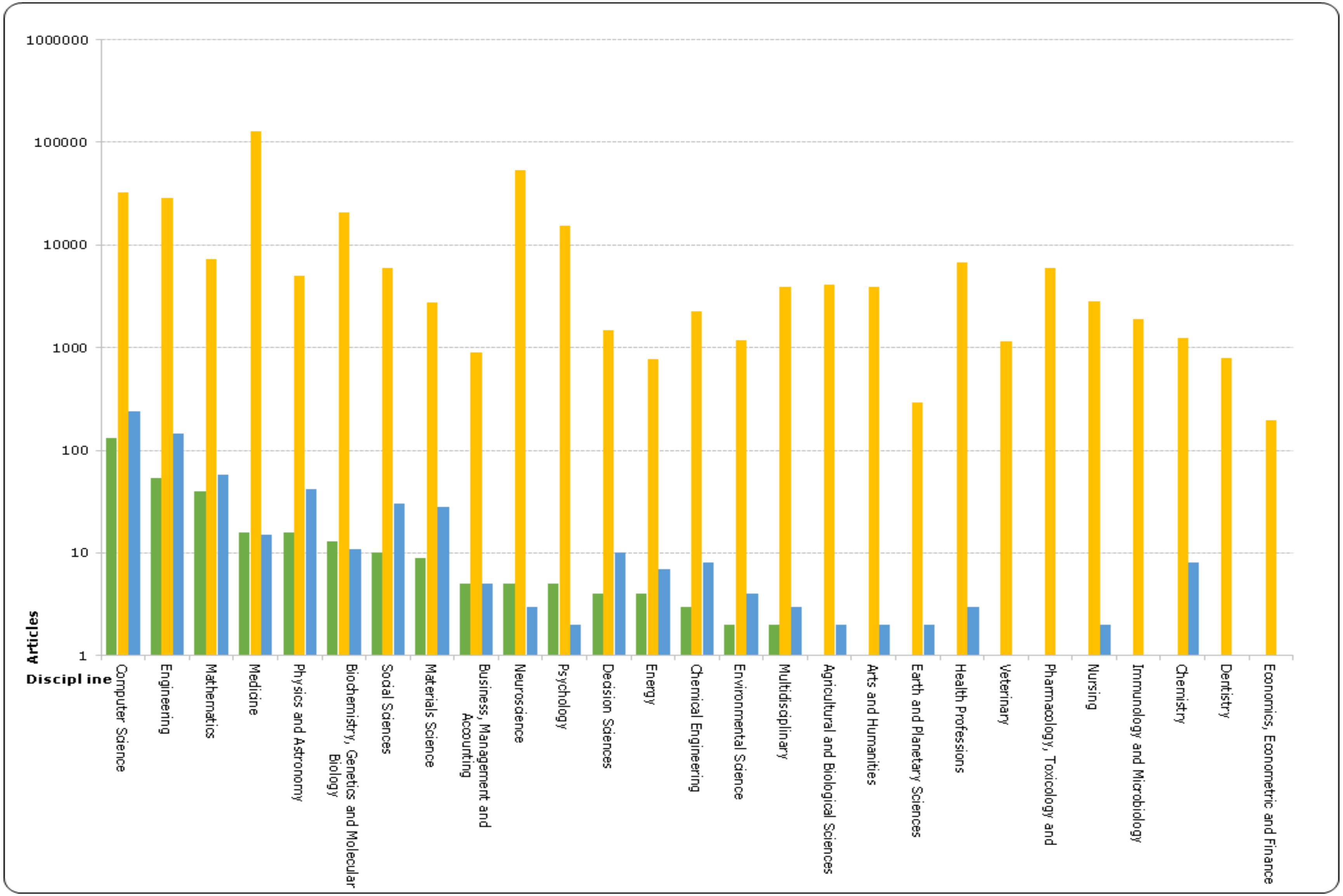


Figure 5 The number of articles each discipline have published. Some articles may overlap due to the multidisciplinary biometric research invoke. Search 1 (Green), search 2 (orange), and search 3 (blue)

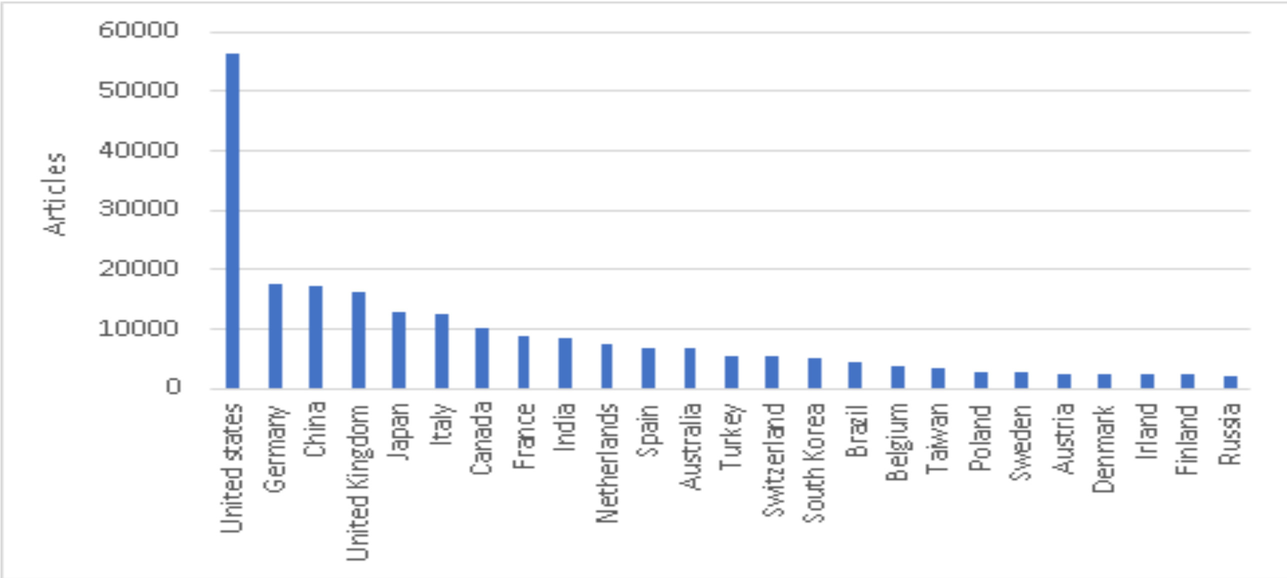


Figure 6 Total amount of publications in a country involving biometric research, when searching in the abstract, keywords or title between 2005-2020. Source: Own

5.3 Synchronizing sources

When mapping the complexity of practical and theoretical challenges and the behaviour of researchers, the validity of findings must be confirmed through the convergence of different perspectives (Turner & Turner, 2009). Brender defines this method as triangulation: 'Used at different levels in a methodology: methods, measures, and data triangulation, as well as investigators and theory triangulation' (Brender, 2006:316). This has the advantage of compensating for weakness in the methods applied in cases with no stronger methods available or feasible (ibid.). Triangulation eases framing of the problems identified, in this case, within biometric research, and distinguishing between the relevance of the topics. The method also recognises that skill shortages might not be the only limitation impeding data quality: available resources and relevant cases also impact the preconditions and judgement of preconditions against the ambitions of a research project (ibid.). For valid empirically collected data, it needs to feature multiple perspectives from different sources (Turner & Turner, 2009:172); in our case, this meant going to laboratories and conducting interviews with different actors. Investigations are a natural part of qualitative studies and typically involve a coding phase. Triangulation is confirmatory and demonstrates the reliability of the coding instrument (ibid.:173).

Investigations also enhance confidence in triangulation by illuminating the potential divergences a study features (Brender, 2006:316). The data was derived through comprehensive application of multiple approaches, with our panoply of methods aiming to provide 'a picture as complete as possible of the learning experience rather than to challenge or contest findings' (Turner & Turner, 2009:173).

As Turner and Turner recommended, we have collected empirical data through qualitative measures, which included semi-structured interviews (in person or through videoconferencing technology), thematic coding, classification of open-ended responses, review of scientific articles and expert reviews from different disciplines, insight from technical experts and experienced users, and identification of illustrative and explanatory examples (ibid.:174). This provided insights accommodating both temporal variation and spatial variations – the distinct findings of different researchers in the same environment (ibid.:173).

5.4 Observing Copenhagen Business School and iMotion

Throughout our observations at two laboratories and one workshop, we have reflected upon our position in the field, considering how we might be perceived by researchers. When entering an unexplored field and engaging in social situations with no comparable frame of reference on correct praxis, it is necessary to build this through experience (Spradley, 1980:53). For example, we entered the field of biometric research without being acquainted with the tacit rules of behaviour, in which we falled naturally into the role of participant observation (ibid.). When conducting observations, it can help to relate to the actors in the field of study and open the field to inquiry. Additionally, observational fieldwork enables the researcher to ask questions found most 'correct' in the interviews, creating a more intuitive understanding of the data collected. Furthermore, through describing a practice, observations allow communication of detail, as elaborated on by Szulewicz:

One of the strengths of participatory observations is that it makes the researcher able to provide saturated descriptions [...] which is both an advantage in written communication, oral communication, and when sharing one's observed insights orally with one's colleagues or the observed subjects (Szulewicz, P. 2015:87)

This paper's authors each approached observation differently due to their different personal, cultural, and professional backgrounds: Birita is from the Faroe Islands and has a Bachelor's degree in Techno-Anthropology, while Nichlas is from Denmark and is educated as a construction engineer. As observers, we focused on how different paradigms, universities, and personal opinions had created different experiences of biometric research and how this impacted each researcher's expected behaviour, beliefs, thoughts, and research design. The observational fieldwork was conducted at both the iMotions facility and Copenhagen Business School (CBS). At iMotions, we observed research on people's emotional reactions to political campaign videos. At CBS, one of the projects hypothesised that increasing the exposure to an object increases how much the individual person´s likes it, where its popularity was low to begin with. The second CBS project focused on hotspots on the labels of different products, helping developers determine where and what to change about the label. Our roles varied across the observations. At iMotions, we were both respondents, researchers, and passive observers. In the first experiment at CBS, one was a passive observer, and one was a respondent; in the second CBS experiment, we were only respondents.

Although all of the experiments used facial analysis and eye-tracking, at CBS, data was cross-checked against a post-study questionnaire. In contrast, at iMotions, the researcher took notes constantly throughout the experiment; these notes were referred to during the debriefing interview. Nichlas participated as a respondent in all experiments, while Birita was detached during the CBS project on likeability; for this study, she was a passive participant occupying an 'observations post', playing no active role in the social situation and instead becoming a 'spectator' or 'loiterer' (Spradley, 1980:59). Birita's acquaintance with the project due to observing Nichlas disqualified her as a test subject. At iMotions, we were both 'active practitioners' seeking to understand the cultural rules of the researcher's behaviour; that is, when entering the field as a participant, the observer is able to learn the behaviours of the observed (ibid.:60).

Being active practitioners helped to both document the execution of the research's techniques and understand the reasons for the behaviour of researchers and participants. As researchers, we could control the phase of the experiment, the questions asked and the calibration of the equipment. By observing participant reactions, we were able to formulate questions to ask during the interview. As participants, we were met with the thoughts, confusions, frustrations, emotions, and emergent questions naturally occurring through participating in an experiment. All of the roles included in-situ or off-site documentation of our observations, which, in turn, enabled us to observe ourselves. As outsiders, detached from the situation, we were able to observe both the experimental constellation and the mutual involvement of respondents and scientists, as well as their influence on the experiment. This approach enabled not only controlled alternation between outsider and insider experiences but also the capacity to experience both roles simultaneously (ibid.:54), an approach encouraged by Spradley:

> *"Hayano played many thousands of hours of poker, listened to people talk, and observed their strategies for managing the game. As in insider he shuffled cards, dealt hands, made bids, bluffed, and both won and lost hands. As an insider he felt some of the same emotions during the course of the game that the ordinary participants felt. At the same time he experienced being an outsider, one who viewed the game and himself as objects. He had the uncommon experience of being a poker player and simultaneously observing himself and others behaving as poker players. He was part of the scene, yet outside the scene"* (ibid.:57)

This meant we were able to balance as a moderate participant between an insider and outsider, participation and observation, leading us to indulge the cultural rules of behaviour. Our observations and our roles always engaged with the field to fulfil at least one of two purposes – '(1) to engage in activities appropriate and (2) to observe the activities, people, and physical aspect of the situation' – instead of simply the ordinary participants' purpose of 'engag[ing] in the appropriate activities' (ibid.:54). This recalled both the experiment's general steps and the chronological order of the method, leaving the differences between the experiments and the researchers explanations to remain inside the investigator's head (Spradley, 1980:53). Studying an experiment's physical constellation – its set-up – and the researcher's reactions as they appear enhanced our understanding of the implicit cultural norms. During the product-label experiment at CBS, we spoke with a PhD candidate who familiarised us with a framework of the pivotal elements according to the values of her discipline: authenticity, internal vs external validity, the validity of the data, and the documentation of the science behind the format.

Participating in two experiments allowed us to align certain recurring external factors (light, software platform, equipment, light bulbs and ergonomics) that impacted our thoughts and emotions and, therefore, the data. Also, during the observations, we paid attention to the researcher's context, in terms of education, social status and professional position, especially as this concerned what they found critical to study, what they saw as the benefits of using biometric research, which disciplines they considered to involve, and which particular challenges they faced. In so doing, we could map the less important impressions that are normally excluded due to the complexity of social life (Spradley, 1980). For example, if standing in line at a vending machine that is used everyday, one would notice how the people in line and next to the vending machine behave, how they interact with the vending machine, and how the sounds create different reactions. Whereas, when unfamiliar with biometric research, have we as participant-observers, been able to capture all of the activities, sensory information, and incorporated objects – including the things which, due to brain 'overload', would normally go unnoticed – and overcome 'a system's inability to process inputs from the environment because there are too many inputs for the system to cope with (Milgram 1970:1462)' (Spradley 1980:55), a mechanism that humans could not live without (ibid.).

5.5 Interview

Interviews have been one of the ethnographic methods we have used to answer the research topic because they provide knowledge of other people's opinions and experiences (Tanggard & Brinkmann, 2015). The interviews were semi-structured, ensuring we could adhere to constructed categories while permitting the freedom to elaborate on research questions (ibid). This allowed the interviews to adapt to different respondents according to what seemed most valuable to elaborate on. Furthermore, this enabled the interviewer to ask open-ended questions, which promoted both factual and meaningful responses according to individual experiences (Kvale & Brinkmann, 2009). Kvale recognised this as allowing the interviewer to uncover some essential meaning surrounding a subject through the structuring of the questions and their unravelling by the respondent, even if the interviewer could conceivably influence answers through phrasing or framing of questions (ibid). This concern about potentially leading questions is diminished by triangulation – the interviews were structured with an offset, according to the funnel model, where 'each group begins with a less structured approach that emphasises free discussion and then moves toward a more structured discussion of specific questions' (Morgan, 1997:41).

5.6 Choice of respondents

When answering the research question, it is essential to consider the perspective of generating the information and who appears to have access to the information. Kvale and Brinkmann describe the importance of producing an overview of respondents according to their relevance by categorising them according to their perspective (Kvale & Brinkmann, 2015). Accordingly, we divided our informants into three categories: Danish universities, experts and practical users. Students were excluded due to their narrow experience of how their discipline theoretically and methodologically embrace biometric research. Furthermore, students might not be familiar with the university's structure regarding politics, expectations, and economy, while professors, who have attained a certain professional and personal status, will likely be emotionally invested in biometric research and its applications. These criteria ensured respondents would be information-rich, which complies with our demand of requisite experience of biometric research experiments. To comprehensively map biometric research, it was essential to locate a link between the experts and the researchers. During the interviews, we explored how the tenacity of respondents was challenged by journals and their own competencies both technical and academic; these were the topics the experts found most relevant. When mapping actors in biometric research, the people who have published biometric research are easier to locate than those who have not yet published their research and those who are not interested in the method.

To permit critical insights, we asked our respondents about the opinions of their colleagues towards biometric research, as well as considering how our respondents analyse and perceive the objectivity of biometric data. The respondents were primarily found among the authors of the publications on the iMotions webpage, with the remainder contacted based on recommendations from iMotions or our respondents. A total number of 13 interviews were conducted: nine interviews at three different universities – University of Copenhagen (UCPH), CBS and AAU. The remaining four were not from universities in Denmark but were acquainted with the use of the biometric methods. In the following sections, we present the respondents, including their professional backgrounds, positions, and the experiments they have conducted using biometric technology.

5.6.1 Food studies

We conducted four interviews with researchers resident in food studies, three from UCPH and one at AAU. Søren Boye Olsen, from UCPH, has a Master's degree in forestry and a PhD in environmental economics. He works as a professor at the faculty of environment and natural resources and is head of the MSc in Environmental and Natural Resource Economics. Søren has 15 years experience predicting demand for new food products according to the economic valuation of non-market goods, such as the ecosystem and natural services. His results are used in a cost-benefit analysis to improve the decision-making process of practical applications. Søren´s thoughts are anchored in natural science when designing projects. Søren´s success with biometric research critically stems from his discipline, which allows him to assess the limitations and possibilities of methodologies and theories according to the particular project (University of Copenhagen, 2020, pp. 4).Furthermore, he embraces interdisciplinary and intercultural projects that operate with both qualitative and quantitative data collection methods (University of Copenhagen, 2020:4–5).

The remaining two respondents from UCPH are referred to as his 'descendants'. According to iMotions database, two of the projects was authored by Søren, Catrine Jacobsen and Kennet Christian Uggeldahl,were co-authors. Catrine Jacobsen holds a Master's degree in cognitive and decision science, a background which assisted her to complete a PhD in behavioural science. During the PhD, she focused on activities and societies, which has given her competencies in statistical, mathematical and computational models, as well as methods for analysing behavioural data in natural and online contexts. This allows her to apply theories and methodologies from cognitive science. Catrine works at Denmark's competition and consumer authority as a behavioural insight advisor. Meanwhile, Kennet Christian Uggeldahl, like Søren, has a Master's degree in environmental and natural resources economy. Kenneth completed his Master's thesis as a continuation of Cathrine's work, with Catrine as his supervisor. Following his thesis, Kennet completed a PhD in environmental valuation, choice modelling and eye-tracking. Like Catrine, Kennet works at Denmark's competition and consumer authority as a behavioural insight advisor. It has been interesting to interview and uncover the beliefs and thoughts of these respondents regarding interdisciplinarity, theory and standardisation, especially given they have published scientific articles together and have similar educational backgrounds.

5.6.2 Neuromarketing

Experimentation with aspects of how human behaviour is expressed physically and how it can be affected has interested marketing. Given its applicability in society, as explained in Chapter X, we found it essential to investigate the scientific perspectives from neuromarketing. The respondents, Jesper Clement and Seidi Suurmets, were found through scraping the iMotions database.

Jesper Clement has a PhD in consumer behaviour from marketing at CBS and has been using biometric technology since when it was manually controlled by a joystick (interview with Jesper, 2019:3). Jesper told us about an ongoing experiment we could participate in, which investigated how liking arbitrary but selectively chosen pictures was affected by increased exposure, if the likings was rated low the first time. The liking was set on a scale from 1–10, with Jesper´s interest being how liking changed while repeating the experiment three times, hypothesising that the reaction of the amygdala – which is involved in the experience of emotions – will be less pronounced following repeated exposure to the same picture. The project was conducted in collaboration with a colleague from psychology at UCPH, who designed the research according to the requirements of the most appropriate journal (interview with Jesper Clement, 2019:1). Jesper also works as an associate professor in the marketing department at CBS and is the leader of decision science, which includes research into non-conscious consumer behaviour, the visual impact of brand design and in-store design.

Seidi Suurmets, meanwhile, has a Master's in marketing communication management and is doing a PhD in consumer neuroscience, investigating consumer information processing using eye-tracking. Seidi is hired under Jesper, who is also her PhD supervisor. She is also participating in the afore-mentioned project and has executed many other projects with Jesper. However, Seidi arrives from another discipline, and is a developer for iMotions and worked as a neuroanalyst at Neurons Inc., both of which have provided her with practical, theoretical and methodological experience around the general and specific challenges of using biometric research techniques.

5.6.3 Psychology

Studying the behaviour of a person's eyes, facial expressions, sweat and heart rate is routine in psychology. Anne Bjertrup has a Master's degree in neuropsychology and is now completing a PhD in the fields of cognitive neuropsychiatry and developmental psychology at the Institute of Psychology at UCPH. Anne studies new mothers with affective disorders and the interplay between them and their children in an attempt to understand and interpret this mental state. To collect empirical data, she uses biometric techniques when exposing the mothers to videos of different facial expressions of babies, such as crying, laughing, chattering, and not getting attention when crying. Anne uses eye-tracking, galvanic skin response, and facial expressions to measure the mother's arousal (interview with Anne, 2019, pp. 3). With an education that focuses on the emotional and cognitive states of both children and adults with neuropsychiatric diagnoses, Anne embraces the possibilities of biometric research.

Her discipline appeals to the development of new therapeutic methods and techniques, including activation- and training-based methods (University of Copenhagen, 2020). An approach her project attempts to accomplish by combining both qualitative and quantitative assessments of the cognitive deficits of mothers (interview with Anne, 2019:1).

5.6.4 Medicine

Troels Kjær, is a professor of cognitive neuroscience, operating out of his own laboratory in Roskilde. Neuroscience studies the cohesion between cognition and human behaviour, cellular and molecular biology and anatomy and physiology in an attempt to map the brain at a purely physical and deterministic level. Neuroscience stems from natural science but operates in close contact with disciplines such as psychology, medicine, engineering, linguistics, mathematics and computer science, which involve both qualitative and quantitative methods (Sampson, 2018). Troels works at UCPH as a professor at the institute of neuroscience and clinical medicine and at Sjælland´s university hospital as head physician (overlæge). He was contacted through a project conducted for Ford regarding driving pleasure. The project examined sections of the brain related to joy or pleasure and when they were activated. Although Ford wanted to generalise findings about increases in driving pleasure, Troels made clear that driving pleasure is subjective and difficult, if not impossible, to generalise.

5.6.5 iMotions

Considering the scarce amount of interest biometric research has gotten in terms of publication, we considered it essential to interview experts from iMotions about what they saw as success for the field.

Mike Thomsen has a Master's in interactive digital media and works as a technical specialist at the company. He has thorough knowledge of the relationship between technology and scientific standards, choice of sensor, validation of the data, and publication opportunities. Given his educational focus on mediating research between disciplines according to practical challenges, Mike consults researchers who need help with research design. He also uses his critical skills to evaluate scientific theories related to design, cognition and communicative methods, making him a valuable asset for comparison with our other respondents.

Oscar Haven holds a Master's in research and experimental psychology with a focus on clinical and psychological cognitive neuroscience. Oscar works as a customer success manager at iMotions, consulting on constructing research designs that ensure valid data that aligns with the research questions and the format of a journal, as well as helping researchers analyse their raw data.

5.6.6 The Centre for Telepsychiatry in the Region of Southern Denmark

We interviewed experts from the Centre for Telepsychiatry in the Region of Southern Denmark because of their interest in biometric equipment. Biometric technology was not yet part of their practice because of the absence of empirical data. Nonetheless, we were interested because Johan Rasmussen's work expressed concerns regarding the absence of empirical data to substantiate the efficiency of the method. Johan is further challenged by the absence of courses at universities, as they do not have time to educate people on how to use biometric equipment. Johan has a Master's degree in social science, political communication, and management and works as a technical leader of health technology, which intersects developing and implementing technology and treatment methods. He believes biometric technology can create a better environment for patients avoiding the point at which syringes, pills or fixation need to be used.

5.6.7 LEGO Education

The final interview was with Rasmus Horn of LEGO Education. For about 40 years, LEGO Education has developed playful learning experiences for kindergartens trying to make learning fun and impactful. Rasmus has researched children's development and preferences in collaboration with specialists and educators to ensure effective research design and results that can optimize the appeal of toys and improve the learning curve. Although a profit-driven company like LEGO cannot be considered an 'academic actor', its research can still be rooted in scientific values. Rasmus has a background as a multimedia designer with a focus on user experience, and we considered him relevant for understanding practical issues and technological limitations. Also, how the results can be misinterpreted, especially in a time-pressured context.

5.7 Interview guides

Based on the premises above, we tailored our semi-structured interviews guides using an inductive approach. The inductive approach involves asking respondents open questions about their practice, before building ideas about patterns and coherence according to what we consider empirically relevant. The approach suits our scientific approach, actor–network theory, which analyses the social and natural worlds to generate responses within a web of relations. This approach provides an appropriate toolbox for explaining relations between phenomena. The interviews provided insight into the personal and professional competencies of respondents and their opinions regarding biometric research. We wanted to understand respondents' perceptions of biometric research and future intentions for its application, as well as understand the impact different actors have in the practical and structural dimensions. Therefore, we formulated open questions forcing reflection on individual thoughts (Kvale & Brinkmann, 2009:45). The interview questions were generally characterised by being concrete and descriptive.

For example, questions like 'How do you find this new method accepted?' and 'What kind of, if any, complications have you met with the platform and equipment so far?' were not anchored in a specific theory, but rather served as clarifying questions based on categories we found interesting during the desktop research. The interview guides were structured according to the respondent's individual focus on biometric research, as well as their professional position, as presented in the interview guides (Appendi 12-17). When conducting the interviews at iMotions, respondents were beforehand, given the technical questons to ensure they would be answered; consequently, answers were delivered completely naturally (Kvale & Brinkmann, 2009, pp. 46). It should be noted that the interview with Troels Kjær was conducted over Skype, which creates a different atmosphere. Given participants were not anonymised, the consequences the information could have on the private and professional lives of participants was carefully considered and the interviews were conducted with transparent respect for each respondent's safety (Kvale & Brinkmann, 2009, pp.45.48).

5.8 Mapping

The goal here is to layout as best one can all the human and nonhuman elements in the situation of concern of the research broadly conceived. (Clarke, 2003:561)

Adele Clarke's development of situational analysis accommodates the flaws that grounded theory is believed to have. Adele Clarke is a professor of sociology and history of health, and wrote the book 'Situational Analysis in Practice: Mapping Research with Grounded Theory'. Situational analysis attempts to resituate the theory through a postmodernist lens in the hope that a new approach to analysis can adopt a more flexible framework (Clarke, 2003:553). The alterations – new approaches, situational maps, and analysis – are useful for research projects whose data is derived from interviews, ethnography and visual, historical and multi-site research. It was appealing for this project because of our ethnographic fieldwork. Situational analysis allows researchers to analyse complex inquiries by combining studies of discourse, agency, structure, context, history, and the contemporary moment (ibid.). This thesis has embraced the approach because of the radically different conceptual structure it applies to basic social processes in comparison to that of grounded theory. Situational analysis has, thus, offered us two main cartographic approaches:

1. Situational maps, which lay out the human and non-human actors and the discursive and relevant elements of biometric research situations, provoking analysis of their relationships; and

2. Social worlds, or arenas, which lay out how actors are collectively linked, who the key actors are and which arena they negotiate from.

These maps provide an analytical approach to our social science data and are especially recommended for contemporary studies based on interviews, observations and fieldnotes (Clarke, 2003:554). Situational analysis focuses on centring complexities, such as the conditions and key elements characterising both the biometric research and the individual researcher. Clarke's work provides a way of considering both the collective and individual challenges, as expressed by the respondent in terms of the professional, the personal, the structural, or the technological. Situational analysis deeply situates research 'individual[ly], collectively, social organisationally and institutionally, temporally, geographically, materiality, culturally, symbolically, visually, and discursively' (ibid.). That is, the postmodern lens shifts emphasis away from universality, simplification, homogeneity, sufficiency, generalisation, wholeness and rationality and towards positionality, instability, contradictions, situatedness and heterogeneities (ibid.:555).

Although this thesis was not undertaken with a complete situational analysis, it informed our awareness that our work relies on the analysis of social arenas. This is because our focus on researchers, economy, competencies, paradigms, technological understanding, theory, methodology, politics, external and internal factors interfering, competition, prestige, and data validation led this multi-site study to take a nonhuman object – biometric research – as its centre. The coding comprises themes categorised in our interview guide and themes that arose during our interview and transcription process, leading to the situational map – the messy map – which is rooted metaphorically at the meso level and enables individual analysis and exploration of new social worlds (ibid.:558); this is represented in Figure 7 and exemplifies how situational analysis differs from grounded theory, which focuses on social processes or action.

Finally, we considered relations between actors, indicating how they were linked, which 'helps silences to speak' known as non-human actors. Laying out the collective actors and the arena(s) of commitment which manifest ongoing negotiations enables meso-level interpretation of the interactions between institutional, social, and organisational influences (ibid.:560), as seen in Table 2. Categories assigned to relations are situated within the research; thus, departing from Clarke´s ordered situational map, our project has the flexibility to judiciously select the relevant categories

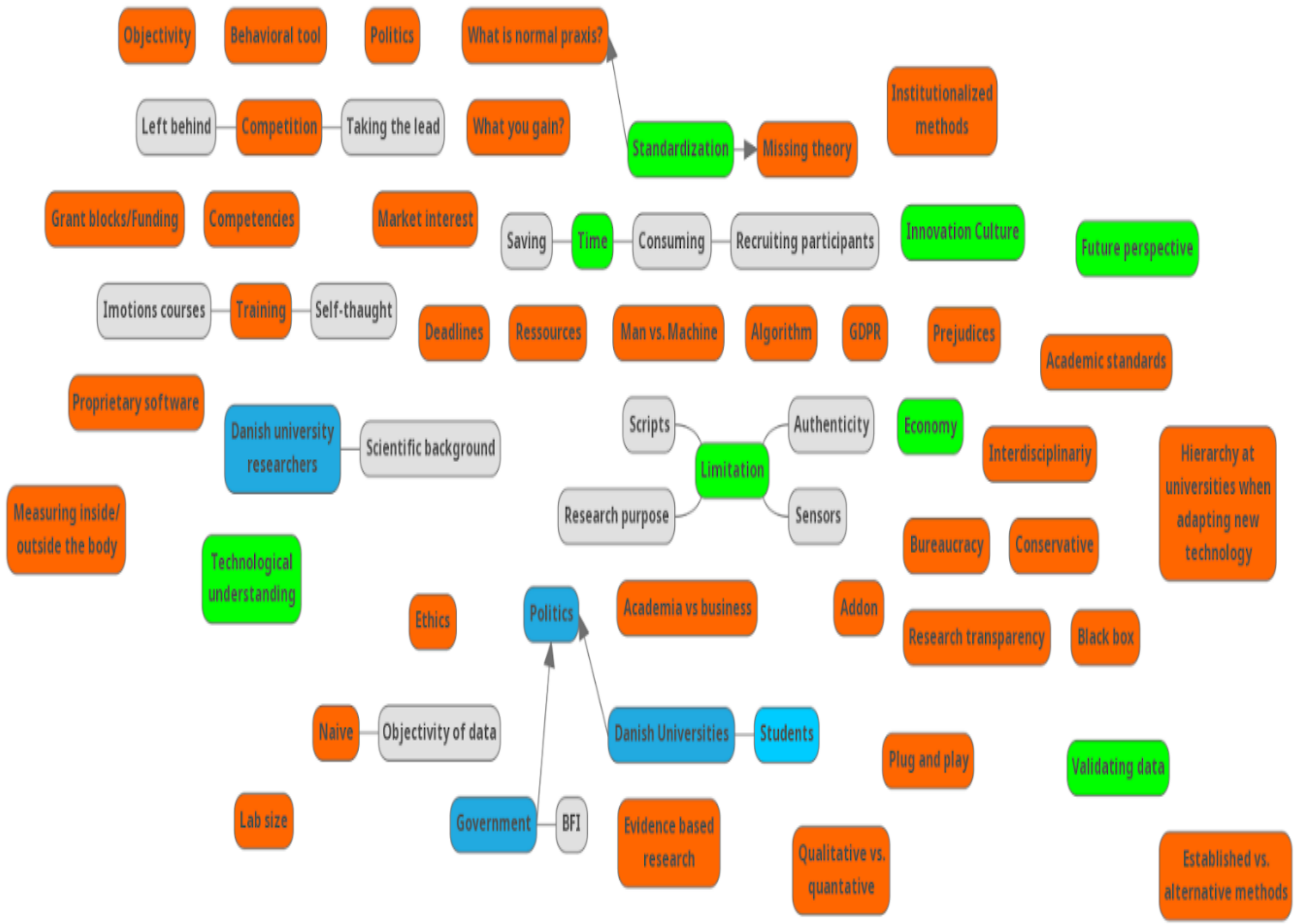


Figure 7 The messy mapping of our empirical data in three categories: Themes (green), human actors (blue), and non-human actors (orange)

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Individual human elements/actors	Non-human actor
- Students - Researchers	- Paradigm - Sensors - Scripts - Economy - Prestige - Objective vs. subjective data - Black box around the algorithm - Interdisciplinarity - Praxis - Theory - Academic standards - Internal and external factors according to the setup
Collective human elements/actors	**Sociocultural/symbolic elements**
- The State - Politicians - Journals - University and their board - The business sector - Academia - iMotions - BFI - Ministry of education - Expert/Non-experts - Students - Research groups	- Experts/Non-Experts - Ethics - Competencies - Paradigm - Between countries - Researchers - Societal challenges
Political/Economic elements	**Spatial Elements**
- Global competition - Cost of using biometric research - The interest of the state and ministry of education - The interest of the university - The interest of the researcher - BFI impact on biometric research	Transportation and arrangement of the equipment according to the authenticity of the project

• Journals impact on biometric research	
Major Issues • Economy • Competencies • Global competition • Technological know-how • Missing theory • Standard praxis • Internal and external factors associated with the setup	**Related discourses** • Experts/Non-experts • Economy • Ethics • Researchers • Paradigm • Journals • University • BFI • iMotions • Objective vs. subjective data • Politics • Missing theory • Standard praxis • Global competition • Competencies • Technological know-how • Time • Resources • Algorithm • Academic standards • Interdisciplinary • Validating data • Setup

Table 3 Ordered situational map

Source: Authors

6 Theoretical Framework

In this section, we will account for the theories which will shape the analysis. The theoretical framework of this master's thesis is inspired by Bruno Latour and Michel Callon who are known for the actor-network theory (ANT) and translation process allowing a network to be represented by an individual actor or single entity. Additionally, Kuhn has enlightened how our respondents' paradigms can be an obstacle when elements of what he refers to as the disciplinary matrix are absent.

The point of departure allowed the analysis to position biometric research in the network of researchers, economy, acknowledgement, and disciplines, which is elaborated after analysing the relevant actors. The discussion will explore the differences, similarities, and particular challenges when biometric technology is used in three laboratories and among our respondents, who are researchers working with biometric research.

6.1 Actor-network theory

ANT emerged in the late 1970s and early 1980s, developed by Bruno Latour, and Michel Callon and John Law among others. Bruno Latour and his colleague Steve Woolgar undertook an anthropological visit to Salk Institute to study laboratory life, with the contrary view that facts, specifically scientific facts, are partially socially constructed (Olesen & Kroustrup, 2007). Laboratory life acknowledges constructionism; with the main point that scientific facts are not given through social constructions nor the results of discoveries. Facts are the result of negotiation processes, and these processes involve a wide variety of elements, including laboratory animals, materials, apparatus, literature and social actors. Bruno Latour and Steve Woolgar wrote in 1979 Laboratory Life, which is inspired by American pragmatism, especially the ethnomethodology analyses of how order is created out of disorder through local negotiation processes (Jensen, 2003, pp. 5). However, essential inspiration is also drawn from French semiotics and post-structuralism. For example, Latour & Woolgar are based on Derrida's concept of inscriptions in their description of the laboratory as a factory that transforms substances (experimental animals) into inscriptions (data strips), which are then transformed into other types of inscriptions (scientific articles) (ibid). Many natural scientists felt provoked when perceiving natural and social science as a dichotomy. The claim was not to question the conventional scientific method used but to map the process affecting how facts are constituted.

In further elaboration of this, ANT is not a theory of the same principles as the traditional viewpoint, with interest in answering ´how´ and ´why´; instead, it is a toolbox to investigate the heterogeneous network and its underlying structures constituting an entity (Latour, 2005). The ontological viewpoint in ANT is that a theory, a scientific fact, a technology, a disease or any other object is what it is, by virtue of its relationships with other 'entities'. ANT's claim is that no object has an essence given by itself. An object is completely defined by its relationships to other objects in the network.

The manifest In ANT is that an actor is a semiotic term, which means that an 'actor' is not necessarily a person. A semiotic actor is what is attributed to action, and it can literally be anything; an electron, an organ, a human, a global organisation, a hole in the ozone layer and so on. The actor-network theory encourages looking at what has an effect in a situation. What represents what? Who speaks on behalf of whom? What connections are there between the actants? Which connections are made? How are these compounds transformed? And how are actants moved and displaced? (Jensen, 1999, pp. 10).

6.2 Background

ANT sees scientific facts as a constitution of a chain of processes and actors within a network. In philosophy, a discussion prevails between the postmodernist and the modernist regarding the definition of 'truth', in which ANT takes no part in. The postmodernists do not believe in the concept of truth, or they believe that humans can create their own. Whereas, the modernist claim that the truth is out in the world, free from humans waiting to be discovered (Dankert, 2012, pp. 46). ANT, sees truth as a state of affairs and thereby is dynamic as time passes and actors attach or detach from the network. This means that "essense" and "truth" is not a focal point in ANT. Instead, focus centres on the factors determining them and the way negotiations occur (ibid.). Thus, the network is heterogeneous due to the actor's shape as either a human or non-human. The notion ´actor´ is understood as any entity with agency, which is why non-human artefacts are relevant, because it depletes the separation of human and non-human into a symmetrical importance revolving around power-structures and negotiations of the relations in a heterogeneous network, as explained by Olesen and Kroustrup:

“In other words, the scientist needs to refrain from dividing the world into regions and mattering subjects in advance. Instead of focusing on a well defined, homogenous world, the ANT-scientist will study the formation of heterogeneous networks where actors of any kind partake in mutual alliances to gain results which they can join and gain from”(Olesen & Kroustrup, 2007, pp. 72)

The ANT is utilised as an identifier and analyser of the multitude of actors in the network of researchers, economy, acknowledgement, bureaucracy, and disciplines. ANT will also contribute to the discussion of the power-relations biometric research is subjected to and how non-human actors potentially can be used in negotiations with other actors to their advantage.

6.3 ANT concepts

Before using ANT, we will explain the underlying concepts of ANT. Translation is the notion when developing a network of connections with actors through a transformation, to make them fit into an actor-network. The process of translation refers to the act of negotiations, calculations, persuasion, intrigues, and even violence through which the actor changes to fit within a network (Dankert, 2012:48). The four moments of translation: problematisation, interessement, enrollment and mobilisation (Callon, 1986) will be elaborated below. Not to mention the importance of explaining the obligatory passage point, spokesperson, black box, and inscription device.

6.3.1 Obligatory passage point

An obligatory passage point (OPP) refers to a part of the translation that happens if proceeding through a certain point or actor. Being in control of a process in translation to get past an OPP may be in the favour of an actor, as they will have the overview, and to an extent, control of the other actors´ abilities and position to negotiate (ibid, pp. 7-8). The OPP possess dynamic properties, in which certain alliances are forged and movements accepted, which cannot be achieved alone. Reaching the stage as an indispensable OPP in the network is an element of the moment of problematisation (ibid, pp. 205-206.).

6.3.2 Problematisation

The first moment in translation is the moment of problematisation. Problematisation takes off in an investigation of the central problem and to identify relevant actors. Accordingly, it is pivotal to consider the problem in the perspective of the actors, regarding their position, important points of negotiation, and alignments in the continued process of translation. Briefly, the problematisation centres around a description of the system of alliances or associations between actors, thereby defining the identity and what they want (ibid, pp. 204-205).

6.3.3 Interessement

The second moment in the translation is interessement. This moment coincides with a series of processes by which the actor in question - biometric research - seeks closure on the actor's role according to how it has suggested a role for their own benefit (ibid, pp. 207-208). The strategies can be anything in between seduction to simple solicitation with or without the use of interessement devices to interest actors into the desired goal (ibid, pp. 205-206). To create an overview, we will in the analysis, discuss the potential of using an interessement device to attract researchers in the network of researchers, economy, acknowledgement, bureaucracy, and disciplines.

6.3.4 Enrollment

If the previous moment (interessement) ends as an succes, the third moment in the process of translation, enrollment, begins. The moment of enrollment consists of multilateral negotiations testing and adjusting their relations in order to accompany the interessements and enable them to succeed (ibid, pp. 211). By constantly testing the interrelated roles and negotiations of the actors, it means that enrollment does not resort to functionalist or cultural sociology, but simply does not imply or exclude pre-established roles. In short, enrollment is substantiated on the basis of interrelated and attributed roles ascribed and accepted by actors in the moment of interessement. That becomes the strategy in which the central actor - Biometric research - tries to define and describe the many roles allocated to the respectively relevant actors constituting the network (ibid, pp. 211-212)

6.3.5 Mobilisation

The final moment of translation is mobilisation. Mobilisation consists of various strategies ensuring that appropriate spokespersons and transformations for the relevant support base are properly represented and not later betrayed by the latter (ibid, pp. 214-216). The notion of mobilisation thereby emphasises all necessary displacements, in which previous steps of displaced actors become reassembled, rendering them mobile and easily accessible for the goal to be established (ibid.).

Although importance lies in accepting that a translation is never a fully completed accomplishment, as different goals, identities, relationships, and negotiations of the different actors are dynamic actions. Also, new actors may arrive and have to be properly placed into the network, meaning that the consensus, alliances, power-structure, and translation can be contested at any time.

6.3.6 Spokesperson

A spokesperson may be of great importance for each actor ´group´ as mentioned in the four moments. A spokesperson is not determined as a human entity, but can take form as a non-human actor. The term is inspired from the worker unions system, where representatives speak on behalf of the group to other actors, where the quality as a negotiator is of utmost importance, as it will be weighted accordingly to the actors in which negotiations have led to alliances. As negotiations never become static, the designation of a spokesperson depends on the ability to keep holding value worth negotiating about (Callon, 1986, pp. 214).

6.3.7 Inscription device

An inscription device was introduced during the laboratory studies and later elaborated by Latour in his book "Science in action" (Latour, 1987). The notion was illustrated when questioning the visualisation of a graph and its results in an article. After witnessing the laboratory from which the graph was created, Latour´ realised the magnitude of intermediary steps (devices or machines) contributing to the last device creating the inscription (graph) and how the results were continuously juxtaposed to external literature. The discovery positioned him between two worlds: a world of paper and a world of instruments. Amended by the devices, Latour realises how the most visual and concrete in the article, is the most abstract and textural element in the array of devices (ibid, pp. 64-65), as Latour describes it:

"When we doubt a scientific text we do not go from the world of literature to nature as it is. Nature is not directly beneath the scientific article; it is there indirectly at best. Going from the paper to the laboratory is going from an array of rhetorical resources to a set of new resources devised in such a way as to provide the literature with its most powerful tool: the visual display" (Latour, 1987, pp. 65)

Moving between papers and laboratories witnessing the convoluted ways literature is created, Latour defines an inscription device as a set-up independent of size, nature and cost, but which provides the final layer in a scientific text (Latour, 1987, pp. 65-67).

6.3.8 Black boxes

In ANT, a black box refers to the idea of an opaque or inner complexity of an artefact e.g., technology, where only the out and input are known, or as Cressmann explains: "Taken up by the sociology of science, the concept was used to refer to the unquestioned acceptance of the scientific method as objective truth" (Cressmann, 2009, pp. 6). When opening a black box, it reveals an array of methods and theories that makes up a device such as a laptop, or in this case, the sensor or iMotions platform, in which technical elements and social aspects are associated and unite into a whole (ibid, pp. 7).

6.4 The structure of scientific revolutions

In this section, a theoretical presentation of how biometric research has created challenges in some paradigms, will take place. Thomas Kuhn, an American philosopher and author of the book, "The Structure of Scientific Revolutions", believed science as a cumulative process in which science exists of paradigms and evolves under revolutions. Kuhn painted a picture of the development of science differently compared to his predecessors; stating how science ought to develop differently than as a by-product of the prevailing philosophy of science, along with the popular, heroic view of progress in science (Kuhn, 1970, pp. 2-3). According to his opinion, it was futile to see science develop through the addition of new truths to the stock of old ones, or the growing approximation of theories to the truth, or for the correction of past errors. A view that could probably accelerate in the hands of a great scientist, but progress itself is guaranteed through the scientific method. Instead, Kuhn made it clear that scientific change was not as straightforward as the traditional view would have it. Kuhn believed the development of a science or paradigm was rarely uniform but alternated between normal and revolutionary phases. Though normal science resembles the standard cumulative picture of scientific progress, Kuhn refers to it as ´puzzle-solving´ (ibid, pp. 35-42). He suggested that normal science is with a main purpose to convey the idea of solving a crossword puzzle or a jigsaw, with a reasonable chance of solving it. With the solution and puzzle affected by only the abilities of the one solving the puzzle and the methods used (Bird, 2018). A puzzle-solver will not enter completely uncharted territory. Revolutionary science, however, is not cumulative but a scientific revolution altering the existing scientific belief or practice (ibid, pp. 2-3, 175), also known as upheavals or paradigm shifts. A scientific revolution does not occur because the old paradigm is inadequate, neither are all achievements of the preceding period preserved in a revolution, whereby results in a science may find itself without an explanation for a previous known phenomenon (ibid). For Kuhn, the content of a science embeds a particular language, habits, methods, and theories. All determined and upheld by the scientists who live and are educated in the scientific community, that despite the different schools approaching the same field, feel obligated to educate their descendants in their beliefs (ibid). Thereby, Kuhn differs from Popper, by referring to the existence of a paradigm to the commitment of the relevant scientific community and their shared values, techniques, theoretical beliefs, and instruments (ibid, pp. 175), as he describes:

“A scientific community consists, on this view, of the practitioners of a scientific speciality. To an extent unparalleled in most other fields, they have undergone similar educations and professional initiations; in the process, they have absorbed the same technical literature and drawn many of the same lessons from it. Usually, the boundaries of that standard literature mark the limits of a scientific subject matter, and each community ordinarily has a subject matter of its own” (Kuhn, 1970, pp. 177)

This constellation of commitment shared among a group is referred to by Kuhn as the disciplinary matrix, also referred to as what makes up a paradigm (ibid). Kuhn’s view is that in the period of normal science, scientists neither seek to confirm or test the theories of their disciplinary matrix or see an anomaly as a result of a falsification of those theories (Kuhn, 1970, pp. 78). Instead, anomalies are explained or ignored away, and first taken seriously when imposing a threat to the practice of normal science (ibid). If an anomaly reveals inadequacies in a commonly used equipment or method, by casting doubt on a theory, it will increase the insecurity of using the equipment or method, also known as a crisis (ibid, pp.74). Interestingly about a crisis, is the strive for a revised disciplinary matrix, allowing the elimination of previous pressing anomalies and hopefully the solution of other unsolved puzzles. Again Kuhn differs from Popper, on his view that a revolutionary overthrow is neither logically requiring an anomaly, nor is rationally compelled and nor will the particular choice of revision be rationally compelled (Bird, 2018). This means that a revolutionary phase is open to competition among the rational disagreements and ideas from the schools representing a field. Kuhn later added a side note to his work, ensuring how extra-scientific factors such as the nationalities and personalities of the leading protagonists might have an effect on the outcome of a revolution (Kuhn, 1970, pp. 152-153). The revolutionary search for a more satisfying paradigm is motivated by a significant enough failure of the existing paradigm trying to solve certain anomalies.

Similarities and differences between disciplines are common, but not necessarily a hindrance for collaborative work. During our fieldwork, Jesper Clement explained how his research on non-conscious and repeated decision-making processes was in collaboration with a psychologist. Despite their different perspective on the data, they managed to make use of the same data, as Jesper described:

“At the institution of psychology, they study phenomena that do not make sense. They say that in the peripheral field of view, lies a lot of information ready to be found, but as a business school we cannot justify the relevance to an organisation knowing where a person is looking for a split second?” (Interview with Jesper Clement, 2019, pp. 5)

6.5 The concept of a paradigm

A pivotal part of Kuhn´s focus in his postscript of The Structure of Scientific Revolutions emphasises the constitution of a disciplinary matrix as a paradigms-as-exemplars. In the script, he intends to explain the nature of normal science but also the process of revolution and crisis. To do so, he divided the disciplinary matrix into four main parts: Symbolic generalisation, metaphysical paradigms, values, and illustrations. Roughly speaking, this matrix consists of the scientist’s background-theories, used in their daily work.

6.5.1 Symbolic generalisation

The first part, symbolic generalisation, is assumptions that can be expressed as a sentence, which are shared within the discipline and functions as laws (or more often as definitions), often positioned in an unquestionable position. The phrases can be anchored in symbolic formulas or expressed in words (Kuhn, 1970, pp. 182-183), as described by Kuhn:

"It is not quite the case that logical and mathematical manipulation are applied directly to f = ma. That expression proves on examination to be a law-sketch or law-schema. As the student or the practising scientist moves from one problem situation to the next, the symbolic generalisation to which such manipulations apply changes. For the case of free fall, f = ma becomes mg = md2s/dt2 ; for the simple pendulum it is transformed to mg sinh = -ml d2 h/dt2; for a pair of interacting harmonic oscillators it becomes two equations, the first of which may be written m1d2s1/dt2 + k1s1 = k2(s2 - s1) + d, the family resemblance of which to f = ma is still harder to discover" (Kuhn 1970, pp. 188–189)

Elaborating on this, we witnessed during our ethnographic, Anne, who stated how grateful she was for 'The Ekman facial action coding system' (FACS), because of its unbiased and universal way of analysing facial gestures (Interview with Anne, 2019, pp. 7). The system was described without hesitation or deviation, which Kuhn describes as the essence of symbolic generalisation. The common acceptance of definitions in a paradigm is what Kuhn sees as crucial because a scientific community is strengthened by the number of symbolic generalisations (Kuhn, 1970, pp. 183). A concept in Kuhn's theory is the battle of definitions: two groups of scientists see a phenomenon differently, also known as incommensurability. The gestalt switch of the duck-rabbit is a metaphor of how two individuals with the same retinal impressions talk past each other because they see two different things (ibid, pp. 149-150).

6.5.2 Metaphysical paradigm

The next part of the matrix is the metaphysical paradigm: The common commitment of beliefs. It embodies a subliminal metaphysical focus which is rather incontrovertible, but also rarely explicit. Instead, a scientist sticks to the normal activities a scientist is expected to do when pursuing a goal and how it should be presented for juxtaposing. A scientist may end with restructuring or adjusting a theory, but the guiding principles of scientific work embodied within the paradigm are not challenged. In short, these are the accepted and established practices of doing science and the admissibility of evidence. These are the heuristic norms that determines the nature of reality within the paradigm, which normally cannot be determined experimentally, as Kuhn describes:

> *"The electric circuit may be regarded as a steady-state hydrodynamic system; the molecules of a gas behave like tiny elastic billiard balls in random motion. Though the strength of group commitment varies, with non-trivial consequences, along the spectrum from heuristic to ontological models, all models have similar functions"* (Kuhn, 1970, pp. 184)

The common beliefs supply the scientific group with legitimate metaphors and analogies, which helps to explain the acceptable explanations within the paradigm (ibid). By defining what is accepted as a justification and as puzzle-solving, it also defines the list of unsolved puzzles. In the perspective of biometric research, which has not been properly established in many scientific field we have not come across any visible permissible analogies and metaphors.

6.5.3 Value

The third part of the matrix is values. Values are criteria for what applies for a good theory or method. These are common criteria and requirements for the formulation and simplicity of theories, as well as the nature of the data that are considered particularly good and must be sought through observations, interviews, questionnaires, etc. Compared to the communities of symbolic generalisations or the common commitments with the shared model, are values broadly shared among different communities to create a feeling in a community as natural scientists, as an entity (ibid, pp. 184).

6.5.4 Illustrations

The fourth and last definition is illustrations. Illustration is a great example of the paradigm's successful use of problem-solving. This is the knowledge a scientist has in a paradigm. This can be problem-solving in textbooks or laboratories and how they are educated to solve problems at work (ibid, pp. 197). According to Kuhn, a scientist who is raised in a paradigm enacts in a proven and group authorised way of seeing the world, and this view is unconscious and automatically driven. With time, the formulation of the criteria gets too blurry for a scientist to explain and is why Kuhn means this part of the paradigm precedes when it comes to applying the formulated criteria and rules in a research project (Brier, 2006, pp. 207).

6.5.5 Normal science

When a scientific community researches inside a paradigm, it is referred to as normal science. A precondition of normal science is the presence of a relatively solid sense of theoretical foundation, pinpointing the relevant aspects. When it comes to scientific discoveries, technology has often played a crucial character. When a discovery is under development, it is not unusual to see people with different approaches in the same field. Furthermore, the amount of information varies, meaning that no one has a complete overview of the situation. A result of this is that new schools arise and begin to defend their own 'small' paradigm (Kuhn, 1970, pp. 15-16). Kuhn claims that small revolutions, as well as huge ones, can take place, and some revolutions are only affecting the group-members in a specific professionality. These small groups can undergo revolutions when discovering unforeseen circumstances (ibid, pp. 49). Although all schools can contribute with significant importance, a school cannot be called a science until it shares a common theoretical base, with a coherent theory that can solve a number of crucial questions, not just in that specific case, but also in the future. Kuhn sets some requirements for a paradigm that must be fulfilled in order to lead research into what he calls 'the mature phase': The theory needs to be empirically testable. In other words, it shall be possible to make a hypothesis which can either be verified or falsified (Brier, 2006, pp. 208-209).

In the development of science, individuals or groups emerge to produce a synthesis in the attempt to attract supporters and let the older generation fade out, as Kuhn describes:

> *"In the development of a natural science, an individual or group first produces a synthesis able to attract most of the next generation's practitioners, the older schools gradually disappear. In part their disappearance is caused by their members' conversion to the new paradigm. But there are always some men who cling to one or another of the older views, and they are simply read out of the profession, which thereafter ignores their work. The new paradigm implies a new and more rigid definition of the field"* (Kuhn, 1970:19)

In this thesis, we will use Kuhn´s theory on paradigms to analyse our empirical findings regarding the challenges our respondents have faced when presenting the results. Furthermore, is it worth mentioning that the majority of our respondents belongs to the younger generation, who are capable of manoeuvring between old and new methods.

7 GENERALIZING BIOMETRIC RESEARCH

To understand the Danish university researcher's professional and personal interest in learning, researching and publishing through biometric research, research cases are presented as they become relevant to the topic under discussion. Meanwhile, Mike and Oscar from iMotions act as experts providing technical clarification and the common inquiries from researchers.

The selection of cases was not information-oriented, but based on practicality and possibility; that is, these cases were geographically accessible and were ongoing projects matching our intended site of ethnographic fieldwork. Nonetheless, the laboratories and projects were arguably chosen at random and eventually formed an array of deviant case studies due to an emphasis on the causes of the problem rather than the symptoms. According to Flyvbjerg, deviant cases:

> *"reveal more information because they activate more actors and more basic mechanisms in the situation studied. In addition, from both an understanding oriented and an action-oriented perspective, it is often more important to clarify the deeper causes behind a given problem and its consequences than to describe the symptoms of the problem and how frequently they occur"* (Flyvbjerg, 2006, p. 229)

Taking the ethnographic fieldwork of Latour and Woolgar as inspiration, analysis began by unravelling the observational case at CBS to create an understanding of the underlying procedures, rather than just those mentioned explicitly. Laboratory studies are essential to acquiring ethnographic insight into a foreign culture and studying the native habits, beliefs and rituals. Centrally, a laboratory should be acknowledged as a physical space of experimentation where independent knowledge-producing significance occurs, constructed by various controversies and unfinished facts (Olesen and Kroustrup 2007, pp. 72–73). When mapping the practical applications of biometric research, it is relevant to ask questions regarding how biometric research constitutes a material setting in a laboratory and how facts are being constructed.

The observational studies at iMotions are considered in a later section, where we facilitated an experiment, allowing insight from and embodiment of the considerations and thought involved in the experiment. The rest of the respondents are used to map individual responses and the challenges of individual projects according to their decisions, competencies and reaction of the scientific community, such as, for example, where the visualisation of a curve, peak or hot spot on a graph or image is not necessarily understood. These cases have enabled a cross-case analysis of the mechanisms of biometric research, with the subsequent analysis focusing on the challenges, successes and similarities and differences of each project. Table 4 presents the sensor(s), disciplines and data collecting methods considered. Before beginning analysis, the terminology surrounding competencies, research designs and technology must be clearly understood. Competencies describe the background and skills affecting the use of biometric research. Research design should be understood as the awareness of the ways of framing a project with consideration for the available sensors. Technology is the reified theory comprising the sensors and their specifications.

Using ANT as a theoretical framework, it is possible to zoom in on and out from different places in the network. As this analysis tries to identify the challenges biometric research meets in an academic context, we have chosen to zoom in on the following actors:

Researcher	Discipline	Data collection methods	Sensor
Jesper Clement and Seidi Suurmetz	Neuromarketing and Psychology	Biometric research Questionnaire Interview	Eye-tracking, Facial expression analysis
Students at CBS	Neuromarketing	Biometric Research Questionnaire Interview	Eye-tracking, Facial expression analysis
iMotions	Sociology Techno-Anthropology	Biometric research Interview	Eye-tracking, Facial expression analysis
Anne Bjertrup	Psychology	Post-meeting, Biometric research, Clarifying questions	Eye-tracking, Facial expression analysis, Galvanic skin response
Søren Bøye Olsen, Catrine Jacobsen, and Kenneth Uggedahl	Food Studies	Biometric research, questionnaire	Eye-tracking, Facial expression analysis
Troels Kjær	Medicine	Biometric research	All type of sensor
Lego Education	Learning and business	Biometric research	Eye-tracking, Facial expression analysis, Galvanic skin response

Table 4 The respondents focus area, data collection methods and use of sensor

Source: Authors

7.1 The business laboratory

Our observation at CBS in Frederiksberg took place in a laboratory located in site building attached to the marketing department's main building. The department focuses on consumer behaviour, neuroscience, neuroeconomics, psychology and ethical marketing. Jesper Clement and his PhD student, Seidi Surrmetz, are affiliated with the laboratory, and their working relationship resembles two sparring partners; that is, they complement each other to develop successful biometric experiments. Jesper, the laboratory head, teaches behavioural neuroscience and economy while supervising graduate students researching branding, consumer behaviour and neuroscience. Jesper´s competencies and interests in biometric equipment are some of the reasons CBS invested in the equipment (Interview with Jesper 2019, p. 9). Therefore, in the context of biometric research, he is a valuable asset for CBS, students and his colleagues.

The person we met at CBS was Jesper, who, before we conducted the interview, asked if we could take part in an experiment. This was ideal, as it meant we could participate in an experiment, observe its conduct, and then interview the researchers afterwards. Jesper began explaining the purpose of the project:

> *"We are interested in how the activity of the amygdala changes, as an expression of… pupil deviation. Because we believe that the release of stress hormones decreases as the familiarity with a picture increases. Therefore, we need to make sure that natural and unnatural light [do] not change during the experiment because it will change the pupil and give us false data. Also, the sample size has to be 100 respondents because of the many personalities that exist [and] the noise [in] the data and [because] 10% of… eye-tracking data is useless"* (ibid., pp. 1–2)

Nichlas described his experience of participating in a biometric research experiment in his notes:

> *"Upon entering the laboratory, you urgently felt the gloomy atmosphere closing in on you, a result of the closed blinds, dimmed light and narrow cubicles. The cubicles were placed in the corner of the room made with fake walls, and in each one there was a table and a chair, as seen in Figure 7. The rooms were approximately 30 m2, with half of each hidden behind a curtain. The chair was somehow uncomfortable to sit on, especially when focusing on the monitor. The monitor was placed on some books, which made it look like it had been arranged two minutes before we arrived"* (Nichlas´ fieldnotes, 2019, p. 2)

Jesper sat in the other cubicle controlling the experiment. During the experiment, he continuously looked at two different interfaces: one monitored the calibration and positioning of the parameters of the sensors to ensure Nichlas was being recorded (see Figure 10); the other provided Jesper with a live feed of Nichlas´s fixations and facial gestures as they occurred during the experiment (Interview with Jesper 2019, pp. 1–5; see Figure 7).

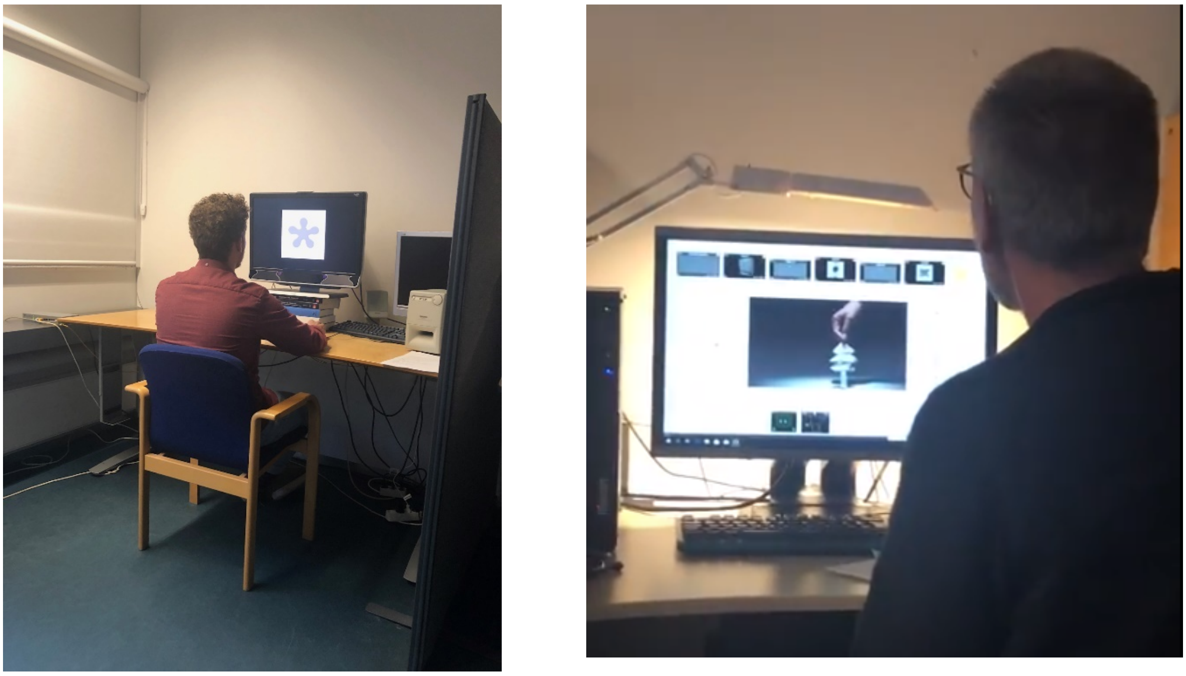

Figure 7 Nichlas conducting a biometric research experiment on the left side, and Jesper looking at the experiment Nichlas is conducting, while ensuring that the eye-tracker and facial expression recognition works Source: Authors

Jesper used the live feed to write down his reactions during the experiment, which he could elaborate on through questioning after the experiment. While it was important to monitor factors such as light constant, especially given the project was investigating the pupil, Jesper also observed that when respondents used the mouse when answering questions, attention was allocated away from the experiment and towards the mouse, a problem which voice commands could solve (ibid., p. 4).

As Jesper explained his project, Nichlas was asked to complete a questionnaire. Upon returning the questionnaire, the answers were strictly juxtaposed against the eye-tracking and facial-expression analysis data, while gazing towards a journal. The project was in collaboration with a psychologist and her interest in publishing the research in a psychology journal, which meant that Jesper's desire to publish in a marketing journal was lesser than his desire to conduct a biometric research experiment or reach out to other fields (ibid., p. 6). As the conversation continued, we noted the journals and data sheets lying on Jesper´s side of the table. As Jesper noticed this and proudly presented these datasheets to us. They belonged to two projects focusing on optimising the equipment while researching a topic of interest. The first project was undertaken before Jesper had his own equipment, meaning that he had borrowed it on the premise that the iMotions development team would have access to the data to optimise their equipment:

> *"They lent me the wireless sensor and asked if I could use it for three weeks and then share the data, so they could develop on that. But the wireless connection to my computer and over to the wireless sensor, created a lot of noise. I analysed the data frame by frame, meaning every 25 milliseconds because then I could see where the eyes were moving towards. So, analysing a video of someone standing in front of a product in a couple of minutes could take a whole day"* (ibid., appendix 1.1, p. 9)

That is, in the attempt to create the desired artificial reality, Jesper had to make use of wireless eye-trackers, which generated a noise phenomenon, which meant that more useless data was generated than would be if a wired eye-tracker were used. Consequently, Jesper had to treat the data manually, meaning a 1.5-minute long video took a whole day to analyse for validated results (ibid., appendix 1.1, p. 9). This recalls Latour and Woolgar, who considered the individual apparatus, the sensor, a part of the structure shaping the inscription for the platform (Latour & Woolgar, 1979, pp. 54). Jesper's other project was executed in collaboration with DTU and iMotions to optimise the accuracy of wearable eye-trackers. As he explained the collaboration, he removed a curtain in the laboratory, revealing an artificial aisle:

> *"The project was [a] collaboration with iMotions and DTU focusing on optimisingportable glasses. DTU made the algorithm that [would] optimise analysis of the data, while we framed a project about the*

> *link between a customer's focus on a screen and in real life. Then we agreed to produce an article together, which has been published in a technical journal. Although we have not managed to publish the article in marketing journal because the reviewers see it as a white paper for someone who wants their algorithm validated"* (Interview with Jesper 2019, p. 6)

However, the project had been conducted three years ago, which raised questions about why he was still trying to publish the paper in a marketing journal. Additionally, Jesper explained that before the automatisation and release of the iMotions platform, he controlled the eye-tracker with a joystick; this led to a huge loss of data but also gave him competencies to adjust features like contrast before and during an experiment (ibid., pp. 2–3). Table 5 and 6 compare Jesper's preparations with the old and new systems, indicating how many manual processes have been automated, removing researcher impact on the data considering the competencies needed to operate the eye-tracker. This suggests output is less biased following automatisation of some tasks because those tasks then rely less on a researcher's technical competencies, creating a more consistent data flow and identical treatment of the data between different researchers. According to Latour and Woolgar, is it important to be aware of the material setting and how it creates the artificial reality, which is affected by removal or change (1979, p. 64), as well as how routinised skills – such as operating and preparing eye-trackers or facial expression analysis – are important when actions are automated because

> *"the string of events to which each curve owes its very existence is too long for any observer, technician, or scientist to remember. And yet each step is crucial, for its omission or mishandling can nullify the entire process "* (ibid., p. 69)

As such, although Jesper's ability to operate a joystick may now be redundant, because he understands the basic mechanisms of the eye-tracker and how it uses infrared wavelengths and vectors to calculate the position of the eye, he is a valuable asset to many.

	Legacy systems	State-of-the-art
Technology	Analog video	Digital video
Calibration	5- or 9-point, tracker controlled	Any number, application controlled
Optics	Manual focusing/thresholding	Auto-focus
Communication	Serial (polling/streaming)	TCP/IP/Client server
Syncronization	Status byte word	API Callback

Table 5 Eye-tracker comparison

Source: Andrew Duchowski, Eye tracking methodology (2017)

1. Login to console. 2. Turn on eye tracking equipment. 3. Turn on eye/scene monitors. 4. Turn on eye tracking PC. 5. Run eye tracking program. 6. Turn on camera. 7. Turn on illumination control. 8. Adjust head/chin rest. 9. Adjust pan/tilt unit. 10. Adjust camera zoom. 11. Adjust camera focus. 12. Adjust pupil/corneal thresholds 13. Calibrate. 14. Run	1. Login to console. 2. Turn on eye tracking PC. 3. Run eye tracking program. 4. Calibrate. 5. Run

Table 6 Preparations required when comparing the old and new system of an eye-tracker

Source: Andrew Duchowski, Eye tracking methodology (2017)

In another section of the laboratory, we observed a desk with one side covered with journals, articles and books and the other side featuring a paper block next to summarised versions of data (see Figure 8). It turned out that the journals were a mix of psychology and marketing journals, all of which had been meticulously scrutinised and annotated to recognise the journals preference for figure types – e.g., round, square, objects, abstract – movies, theories and methods, providing insight into what the journal considered proper scientific work (Interview with Jesper 2019, p. 3). Jesper and the psychologist avoid questions such as 'why did you ask about that?' by referring to previous articles who have validated the use of such figures. If the methods available in the preferred journal are not appealing, you need to find another journal to publish in (Interview with Jesper, 2019:3).

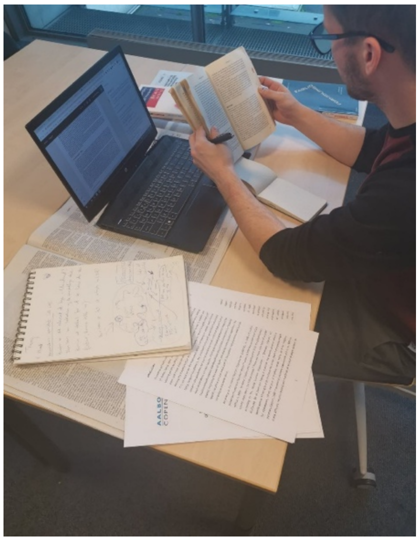

Figure 8 Reconstruction of Jesper´s desc, Source: Authors

In Laboratory Life, Latour explains how the researchers juxtapose internal literature with external:

> *"If two types of literature are being juxtaposed: One type is printed and published outside the laboratory; the other type comprises documents produced within the laboratory, such as hastily drawn diagrams and files containing pages of figures. Beneath the documents at the centre of the desk lies a draft. Just like the drafts of a novel or a report, this draft is scribbled, its pages heavy with corrections, question marks, and alterations. Unlike most novels, however, the text of the draft is peppered with references, either to other papers or to diagrams, tables, or documents"* (Latour & Woolgar 1979:47)

That is, a project is not simply constructed based on the experience and competencies the researcher has acquired during their education and professional life. Instead, in this case, the laboratory could be understood by the noticeable distinction between the area of devices and the area of literature (see Figure 9). While Section A contained various apparatus, including the stationary set-up featured in the project we observed, section B contained journals, books and datasheets that were constantly being juxtaposed. It became clear how journals partook in the construction of section A, which later contributed data sheets to produce the articles found in section B. Latour and Woolgar described this as a laboratory appearing as a system of literary inscriptions (ibid., pp. 52).

Additionally, Jesper´s impulse to use biometric research derives from the desire for a qualified answer to the question of whether a design might be profitable. In this case, utilising potential and sharing knowledge, regardless of the platform, is more appealing than not using biometric research as a method, as this ensures he can publish his findings in a marketing journal. This is arguably a result of him being the only one teaching biometric research, maintaining the laboratory, helping students using the equipment, and writing the articles. This has led to slow progress in terms of conducting experiments and writing articles, explaining why, at the time of the interview, he had three articles under review and more coming (Interview with Jesper 2019, p. 10). Jesper likely accepts publishing in journals outside his field because it enables him to conduct more projects and there is not much literature in his field, as demonstrated during a workshop Seidi would facilitate once a week, which is elaborated upon in the following section.

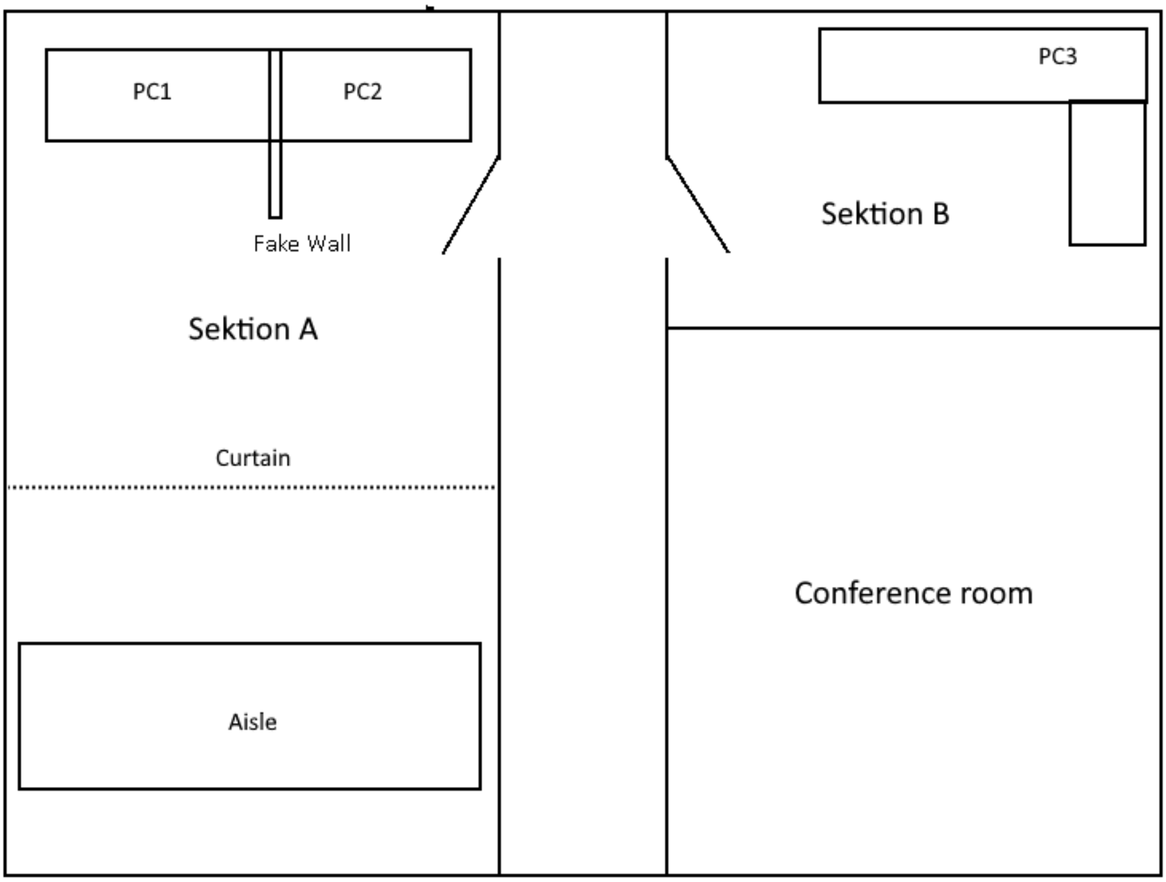

Figure 9 Illustration of the laboratory at CBS, showing the difference between section A and B, and the partitions described in the figure. Source: Authors

7.1.1 The workshop

The workshop at CBS helps bachelor and master's students to understand how biometric research works and is a place for discussing relevant literature regarding theories and ways of analysing data. If students do not know how to frame a project – by choosing the right sensor(s), appropriately setting up an experiment, and properly calibrating and using the equipment – the validity of the data can be impacted. The workshop hopes that students will advocate biometric research to their fellow students (Interview with Seidi 2019, p. X). At the end of the workshop, Seidi explained what she considered its importance:

> *"The students voluntarily participate, and I think we [have] 30 students this semester. They learn about… randomisation, stimuli and [the] importance of having a fixation cross in the middle. They will probably not use it in 'real life', but I think it is a good experience and they find it interesting. I think it is a challenge for many, especially because it is so much easier to prepare a survey, send it out to all of your Facebook friends, do some pretesting, and [then] you have a study. Whereas the people using biometric research spend days preparing the stimuli, randomising the position and extracting huge eye-tracking data files. It is a lot more work"* (ibid., pp. 7–8)

Seidi´s concern regarding biometric research being used in ´real-life´ followed her attending American Market Association and American Consumer Research conferences, where only two out of ten papers involved biometric research techniques (ibid., p. 3). In translating the biometric research program, Jesper and Seidi are the students and their colleagues OPP; that is, they have the competencies, the authority and the access to the expensive laboratory equipment. By managing the laboratory and having those abilities, they have substantial control to negotiate alliances and eradicate confusion regarding whether a fixation or algorithm is scientific. Their Kuhnian perspective allows them to persuade students so that the method is more accessible for the next generation; this is made possible by students accepting theories and methods based on the authority of teachers and not on the evidence. That is, teaching students forms part of changing the paradigm and current practice (Kuhn 1970, pp. 80–81). Even by persuading a few students at a time, the accumulation of those few leads to ultimate success. Without students entering the debate around introducing biometric research to the existing paradigm, it may never develop sufficiently to attract the broader allegiance of their scientific community (ibid., p. 155).

At the workshop, it was easy to recognise the relevance of biometric research. Students bonded across disciplines and shared literature in the hope of identifying useful literature. Sharing articles produced recurrent discussions about relevance, often considering whether certain approaches were valid and acknowledged in the students' individual fields. Upon finding acknowledged literature, the next challenge was to mediate it from its field into their own field (Nichlas' field notes 2019, p. xx). Commenting on the workshop's existence, Seidi revealed:

> *"I would have my PhD if there was some clarity about what a fixation is. I went with my project, and I had just used the Tobii algorithm for the fixations. Then my opponents were like 'yeah, but there are no fixations in the real world. Because your eyes can move while being stuck on a stimulus; therefore, do you check the gaze 50 times each second, to calculate how long people are looking at it, based on the frame by frame data. I had hours of recording, which would have taken me months to count every frame, and check the specific position of the gaze. So, they were like 'no this is not science, you cannot publish based on your Tobii algorithm"* (Interview with Seidi 2019, p. 10)

This indicates that the automatisation of eye-tracking, which has removed the manual process of observing frame-by-frame, has made the process non-scientific, according to the scientific community. This explanation did not consider other factors that might have been factors in Seidi failing her PhD defence, which is relevant to reaching an absolute conclusion regarding whether the eye-tracking data was the specific or only reason for the project's failure. As Seidi completes her PhD again, she has considered validity, especially clarifying the degree of the project's internal and external validity. These two measures act as two poles: while isolating an object from its surroundings to study or innovate creates high internal validity, considering an object in its real-life setting creates high external validity. For example, if a product label's design were optimised, internal validity is considered. That is, the product is isolated from everything else with the product as the only viable (Interview with Seidi 2019, pp. 5–6). In contrast, external validity perceives the whole in the context of surrounding stimuli. According to Latour and Woolgar, this indicates how whichever particular phenomena the researchers discuss depends on the material instrumentation; that is, the phenomena a researcher wants to constitute is constituted by the material setting of their laboratory, even if it is based on authenticity or internal or external validity (1979, p. 64). Additionally, any particular set-up features a variety of different factors affecting the data, which, if not considered, can result in useless data being generated. This can be complicated and time-consuming to track and ultimately prolong the study.

A reasonable assumption would be to consider the similarities between students at the workshop and the censoring community; it can be challenging to locate and understand literature across disciplines according to theories constituting sensor algorithms (e.g., fixation, iris, infrared) and the discipline the theory originated from (e.g., computer science, psychology, biology, chemistry, mathematics). This is especially true for students and time-pressured researchers, for whom the method constitutes an overwhelming change to scientific traditions (Kuhn 1970, p. 112). Nonetheless, despite students struggling to find and understand the literature, the machines and skills that are now current in different praxises are current as a result of past debate in the literature of another field. That is, any given theory has been the object of debate in some certain field before becoming available in other fields, which generally requires several papers to have been published on that object (Latour and Woolgar 1979, p. 66), leading Latour and Woolgar to refer to technology as a reified theory. In the case of this research, the inscription device is the software, which visualises the analysed data as graphs, pictures or videos (see Figure 10), with the preparations, set-up, calibration, algorithm, eye-tracker and facial expression recognition being intermediary steps. If Seidi and Jesper want to accelerate the acceptance and wider adoption of biometric research techniques, they need to re-educate the world around them such that the new method is accepted as scientific fact (Kuhn 1970, p. 112). Kuhn considers this an adaptation that requires an individual or group to produce a synthesis appealing enough to attract the next generation´s practitioners, which is followed by the gradual disappearance of older schools of thought (Kuhn 1970, p. 18).

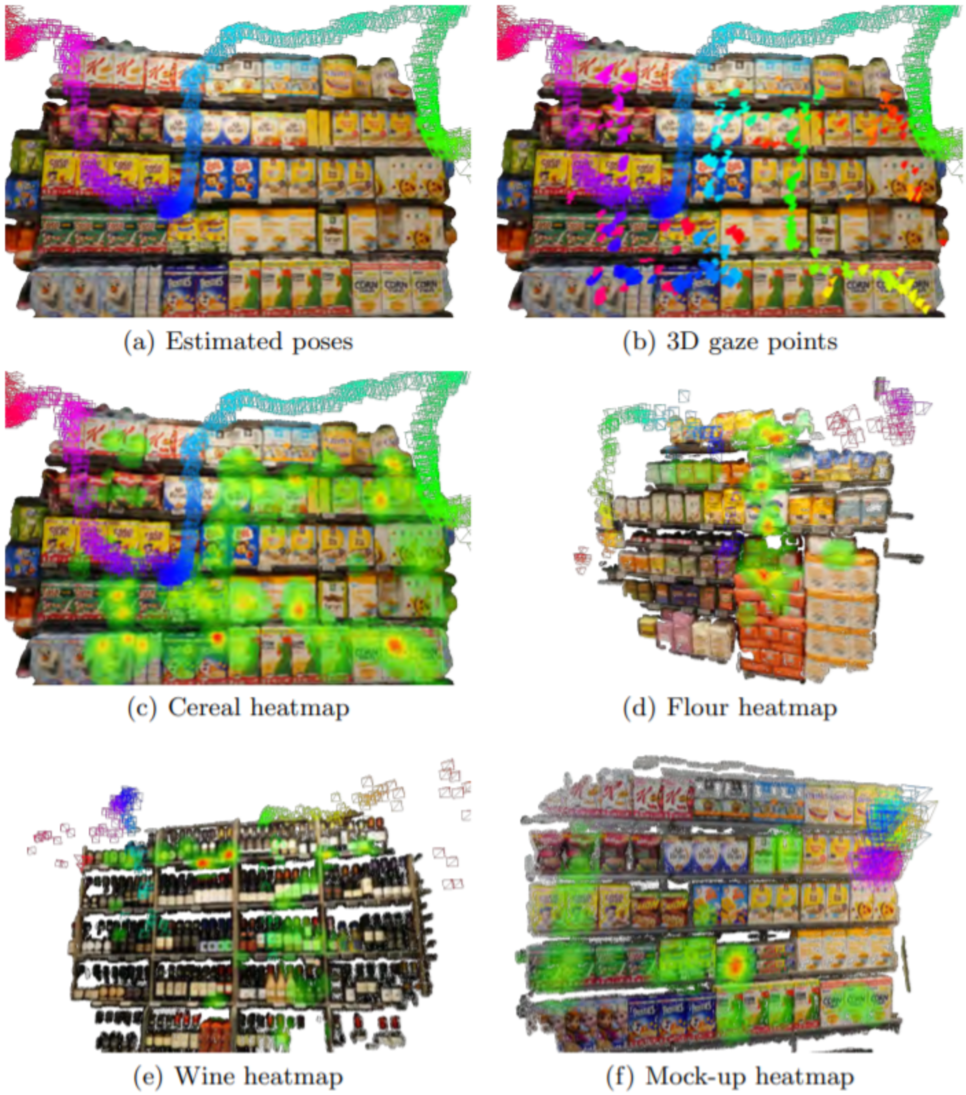

Figure 10 : A picture mapping respondents' area of interest when looking at a grocery aisle Source: I spy with my little eye (cbswire.dk)

For her PhD, Seidi dove into the field of psychophysiology to theoretically justify the scientific relevance of biometric research (Interview with Seidi 2019, p. 3). Despite the contribution of psychophysiology literature and 50.000 neuroscience articles, the censors could not be convinced of the scientific validity of her fixations theory. Accordingly, if the fixation and algorithm were certainly the motivation for the censor's negation, this, coupled with the opposition of Jesper and Seidi´s colleagues (Interview with Seidi 2019, p. 3), might be considered the result of a predetermined “*correspondence between a particular group, network, or laboratory* *and a complex mixture of beliefs, habits, systematised knowledge, exemplary achievements, experimental practices, oral traditions, and craft skills"* (Latour and Woolgar 1979, p. 54).

To understand the common and unique challenges that emerge when using biometric research as a data collection and analysis method, the following section considers the experiences of our respondents in the context of their disciplines and interests.

7.2 Following the steps of a psychology researcher

The next case we will present is the case at the Institute of Psychology at UCPH. The researcher, Anne Bjertrup, is doing a PhD in the area of cognitive neuropsychiatry, developmental psychology and association. More precisely, Anne studies new mothers with an affective disorder and considers the interplay between the mother and the child in an attempt to understand and interpret the minds of those in another mental state. She is using traditional methods from psychology, such as interviews and observations, while also adopting some biometric research techniques. This has involved showing various videos of facial expressions of babies when they are laughing, chattering and not getting attention while crying. For this, she is using biometric measurements (eye-tracking, GSR and facial expression) to measure each mother's arousal, where and what her eyes are focusing on, and how her facial expressions suggest her interpretation of the stimulus (Interview with Anne 2019:2).

Making studies as authentic as possible is of major importance in the psychology paradigm. Accordingly, Anne has chosen to perform her experiments at the homes of participants, meaning bringing all of the equipment with her. In addition, she indicated that when she was beginning, she had to learn both how to behave and how to make it both practical and logistical to carry the equipment around. A concern as simple as fitting everything in her backpack and transporting it to different places in the country was, thus, part of the initial learning curve (Interview with Anne 2019). It was interesting to understand Anne's incentive for using biometric research in her study, especially considering none of her colleagues or students used such methods. When asked whether she had encountered resistance in her field, given she was studying a psychological phenomenon that produced a physiological response, she answered:

"There will certainly be some psychologists who absolutely do not think it makes sense to understand psychological processes from that point of view" (Interview with Anne 2019, p. 9)

From a Kuhnian point of view, this can be considered the attempt of a minor school of thought to compete with the dominating paradigm; not to transform it, necessarily, but rather to expand its perception of already accepted methods. Anne explained that she had not met any proponents, meaning she was part of a process challenging her own paradigm through new discoveries and techniques and substantiating them with existing knowledge and literature. Accordingly, she claimed to draw from a deep-rooted and universally recognised research approach; that is, argument for this type of research can be made based on the traditions of psychological research:

"It's quite new to do eye-tracking that can be so sensitive and accurate. And all this affective technology to decode facial expressions is very new. But in terms of emotion research, which is perhaps more grounded and old[er], it actually started with Darwin, who identified different emotional expressions. Perhaps Ekman's research on how basic emotions are expressed is even more relevant. Ekman calculated the algorithms based on an old universal research study of the muscles, which affective technology is based on" (Interview with Anne 2019, p. 7)

This is supported by observations Latour and Woolgar made regarding the culture of the laboratory, in which the researchers made sense of juxtaposed literature by referring to the world outside the laboratory. The number of… (Latour and Woolgar 1979, pp. 54–56). Although Anne's approach to these psychological processes – considering psychophysiological responses – is an unconventional way of applying science to psychology, she argues that these intangible processes are difficult to examine or measure, but her techniques are based on accepted research. Biometric research is capable of meeting those challenges by reliably quantifying certain psychological processes (Interview with Anne 2019, p. 7). Using new methods to quantify this intangible phenomenon suggests a drive to contribute a different type of research; this might lead to her becoming a recognised researcher in the future.

However, for her study to be successful, many smaller problems need to be resolved. To draw on laboratory life, scientific facts are neither given nor results of discoveries. Instead, facts result from negotiation processes, which involve a variety of elements, including materials, apparatus, literature and social actors (Jensen 2003, p. 5). Reaching for authenticity often requires a trade-off and Anne is accordingly challenged by certain external factors in her pursuit of authenticity; namely, practical circumstances such as the mothers' subconscious thoughts shifting from the experiment to their child if it starts making noises. Another consideration in the search for authenticity was the potential role of a research assistant; Anne initially planned for a research assistant to take care of the children while the mothers participated in the experiment. However, Anne realised that four-month-old babies might not be comfortable being babysat by strangers. More crucially, the mothers might not have wanted a stranger taking care of their child (Interview with Anne 2019, p. 4), which might, in turn, have impacted the quality of the data. There are always trade-offs regarding factors such as these in research design; thus, they must be considered carefully.

Anne also mentioned lighting and space conditions as crucial factors in the study. The eye-tracker and the camera controlling facial analysis can be affected by lighting being too bright and it can be difficult for respondents to focus on the screen if they are blinded by the sun. Meanwhile, both the eye tracker and the facial analysis camera need to be a certain distance from the respondent to work properly, which can produce problems when conducting experiments at different homes. It is also important to ensure respondents can sit comfortably to avoid impacting the facial expressions and eye movements.

When Anne was asked about her experiences with the iMotions software platform, she reflected on the process from the beginning and how she slowly became acquainted and adapted her working style, elaborating:

> *"One thing I think quite often is a challenge is that the participants cannot calibrate. I wonder why it is so hard for them because I think it is relatively easy, and I [give] a relatively quick introduction of what they need to do, but some find it difficult. [There] was also a patient who had some kind of spasms in her eyes, so the calibration just failed. That is, of course, obvious. And there is always someone who uses glasses, and that can be difficult too"* (Interview with Anne 2019, p. 9)

These practical circumstances involving calibration seem to have been a major factor in making the experiment successful. If the participants could not calibrate with the machine, it was impossible for the participant and the 'machine' to work together. This problem was affected by an exogenous factor which might have been beyond Anne's power but might also have been due to the quality of her equipment. That is, calibration problems might be due to the sensor being low-quality and imprecise, necessitating a more mobile sensor. Given we did not test the sensor, it is not possible to provide specific insight into the degree to which this was the case.

Anne's interview demonstrated that different actors and inscriptions were in play. Actors included Anne, the mothers, their children and the other parent taking care of the baby during the experiment, as well as the lighting conditions (the sun), the baby's sleeping requirements, calibration of the respondent, and the presence of the respondent for the duration of the experiment. Anne had to consider all of these elements – what Latour and Woolgar called intermediary steps – to minimise their effect on the data and obtain an inscription of the highest degree of authenticity.

> *"I have a very long agenda due to the studies I have to go through, but the mothers are prepared for it. I have prepared them before the experiment [during] an information conversation. They are prepared for the time it is going to take, so we are doing it in the order that makes sense for their child. It is very special to [conduct] this kind of study because everything is on the child's premises. So, the 'computer show' we typically do when the baby is going to sleep. And then I set it up, find the best possible place at a dining table where the light[ing] conditions are as good as possible and not disturbing and so on"* (Interview with Anne 2019, p. 4)

The material setting involving each respondent's home can be considered an attempt to create the most authentic reality and the most reliable data. However, travelling to each respondent risked interruption or having data affected by sensor or respondent factors. Lighting conditions, the number of people present during the experiment, and sudden events inside or outside the respondent's home are examples of such factors and are unique for each set-up. Additionally, the respondent's state of mind must be considered when analysing the data because the perception of and reaction to a stimulus can change according to their mood and the people in the room. That is, the respondent's mindset is a relevant factor because of the impact it can have on the data. For instance, the output data from the sensors could be related to other elements demanding the respondent's attention, such as family, friends, a dishwasher or a vacuum.

Anne´s mobile set-up creates a more logistical challenge. The sensors are very fragile, meaning the equipment must be packed in a special suitcase to avoid damage (see Figure 11). However, the easiest way for Anne to reach each respondent's home was by bicycle, meaning the suitcase presented a challenge for equipment transportation. Consequently, she had to reinvent the way the equipment was packed. The solution was a backpack within which she wrapped the sensors in a protective shell to minimise damage while cycling (Interview with Anne 2019, p. 9).

Figure 11 A portable system of sensors and instrumentation for static and dynamic measurements in a clinical setting. Source: Medicalexpo.com

Another revelation from the interview with Anne was that her challenges were derived not only from the material settings but also from her technological know-how. Such discrepancies might have been the cause of certain technical problems, as Anne explained:

> *"I set up the experiment where I find it best possible. It will often be at the dining table where the light conditions are good. The experiment takes 45 minutes, but the test-person needs to calibrate.*

Sometimes, they will not calibrate, and we have to do it over and over. Sometimes it can take an hour, and sometimes it never succeeds. I have also tried, that the sensors stop during an experiment" (Interview with Anne 2019, p. 5)

The specifications of the sensors might have obstructed some of the success of her experiment, as exemplified by the specifications of Tobii´s newest eye-tracker, EyeX, which are presented in Table 7. Notably, these specifications change according to the type and model of the sensor and they are essential for the sensor's accuracy.

Size	20 x 15 x 318 mm (0.8 x 0.6 x 12.5 in)
Weight	91 grams (0.2 lb)
Max Screen Size	27 inches
Operating Distance	20 - 35" / 50 - 90 cm
Track Box Dimensions	16 x 12" / 40 x 30 cm at 29.5" / 75 cm
Tobii EyeChip	No
Connectivity	USB 3.0 (separate cord)
USB Cable Length	180 cm
Head Tracking	No
OS Compatibility	Windows 10 (64-bit only)
CPU Load	10%
Power Consumption	4.5 Watt
USB Data Transfer Rate	20 MB/s

Frequency	70 Hz
Illuminators	Backlight Assisted Near Infrared (NIR 850nm + red light (650nm))
Tracking Population	95%
System Performance	2.0 GHz Quad-Core Intel i5 or i7, 8 GB RAM

Table 7 Specification of Tobii´s eye-tracker "EyeX"

Source: Tobii.com

It is relevant to take notice that they change according to the type and model of the sensor. The specifications are essential to ensure the sensor to be most efficient, which arguably have been the reason for some of Anne´s technical problems. She explains:

> *"I set up the experiment where I find it best possible. It will often be at the dining table where the light conditions are good. The experiment takes 45 minutes, but the test-person needs to calibrate. Sometimes, they will not calibrate, and we have to do it over and over. Sometimes it can take an hour, and sometimes it never succeeds. I have also tried, or actually quite often, that it has stopped during an experiment"* (Interview with Anne, 2019:5)

As a response to Anne´s problems, a number of different things may have caused it. The reason can be Anne´s technical know-how or lack thereof, caused by the sensor(s) limitations. In regards of the eye-tracker, the size of the monitor is relevant for the gaze angle ($\boldsymbol{\alpha}$) and recommended distance. The gaze angle is measured on the basis of the recommended distance, which ensures that the optimal angle is upheld, as seen in figure 12. According to how far the actual angle is from the gaze angle (normally 35-36 degrees), it will have an effect on eye-trackers' fixation, the extent of the effect depends on the gaze accuracy, which depends on the model. The gaze accuracy tells how sensitive the eye-tracker is to lose its fixation according to the difference between the gaze angle and the actual angle. Meaning that, the gaze accuracy alters according to the model, which is a relevant factor to consider when picking the sensor for a project.

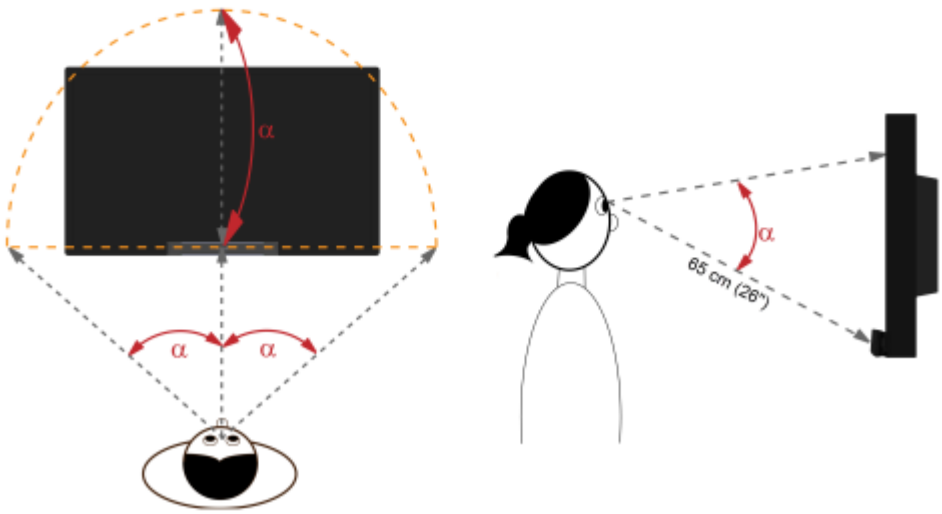

Figure 12 Illustration of how the eye-tracker works

Source: Tobiipro.com

The recommended distance is the distance between the respondent´s eye and the sensor, as seen in figure 19. The optimal distance is 65 centimeters, but due to the difficulties in achieving the exact distance, it is normally an interval of e.g. 50-80 centimeters. This helps when studying ADHD, kids, or other respondents who may have difficulties in maintaining a distance of 65 centimeters. A consequence of the actual distance between the sensor and the respondents´ eye is how much the respondent's can move their head during the experiment, also called freedom of head movement (tobiipro.com). Therefore, is it the researchers responsibility to consider the correct model of a sensor according to the project. In table 8, are the factors, not exhaustive, that can result in more useless data being generated if not considered, which can prolong the data collection process, thus, extend the time to complete the project or in worst case cancel the project. The domino effect then takes its toll on the publication rate and would decline when fewer projects are completed. The last considerations we will mention is how informed the respondent should be about the intricacies and positioning of the sensors, which can both scare or attract attention to the sensor instead of the project. This means that the competencies and technological know-how of a researcher can influence the data if the respondents and material setting are not considered when choosing the right sensor.

Specification	Description
Freedom of head movement	How much freedom do the participant have to move their head and still be within the parameters of the sensor
Max head movement speed	The maximum allowed head movement speed while maintaining tracking. The values is only for sideways head movement
Gaze recovery time	It is not unusual that a sensor might lose track of the respondent if they are turning their head away from the sensor. This values tells, when the respondent is positioned correctly, how much time is needed to recover the tracking
Blink recovery time	The eye-tracker loses the ability to track eye gaze, when the respondent is blinking, because the eye is covered. Depending on the time of the blink (a few hundred milliseconds), the system will immediately start tracking the pupil again, but only if the respondents´ head is approximately at the same position during the blink.

Table 8 Relevant factors to consider when picking a sensor for a project

Source:Tobiipro.com

7.3 The preferred and honest opinion of a food product

Thus far, we have considered, in psychology and neuromarketing contexts, how the biometric laboratory shapes and is shaped by written documents, the researchers involved and the experimental reality constructed, especially the unique challenges presented by striving for authenticity. Of central importance has been how different documents combine with biometric equipment to produce inscriptions representing the desired object , creating experiences capable of generating further inscriptions . This section maps the challenges and potentials of food studies to provide insights into their experiences of biometric research.

In the context of food studies, biometric research has provided insight into how embedded behaviour can explain individual reactions and processes involved in locating information; for example, observations can be made of the eyes being caught by something specific or moving around without a particular focus (Interview with Catrine 2020 p. 1). In this case, existing theories have not been fully able to connect with the biometric research data, one factor of which is that eye-trackers are unable to study peripheral vision. However, this gap can be filled by a questionnaire (Interview with Kenneth 2019 p. 1), an approach shared by the neuromarketing and food studies, perhaps a result of all researchers having been taught by the neuropsychologist Thomas Ranshøj, a biometric research leader (Interview with Catrine 2020, pp. 2–4; Interview with Seidi 2019 pp. 2–3). Catrine also indicated that the link between the approaches of the two fields might be seen in Jesper's and hers focus on the amygdala and participants liking:

> *"The project looked into how unpredictability in the sensory system of a human increases the activity of the amygdala in the attempt to locate the source, which should result in a decline in the liking [of] the object. We then measured the reaction based on pupil dilation, whether participants moved away from the screen and facial expressions"* (Interview with Catrine 2020, p. 2)

Additionally, Kenneth's introduction to biometric research, and his interest in utilising it in his thesis, ended with him elaborating on Catrine's thesis , with Catrine as a supervisor; this was especially due to how narrowing the literature available directed him:

> *"The only literature previously had [looked] at the information people ignore when answering surveys, and where people have been looking when asked: What did you ignore? That is an obvious case where eye-tracking is the big one and is where most studies in my field are done"* (Interview with Kenneth 2019, p. 1)

That is, Kenneth agreed to elaborate on Catrine's thesis. Next, it was necessary to decide whether the experiment would take place in a natural or controlled environment. Because it is more difficult to control sounds and other factors affecting how people react outside the laboratory (Interview with Catrine 2020, p. 2), Catrine believed that the information could be used in various contexts, such as more efficiently registering people getting tired when driving (ibid.). Our conversation revealed that their theses focused on the certainty of being uncertain, as she explained:

> *"The more times you revisit a choice in a binary or alternative situation indicates how uncertain you are about a choice. For example, if having to choose between two products, it is the uncertainty when revisiting the choices that indicates how closely valued they are"* (ibid., pp. 3¬–4)

The study was conducted based on the belief that the eye is the primary source of information acquisition and can indicate the extent of information acquired used (ibid., p. 4). Although this has become an accepted method when using biometric research in food studies, overcoming the limitations remains an obstacle, especially when observing a person reading individual sentences (ibid.).

As today Catrine use biometric research to identify whether people read their bills or other sensitive information; this is relevant because the information becomes legal upon being read, making this insight critical for senders. That is, a legal claim based on the incorrect assumption of the receiver having read the information could be rejected if evidence were generated to support the behavioural claim that opening a letter is legally insufficient (ibid., pp. 2– 3). Catrine´s experience on both academic and business sides made clear that justifying the raw data in science would be challenged by the absence of standardisation or obvious established theories (ibid., pp. 3–5). During her time at UCPH, she realised that, by creating a theory supported by the data, this started to make sense, but was not always approved of by her field (ibid., p. 8). Catrine's experience led her to be asked to guest lecture at UCPH, where she was surprised that no senior professor had any experience with biometric research, who found the technology very complex (ibid., p. 5). This might be because professors without experience in the area, belonging to an older generation, may find it difficult to comprehend the biology and psychology behind the biometric approach (ibid., pp. 5–6). Another obstacle Catrine had acquired through experience was knowing the focus of the project : the number of fixations, the changing fixations, the length of fixations, or the average; whether there is a pattern or areas of interest . Nevertheless, most people who are introduced to the method find it interesting but are often too busy to use it (ibid.). Although Catrine never doubted generating interest in publishing the work, due to its innovative and efficient approach, it was obvious that as a niche known only by biologists and neuroscientists, it was difficult for outsiders to understand how information search worked, when using biometric research. Thus, biometric research required collaborative work with others who understand it (ibid., p. 7).

Another set of obstacles associated with biometric research are more practical; for example, the loss of data due to calibration issues, glasses, small eyes, make-up, light conditions, money and time (ibid.). In this context, time refers to how an experiment manages its sample size, given that it is necessary to calibrate the equipment at least once between each respondent. Money refers to the costs associated with buying equipment, paying respondents, project costs and researchers; for Catrine's project, this amounted to 375,000 DKK ($60,000) (ibid., p. 8). Additionally, research design needs to consider factors such as a university being bound to certain methods and researchers being incapable of programming the algorithm themselves when needed (ibid., p. 10).
Earlier in this section, we clarified that Kenneth´s thesis built on Catrine's thesis, which was published while Kenneth was finishing his PhD. However, the project also included Søren Boye Olsen among its authors. Søren explained how eye-tracking had supplemented different studies by increasing the certainty that data was perceived as intended:

> *"I have used eye-tracking to understand people's choices when using methods such as choice experiments to see how people value aspects of nature in money. The method interviews people in different ways [about matters] such as their willingness to pay for increasing the quality of water in rivers and lakes. The questions are assumed to provoke people differently according to how [that] person processes… information [regarding improving] the conditions of the environment, [and,] thereby, affecting a person's value. The change in value can [be] measure[d] in DKK when asking 'If you asked to pay, how much would you pay?"*(Interview with Søren 2020, p. 1)

Additionally, using visualisations from the eye-tracker leads respondents to reflect upon the reasons for their fixations, such as, whether the information was too overwhelming or inadequate (ibid., p. 7). Understanding how a person perceives information builds on different theories related to the psychological understanding of information-processing. This method has been criticised based on the difficulty ensuring that the information given to the participant aligns with the researcher's intention (ibid.). If the information is misunderstood, the answers cannot be measured as intended. Therefore, eye-tracking enabled Søren to validate the information sent out to people based on whether they read it all and the extent to which they understood it. For this, Søren used online questionnaires, enabling the process to be understood and indicating that all of the information had been read, based on what the eye-tracker captured. This was followed by assessment of the respondent's orientation after reading the information; for example, whether they read some of the information again. When deciding between different solutions, the amount of times each option has been considered visually is valuable to indicate how closely valued they are. This has increased understanding of the information overlooked – in particular, if a respondent's report of where they have looked does not coincide with the theoretical model´s conclusion, which have always been an uncertainty of the theory, eye-tracking can provide supporting information (ibid., pp. 8–9). However, it is important to consider the eye-tracker's precision, especially given substantial literature exists explaining that the focus area is at the size of a thumbnail (ibid., p. 9). This recognition led Søren to design the experiment to overcome the eye-tracker's uncertainty:

> *"After knowing the size of the focus area of the eye-tracker, we redesigned the experiment to only make the information visible for the respondent when looking at it, creating a feedback loop with the eye-tracker controlling the questionnaire. Meaning that, when not looking at the information, it showed a question mark because then we knew [that] if any question marks were still present, then the information had not influenced the respondent's choice"* (Interview with Søren 2020, pp. 9–10)

This means that the absence of standardised methods challenges the researcher to use their competencies to think outside of the box, in this case, by adapting the eye-tracker's limitations to the purpose of the project.

While Søren was describing how the drive of Catrine and Kenneth formed the beginning of biometric research in their department, he mentioned Catrine and her competencies and experience derived from her time at CBS (ibid., p. 3). An ongoing challenge since the laboratory was constructed, has been for eye-tracking to move from a fascination with the technology and being able to observe people's attention to incorporating it into econometric modelling of people's behaviour. The facial expressions recognition interested Sørens in more deeply understanding a person's mind (ibid.). This investment involved a mobile eye-tracker that was specifically thought to increase authenticity when experimenting on consumer choices, by being able to be moved from the laboratory into the field (for example, into a grocery store; ibid., p. 7).

To finance the research, it was necessary to apply for 300.000 DKK through the Carlsberg fund because the field does not generally use equipment (ibid.). Although Søren was awarded the funds, but the money did not fulfil his vision of the laboratory:

> *"The thoughts we had when buying the equipment [were] that every researcher at the institute would have access to it because many adjacent research fields could benefit from its use. Reality showed that it was harder to go from the fascination with it to its contribution to research. But as a scientist new technology should not scare us away. Additionally, our students could benefit from it, but only a few have shown interest and kept using it because it gives them more job opportunities"* (Interview with Søren 2020, pp. 4–5; 15)

Furthermore, the rejection of several applications for PhD and postgraduate programs, counteracted a streamlined research culture and did not lead to significant use of the laboratory, and the equipment was barely a part of any projects for the first few years (ibid., p. 16).

However, the general difficulties building competencies regarding using different sensors to generate qualitative data resulted in a trial and error phase in which several projects were abandoned; this issue was compounded by Catrine and Kenneth leaving the institute along with all of their technical competencies (ibid., p. 5). This led an assistant named Thomas, who had used the equipment in his thesis and was observing at the laboratory, to begin helping Søren to write guidelines on operating and analysing the facial expression and eye-tracker´s data in combination with focus-group interviews, allowing optimisation of the questionnaire and insight into where the sensors were relevant.

When conducting experiments, a specific sample rate is often required; in Søren´s situation, this was set to 1000. Having 1000 people through an experiment using eye-tracking can take three months or more (Interview with Christian 2019, p. 3), which led Søren to see an opportunity to use eye-tracking installed in phones or computers (ibid., p. 6). The challenge for this is having respondents consent to researchers accessing their private camera.

In terms of publication, the hype of novelty and curiosity towards biometric research can overshadow the science in the food studies context; reviewers do not require explaining on the science behind the sensors unless the researchers aim for a journal focused on behavioural psychology. Instead, a reference to the awareness of the black box is sufficient (ibid., pp. 11–12), meaning that, when a publication based on eye-tracker usage and contribution to a discovery gets published in a renowned journal with sufficient citations, further articles are generated, in turn increasing the impulse to use biometric research (ibid., p. 16).

7.4 Outside universities

To understand why biometric research is so absent in universities, it is important to consider existing debates regarding potential misuse and the responsibility of scientific disciplines to produce guidelines regarding the use of biometric equipment. As an example on the importance of guidelines in society, Rasmus from Lego Education allowed an investigation of the praxis of biometric research at Lego Education, who has found it to be unquestionable according to the objectivity of the data (Interview with Rasmus 2019, p. 9). Rasmus' interest in the company's products reaching the highest level of satisfaction among children defined a goal biometric research could realise by considering how the shape, content and colour of the educational material and online applications were perceived by the children using it. He used the eye-tracker and facial expression analysis to investigate the fixations and emotional expressions of the child in the context of the object under study; this project was also designed to stay as frontrunner and to increase profit (ibid., pp. 10–11). When experimenting, Rasmus does not use GSR because he finds the position of the sensor disturbing for the authenticity, as he explained:

> *"So, it becomes a little artificial when you have to build something with one hand on your lap. That was a problem I had not foreseen when we bought that module, so I have not gotten any value out of GSR".* (ibid., Appendix 1.8, p. 1)

From this, it can be derived that the decision not to use GSR because it immobilised the child's arm, impacting the full experience of a product was an example of a lack of theoretical understanding of the possible ways GSR could operate; that is, the numbers of sweat glands in the human body are highest in the hand and foot regions (200–600 sweat glands per cm2 [6]), where the GSR signal is typically collected from. Therefore, not using GSR changed the artificial reality, thus, the debate by removing a part of the material setting (Latour and Woolgar 1979, p. 64). According to Latour and Woolgar, this indicates that the automated steps have put a demand on the routinised skills related to the expertise needed, in this case choosing sensors and how to use them in a project, just as a bioassay depends on a technician's skills and acquaintance with antisera (Latour and Woolgar 1979, p. 66).

A major reason Rasmus used biometric research was how the object of the debate had moved from how the data should be interpreted and analysed to how the problem could be solved:

> *"Normally I interpret the interviews, meaning that I have to watch… what I am doing, but not with biometric research, objective numbers do not lie... It is satisfying to align the experiment with a questionnaire: What do you remember? What was the most fun to look at? And then compare those answers… I save a lot of time convincing the management to instead discuss the results"* (Interview with Rasmus 2019, pp. 9–11)

This means that simply swapping traditional methods for biometric research minimised the criticism a researcher might face upon capturing and interpreting different reactions by instead generating non-questionable objective data. The focus of discussion now lies on the figure or graph, with intermediary steps having been accepted and black-boxed (Latour and Woolgar 1979, p. 63). The idea of objective data promoted a reasonable argument, potentially derived from Rasmus' position as a tester for a corporation competing with other organisations to have the best product:

> *"The project is much imitated by time and resources. People often say to me: we have this prototype; can you tell us something in 14 days? That is approximately 80% of all my tests. If I am lucky, we have six weeks"* (Interview with Rasmus 2019, p. 3)

That is, Rasmus' rejection of understanding GSR and the idea of biometric research as a generator for objective data exemplify why science should further explore and enlighten biometric research's utility. In this case, considering internal and external validity creates two very different debates around the same object.

7.4.1 Biometric technology at a clinic for mentally ill

Considering a section of society that has mental health at the core of their work, the following paragraphs consider the challenges Johan has faced at the centre for telepsychiatry in trying to implement biometric research into their daily praxis. He believes biometric technology can create a better patient environment by avoiding the need for syringes or pills.

Johan's work with mental health forces compliance with certain ethical rights to avoid accusations of their work being a test centre (Interview with Johan 2019, p. 4). Furthermore, a substantial amount of evidence-based research and a set of practitioners to operate the equipment also need to be present (ibid., pp. 1–6) because it is too time-consuming to provide a small unit with the analytical and practical skills to operate the equipment (ibid., p. 13). Although a solution would be to make it part of the curriculum of certain studies (ibid., p. 13), this would involve a process we have considered in the case studies of the four more noticeable actors and how they are positioned in the discussion of changing the curriculum:

1. The professional committee proposes ideas regarding the length, structure, content and goals of a study to the ministry of education;
2. The Ministry of Higher Education and Science approves it if the curriculum provides students adequate social relevance;
3. The university's board management and faculties can encourage researchers to use and advocate the method to students;
4. The researchers who influence students for different reasons, including relaying researcher interest in certain theoretical and methodological approaches.

It is important to remember that the world students enter is not, however, irreversibly fixed by the nature of the environment on one side and science on the other (Kuhn 1970, p. 112). Instead, students are determined jointly by the particular normal-scientific traditions and environment, according to what they have been trained to pursue. Johan has another hurdle to overcome, in addition to finding qualified personnel to operate the equipment: despite biometric research being a plug-and-play method for many, it demands evidence-based research to substantiate the beneficiaries of its implementation (Interview with Johan 2019, p. 6). Because research is not conducted as technology is developed, when trying to follow the world of science as an outsider and when each branch having its own logic based upon a standardised method, it is challenging to recognise which disciplines are more agile in their approach to technological developments (ibid., pp. 8–9). Finally, it is worth considering the difference between a technology the staff wants and an idea derived from Johan creating different criteria and being accommodated differently by the staff (ibid., p. 9)

In the next section, we consider the models, algorithms and guidelines associated with the use of biometric research and the demands for a project to comply with the guidelines of the researchers' preferred journal.

7.5 iMotions

The use of sensors in different scientific fields needs to comply with certain requirements to publish in a journal. Our case study at iMotions provides insight into the expectations of a facilitator using biometric research. The following section features Mike Thomsen and Oscar Haven as experts helping map the possibilities and limitations of biometric research according to the material setting, creating a more comprehensive understanding of the requirements and technical considerations needed to generate an article which can be published in a journal of interest. These insights are exemplified by the experience of other respondents, allowing a complete understanding of how particular challenges are associated with the material setting.

7.5.1 The experiment

Upon arrival, we walked into a laboratory with four tables. Each table had a monitor, PC and sensors held by a specially designed holder; this ensured that the sensors were stored correctly to avoid damage. We were told not to touch anything because the equipment was expensive; for example, the eye-tracker we used cost $32.000 and the facial expression recognition cost $8.000. Next to the window two of the tables were placed across from each other. On one of the tables, the eye-tracker and facial expression analyser were attached to a monitor, while the other table had another monitor and a PC, to which the sensors and monitors were connected. During the observations, we were both respondents and facilitators: Birita sat on the opposite table to Nichlas as a participant waiting, while Nichlas was introduced to the project's focus areas. Next, a series of preparations began, as Nichlas explained in his field notes:

> *"As I opened the program, I was told by the actual facilitator of the project to make sure that things such as light, noise, and disturbance were [kept] constant. Also, I had to ensure that my respondent sat comfortably enough to hold the same posture during the project. I began to level the table, check the blinds, close the door, dim the lighting and ma[k]e sure Birita was comfortable enough to maintain her posture during the experiment. Afterwards, I had to calibrate the sensors: The eye-tracker wanted Birita to sit approximately 50–80 centimetres from the sensor. But the facilitator told me to aim for 65 centimetres… the facial recognition provided an outline of a head, which Birita had to be inside of. During the project, the program told me that Birita was out of the boundary, which I had to adjust"* (Nichlas' field notes 2019, p. 2-3)

While experimenting, it became clear why both the natural and unnatural light had to be kept constant. In this case, it was because of the interest in the data collection's outliers, which the light would influence if reflections on the sensors, monitor, glasses or other reflecting surfaces in the room changed. Such reflecting light disturbs the sensors and results in the eye-tracker more easily losing its connection with the eye. As mentioned, we did have to calibrate the equipment to Birita. While sitting at the preferred distance, Birita looked at a grey screen with nine dots (see Figure 13), which instructed Birita on what to do. When the sensors were calibrated, Nichlas could start the experiment, which explained:

> *"During the experiment, I was told to take notice of interesting peaks on seven different graphs, each representing an emotion (joy, anger, fear, disgust, contempt, sadness and surprise). When jotting down my observations I had to note the time, fixation, expressed emotion and a question regarding the reaction"* (Nichlas' field notes 2019)

By the end of the test, several peaks had shown up on different graphs. At the top of the program Nichlas controlled, he was able to rewind or fast-forward to see when, in the experiment, the emotions were expressed. An add-on feature combined each reaction with a picture of the hotspots the respondent focused on during the reaction (see Figure 16).

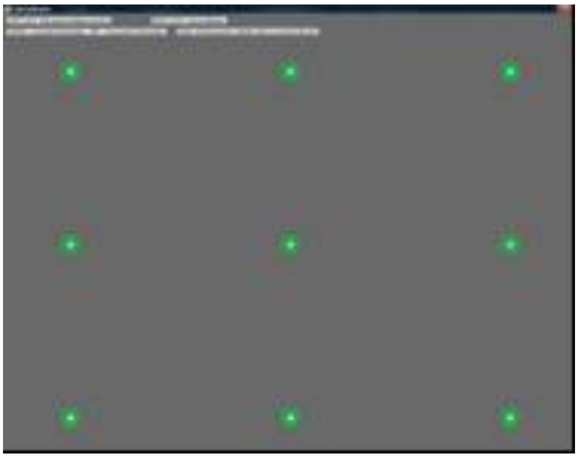

Figure 13 An illustration of the calibration of the eye-tracker

Source: Evaluation of the Average Selection Speed Ratio between an Eye Tracking and a Head Tracking Interaction Interface

The final task was to confirm through questioning whether the emotion coincided with how the respondents felt and whether they remembered expressing each emotion when presented with the stimulus that provoked it. The questions also helped to acquire data from the sensor according to the emotions expressed when asked about their perception of the stimuli (Nichlas' field notes). Based on these answers and the reactions, a researcher with adequate experience knows which follow-up questions to ask or whether some of the data is useless (Birita's field notes 2019, p. 2). Although the follow-up questions – or, as in Jesper's project, questionnaire – validate the data, the inscription provided through intermediary steps like preparations, different sensors, data synchronisation and analysis using a particular algorithm might not be conclusive for all scientific fields.

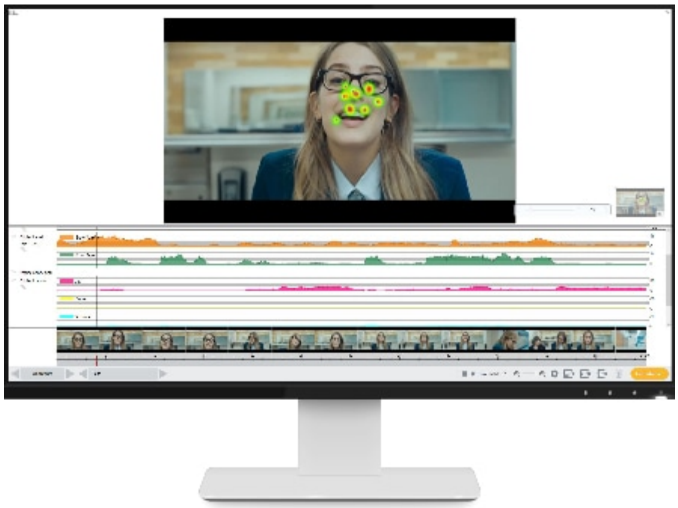

Figure 14 The facilitators layout during an experiment
Source: iMotions.dk

From this, we can recognise that Rasmus has taken advantage of biometric research by justifying it as a neutral ground where researcher influence has been removed to create objective data, which we found interesting in the debate surrounding the possibilities and limitations of biometric research. Because any given research design is created by the researcher, it likely includes both bias and impacts from the researcher's technical competencies. Additionally, the respondent Troels from medicine specialised in clinical neuropsychology and experienced in biometric research through his field, speaks of subjective data as the individual´s experience, whereas objective data is replicable, to some extent. Meaning, that If a person´s electroencephalogram is measured now and then a year later, the results would be different. That is, the wider use of biometric research has created an idea of extracted data as being objective (Interview with Troels, 2019, pp. 2).

This aligns with Latour and Woolgar, who suggested ways computer data can be filed away after the inscription device has provided slopes or peaks of interest, such as 'an interesting reaction to that' and 'is that peak based on prejudices?' (Latour and Woolgar 1979, p. 50). Although, It appears that certainty regarding the precision and reliability of the sensors, algorithm and interpretation of the data remains unsettled across fields; this might be due to the complexity of incorporating the method into a project. A common response from our respondents was that biometric research is an add-on to existing data collection methods – despite the depth of the data obtained, that data still needs to be substantiated by another data collection method. This might be due to the margin of technical error or the many different procedures that can be incorrectly conducted and create low-quality, useless, or false data. In these cases, the data is not taken for granted following inscription because a series of processes have created the data. For example, Jesper and Seidi (neuromarketing), Søren, Cathrine and Kenneth (food studies) and Anne (psychology) all used a questionnaire or an interview method after the experiment, in which questions attempted to confirm the accuracy of the peaks and eye-tracker hotspots, by noting whether they coincide with the respondent's perception, as well as making them aware of where the eye-tracker had not caught the eye´s fixation. In such cases, these methods can help to validate the data.

Our ethnographic fieldwork clearly indicated how much was communicated over a cup of coffee or as a quick question in passing. The information's scientific, technical and practical elements make informal communication predominant. Additionally, the ethnographic fieldwork indicated that the majority of respondents know each other through universities and other research pursuits, likely due to and explaining their acquaintance with biometric research, especially considering Jesper, who collaborates with a researcher from psychology, and Catrine, who moved from CBS to food studies at UCPH.

7.5.2 Experts strive for publication and satisfaction

Speaking with Mike and Oscar altered the focus of the journal's guidelines and the importance of picking the appropriate sensor according to the interest of the project interest. Mike contributed with insights into the eye-tracker´s prerequisites and the challenges the features of the eye-tracker constitute. As one of the few eye-tracking experts on the hardware and software, and how to comply with a particular journal, made him pivotal for iMotions and their academic clients (Interview with Mike 2019, pp. 1-3). When publishing a project, the data must be validated before experimenting, as the validation ensures data to be aligned with the projects´ interest. Meaning that, the validation is found in the journal´s guidelines followed by the choice of sensor which brings certain challenges, as Mike explained:

> *"The requirements from a journal, if the goal is to publish, should be written into the research design. If you want to use ECG or GSR, you will need a 'biopack'. The biopack explains the required sample rate and more, which have been used to publish for over 30 years. If you want to study people playing tennis, the wire will be a problem. However, a wireless sensor comes with a price, in which it influences the*

data with noise: noise makes some of the data useless and the data collection less consistent, which you somehow need to accommodate. So, locating a sensor with the correct sample rate, accuracy, etc. is one step of validation of your data, that with wireless creates a new concern. When recommending sensors It is important not to have more features than the project needs. More features increases the opportunity for mistakes" (Interview with Mike 2019, pp. 4-5)

In addition to this, Mike edified that standards are scientifically based, such as the study of saccades being the average person's reading abilities (Interview with Mike 2019, pp. 9). To elaborate further on this, Kiersten from iMotions explained the specification required according to four different interests (Kiersten Wolf, 2019), as seen in table 9.

Approach	Interest	Specifications
Fixation	Track your eyes when looking at a letter	Sampling rate: 30-60Hz Accuracy: 0.1 dva
Fixation	Track the location of your eyes looking at a picture	Sampling rate: 30-60Hz Accuracy: 0.5 dva
Smooth pursuit	Saccades	Sample rate: 500 Hz Accuracy: Not important
Glissader, drift and tremor	Micro Saccades	Sample rate: 1000 Hz Accuracy: High

Table 9 Standards to comply with according to the focus of the project
Source: Kiersten Wolf

Additionally, sensors can come with requirements not associated with the use of features, but a requirement such as the eye-tracker, spectrum, that only works with a specific monitor used (Interview with Mike 2019, pp. 4-5). Changing minds or having a specific inquiry to the sensor is also common, especially from academics who wants to change the fidelity or number of channels equipped to the sensor. To ensure the best supervising, Mike always advice based on the state of art according to the type of sensors and algorithms used (Interview with Mike 2019, pp. 4-5). After validating the data through the research design and having finished the data collection, is the facial expressions collected based on a majority of agreement among behavioral experts, as Mike explained:

> *"If the graph shows 100% joy on the graph, it means that a 100% of all behavioural analytics will agree, and when it shows 0% then 0% will agree. Meaning that it tells you how many behavioural analytics agrees that the recorded expression is a certain emotion"* (Interview with Mike, 2019, pp. 7)

This indicates that when looking at a graph representing for example joy, is it a representation of how many behavioral analytics agrees on the expressed emotion being joy. This can arguably be the reason why different emotions can be present at the same time, and a fact a researcher may find relevant to consider when analysing the results. A piece of relevant information, helping to avoid a lot of useless data, is to know how the content of the biometric database is constituted. Meaning that, using biometric research in a project or to improve the accuracy of sensors, does not neccesarrily improve its accuracy in general. Instead, it is limited by the type of people that are used when researching or optimizing the sensors, as Mike explained:

> *"This applies to all hardware, the more a test is focusing on a specific group of people, the more solid that group is going to be. if the hardware has been developed on Caucasian people, it will be more accurate with caucasian people compared to other groups. As with the absence of studies on a certain group may result in less accurate studies when studying that group"* (Interview with Mike, 2019, p. 3).

The accuracy of the results is affected by the group of people used, adding uncertainty on the accuracy of the results, especially, when most research is done on caucasian people (Interview with Mike, 2019:3). Therefore, hardware companies' decision on who to involve when developing their hardware influence the accuracy of the equipment. If looking at the algorithm using the database to mold data into peaks, they have different challenges according to whether they are standard uses or made particular for a project. A common challenge is the transparency of the project when the algorithms software is proprietary, especially, if a researcher at a Danish university wants to publish the results because their project needs to be transparent and replicable, as Mike explained :

> *"I believe that the academic world does not like the phenomena we call black box, which is when you are not able to see the calculations in the algorithm[...] It is a business secret, because the organisation wants to ensure their position. If they published the numbers used in the algorithm, everybody could do the same"* (Interview with Mike 2019, pp. 6)

The algorithms 'black-box' is accommodated through the amount of publication using the algorithm but every algorithm made needs to be validated, before a publication can occur using that algorithm (Interview with Mike, 2019, pp1-6). Furthermore, is the algorithm validated further for every article published using the algorithm (Interview with Mike, 2019:1).

After speaking with Mike, we were introduced to Oscar, who as a client success manager has the following responsibility:

> *"Locating the best research design according to the project, when doing behavioral experiments and helping them with analytical and technical challenges, while building on the relation between iMotions and the school or professor. Hopefully it becomes a snowball effect that leads to useful publications in society, which leads to more funding and thereof more setups"* (Interview with Oscar, 2019:1-6)

Advising on having a validated research design is troublesome according to who is being advised. The toughest clients often relate to those with most experience in the field, and least acquaintance with technology, because their values do not always align with the approach of biometric research (Interview with Oscar, 2019:1). The Danish researchers rigid approach combined with how risk-taking they are and the economical interest to invest in biometric research in Denmark, was the reason why iMotions first came to Denmark after establishing an office in Boston, as Oscar explained:

“A lot of what we do now is based on the client we have in America, because they are more willing to put funds into the software, which allowed us to get feedback, develop the software, and reinvest ourselves. Creating a snowball effect, by making the method more appealing to even more people. In Europe you need Germany, european funds, or be able to prove its value before they invest” (Interview with Oscar, 2019:6)

We can derive from this that America is, in the perspective of finding the best place to be funded to develop a potentially new method, finds comfort in the US. A reason may be caused by the culture which makes them want to take the lead, as well as, the economic structure at universities differ between Denmark and the US (Interview with Oscar, 2019:6-7). In the US, the tuitions is generally between 3660-48.510 per student per year (College Board, Annual Survey of Colleges; NCES, IPEDS Fall Enrollment data, 2020), followed by the external revenues from companies and funds. Therefore, the incentive to test new methods, fund development and procure new devices more carefree is an option compared to researchers at Danish universities. By looking at danish universities, 25% of their revenues comes from the amount of publications per year. A topic which has been prevalent throughout the analysis according to the high interest to publish their work, with Jesper trying to published a 3 years old project, and Søren with an interest to publish in a high valued journal. Additionally, the list of accepted journals are not necessarily structured according to what a researcher finds most prestigious or what journals are most open for new initiatives in research. Nevertheless, it comprise 25% of a university´s revenues, which makes the list a beacon for researchers to comply with. Meaning that, if the publication rate changes to drastic, if for example the listed journals do not approve the use of biometric research as a method. It can have an economic effect with considerable damage on areas such as staff, new investments, projects, etc.

As we have reached the end of the analysis, we will in the following section discuss how the relevant actors found in the analysis are positioned according to the translation process.

8 A NETWORK OF RESEARCHERS, ECONOMY, ACKNOWLEDGEMENT AND DISCIPLINES

Throughout our first part of the analysis, we have specified which challenges and barriers the respondents are struggling with are constituting the introduction of biometric research. It is also interesting to know how biometric research at Danish universities is positioned in a network of actors affiliated with researchers, economy, acknowledgement and disciplines. To analyse this phenomena, we will use actor-network theory (ANT) to describe how various events of practical, social and technical elements play a crucial role in the interaction of the network to make biometric research successful. ANT analyses the impact of how an actor manages to get the network arranged in a certain way, by processes that the concept of translation illuminates. In the following, we will address the relevant actors within this network and analyse how they manage to mobilise through the process of translation. The concept of translation implies that something is moved or replaced, and thus a pattern is created which contains both order and disorder (Jensen, 2003, pp.8). The linkage of the relevant actors are found through a mapping of the literature desk-research, references, and essential subjects expressed or shown during our ethnographic fieldwork. Based on the potential of biometric technology as accounted for in chapter 4, we have put forward a question, which is presented as followed: Will biometric research become a more common method in academia? By using Callon's analytical vocabulary, we do not distinguish a priori between natural and social actors. To analyse this question, also called obligatory passage point (OPP), it relates to the goal all actors want to achieve.

To compare with Callon's study about the scallops in the Bay of St. Brieuc in northern France, we consider Biometric Research to be the 'delicacy' that is much appreciated by consumers. In this framework, the consumers are seen as the society that demands for academic standards when it comes to Biometric Research. In the academic environment in Denmark, it is hard for researchers at universities to get biometric knowledge published in high ranked journals. Only at a few universities in Denmark are researchers able to produce knowledge by applying this type of method. Therefore, we seek to find out how this method can be applied? or in other words, a greater adoption of biometric technology into research with a better awareness of the technical and academic competencies required, potential of its use, and the guidelines outsourced by journals and the bibliometric research indicator (BFI).

Our respondents at CBS (Neuromarketing) and UCPH (Psychology, Food Studies) are all interested in improving the work of biometric research. The actors outside of academia, iMotions - the software company, Lego Education and Tele Psychiatry Centre in Odense are also involved to be able to apply biometric research in their work. With our focus on how biometric research is constituted at Danish universities, we have chosen to zoom in on the following actors:

- Scientific Journals
- Universities
- Bibliometric research indicator (BFI)
- Paradigms
- Researchers at Danish universities
- iMotions
- Hardware manufacturers
- Students
- iMotions

In order to process the concepts of translation, an identification of the actors who are influencing the system of alliances in their power-structure is necessary (Callon, 1986). Doing so, we will be guided by Callon´s moment of problematization with a starting point in the actors' identities, what they 'want' and how they position themselves. Callon analyzes this process by following three biologists. He identifies four crucial moments ('moments of translation') which are the researchers' attempts to establish a project around the method. By this framework, we are following the process from the researchers perspective.

8.1 Scientific journals

Journals represent the most vital means for disseminating findings and they usually specialise in specific disciplines or subdisciplines (American Psychological Association, 2020). The motivation and ambition among journals are much alike. Despite the existence of numerous journals with different interests and guidelines to validate and peer-review studies, they will be discussed as a single actor in the analysis. The prestige of a journal is pivotal for Danish university researchers' economy and acknowledgement, and to an extent how biometric research is embraced in a specific field. The existence of journals is based on the satisfaction of its readers, in which topic, theory, and methodology matter because if the articles journals approve are miscredited by the scientific community, it has an impact on their prestige and profit.

It is relevant to mention the proprietary software used when the algorithm evaluates the variables within the algorithm, as it is the organisation's insurance to stay in business (Interview with Mike, 2019:5-6). Meaning, that the transparency in research is tackled differently between journals: some do not approve the method; some have not had to consider their position yet; some have accepted the method. Journals encourage researchers to validate the algorithm, making it easier for future projects to be published. The problem is that the algorithm can either be standardised or made for a particular project, which makes it comprehensive to validate an algorithm every time (Interview with Mike, 2019:1, Interview with Oscar, 2019:2-3). Validating the algorithm before conducting the intentional project is a time-consuming step, forcing a researcher into fields such as computer science, psychology, neuroscience, sociology, and mathematics. Researchers might be theoretically and methodologically challenged when validating an algorithm.

Thereby, the similarity with biometric research is the idea of being able to create and publish new and groundbreaking results. With the possibilities of biometric research and journals, a potential for an alliance between biometric research and journals might prevail. However, they will have to figure out how the theoretical and practical work together on the interdisciplinarity, validation of an algorithm, and which interessement device they will use if collectively attempting to interest, enroll and mobilise the Danish university researchers.

8.2 Universities

Universities in Denmark have over many years, educated students, researched, made innovative efforts to be acknowledged and attractive for experts worldwide, and is a government funded organisation. Danish universities are funded according to a performance based economy model, which is based on education grants (45%), research activities funded by external funds (20%), research bibliometrics (25%), and the number of graduated PhDs (10%) (Ministry of higher education and science, 2020). As mentioned in chapter 2, Danish universities are positioned to produce high-quality education while being innovative, which is why universities are a relevant ally for biometric research, as they have a direct influence on the curriculum and the researchers' activities. Although it is important when negotiating an alliance to remember that the economy and researchers' own opinions are taken into consideration.

In relation to educating and advising researchers and students in biometric research, universities collaborate with iMotions. iMotions has a commercial interest that universities conduct more research which as a result leads to further investments in their equipment. Hence, the need for an alliance with universities is a crucial step towards the program of biometric research. The university aim itself is somewhat less interesting, whereas the researcher or student's mindset is the primary means towards the goal of biometric research. If biometric research wants to interest, enroll, and mobilise researchers and students, it needs to find the right incentive and perspective that ensures economic security for the researchers, as they have more powerful methods to ally with. Biometric research will need to use strategic alliances to call for action within universities and highlight their effectiveness and relevance to show their value.

8.3 The bibliometric research indicator

The bibliometric research indicator (BFI) do we consider as a silent actor because it is a model that lays out the rules for the economic benefits when publishing in specific journals from a university (Ministry of Higher Education and Science, 2017). The bibliometric researcher indicator consists of a list that decides what journals will give access to grant blocks. The list is not necessarily structured according to how researchers find it most prestigious to publish, but nevertheless, it comprises 25% of a university´s revenues, which makes the list a beacon for researchers to comply with. The model is further complicated by demanding all articles to fulfil three criteria: present new knowledge, ensure the articles are presented in a format that enables other researchers to elaborate, and to have it peer-reviewed. According to the number of articles published per year, a certain number of points be given, which can be transferred into grant blocks. But, before receiving the points ascribed to the article, the article has been through two steps: as shown in figure 15, the journals are divided into three levels, as explained by the Ministry of Higher Education and Science:

> *"Publishers can only be ranked on level 1 and level 2, whereas journals, book series and conference series can be ranked on both two and/or three levels. The distribution between the levels for journals, book series and conference series are based on the world production. Each series has a number associated with it called world production, which is a calculation of the average number of scientific publications in the series per year. This number is used to distribute the series within an expert group. Each series world production is added together, and from this a percentage of the series can be put on the three levels"* (ufm.dk, 2020)

The following step looks at the type of publication, as seen in figure 16. Biometric research will need to use a strategic alliance on the model and the change in revenues it may have, according to what journals approve biometric research, who are open, and what journals are on the bibliometric research indicator list, what is the journals´ level, and what has it already published using biometric research.

Percentage of total world production	Level 1	Level 2	Level 3
2 levels	77,5 pct.	22,5 pct.	-
3 levels	80 pct.	17,5 pct.	2,5 pct.

Figure 15 Indicating the level of a journal, book or conference series. With level 1 containing the ordinary channels, level 2 the particularly distinguished, and level 3 the most excellent and prestigious, Source: ufm.dk

Publication type	Level 1	Level 2	Level 3
Research-based monographs	5	8	
Research-based articles in journals, contributions to conferences	1	3	5
Book chapters	0.5	2	

Figure 16 Indicating the points given according to the publication type and ascribed level of a journal, book or conference series, Source: ufm.dk

8.4 Paradigms

When speaking of paradigms, it is important to remember that they relate to a discipline. Paradigms can be seen as a superior school defending the values and beliefs according to how phenomena should be approached and is regularly challenged by other schools to become superior (Kuhn, 1970, pp. 47-48). By allying with different paradigms, biometric research will enable access to pivotal elements by being aware of the technical and scientific challenges that hinder the wide spreading of the method. If getting more knowledge of how the technology and paradigms are barricading the use of biometric research, it can help in the development of the sensors and software.

A paradigm has an agenda which can have similarities and contradictions with paradigms within the same discipline but also between two disciplines. The variations often lie in the expected methods, theories, and competencies acquired. Throughout the process of our fieldwork, the presence of antagonists on the use of biometric technology has been prevalent in different shapes. Even though the paradigms have not been an embedded part of the concept of biometric research, but as a method available for all with interest in human behaviour, paradigms have shown to be pivotal for the researcher regarding, e.g. theories, methods, beliefs, traditions, competencies, and the design of a project. In short, paradigms are an essential actor to be enrolled and mobilised into biometric research, as the paradigms hold a unique position as a global scientific and political institution on right and wrong.

8.5 Danish university researchers

As we have already covered our respondents in chapter 5.6, we will not elaborate further. Although, it is worth mentioning that researchers at Danish universities, do not necessarily approve the method, which will be elaborated when describing students as an actor. All respondents will be seen as spokespersons advocating for a wider use of biometric research, with especially Jesper from Neuromarketing, Søren from Food Studies and Anne from Psychology are highly acquainted with the values of their respective discipline and the structure constituting a researcher at a Danish university.

8.6 Students

An actor, who arguably will have a relevant position in the network of researchers, economy, acknowledgement, and disciplines is students. A student is defined as someone being educated at a college or university (Cambridge Dictionary). In the perspective of biometric research, students find interest with the methods and theories according to how they are introduced by their professor, however most students will be unaware or not find biometric research appealing to explore if not advocated by their professors. The students' mindset of acceptable and possible methods is what the biometric research program intends to change, though a challenge may occur when identifying students who are in dispute between the *problematisation* of Danish university researchers advocating or not for the method. Biometric research will have to create an alliance with university researchers and universities to compete with the interessement from university researchers who do not advocate for the method. By using an interessement device such as the structure of the curriculum and available supervision when using biometric research, it can ease a students fear of the outcome when using a method not approved by the professor. This is a pivotal element which biometric research has to be aware of.

8.7 iMotions

iMotions is one of the primary global companies who has the network to sell biometric software and hardware as a package solution, while supporting the need for sharing experience, expertise, knowledge, and how to assemble a research project properly, according to the guidelines of a journal (interview with Mike, 2019:1-5, Interwith with Oscar, 2019:2-4). iMotions is located in 70 countries with headquarters in Copenhagen. The company consists of technical experts, technical developers, product specialists, client success managers, salesmen, and testers. iMotion is the only company who integrates various sensors by "synchronising and managing multiple data streams from different devices" (imotions.dk) to track different aspects of human responses on one software. iMotion makes research faster, allowing more time to get answers rather than spending the time programming and setting up experiments (imotions.dk). iMotions hosts several events a month where actors of the organisation and different stakeholders can participate, share expertise, knowledge, and experience regarding the use of biometric technology. An opportunity which is also available when contacting iMotions client success manager.

Thereby, iMotions is an organisation where various actors across different fields, with different interests in either learning, supervision or selling can have a say (imotions.dk). iMotions will be a crucial ally for biometric research, as iMotions, is a facilitator and meeting spot for many powerful actors. iMotions is a profit oriented organisation, who provides consultations on correct research designs and sensory use, while having the same programme as biometric research. This means that, despite the attempt to keep a neutral ground for everyone to share knowledge, they will reach out to all the disciplines possible, despite the method being accepted in the field. All of which will be considered in the interessement of iMotions for biometric research.

8.8 Hardware manufacturers

Hardware manufacturers are an extremely general actor. Nevertheless, this actor has an impact on the automatisation, development, and the possibility to use the equipment, as the sensors create issues. The hardware is equipped with a partially proprietary algorithm to ensure survival. In broad terms, the aim and incentive for hardware manufacturers is to make a profit. In the perspective of biometric research, the hardware manufacturers produce the sensors and algorithms which hinder the transparency of the product in a research project, but which is also pivotal in the mass production of the equipment. Additionally, iMotions is the primary intermediary between manufacturers and researchers. To make hardware manufacturers interested in the biometric research program, they need a financial incentive through an increased use of their products to improve an increased turnover.

8.9 Lego Education

Lego Education, Rasmus Horn, as an actor has proven useful. Rasmus is the gatekeeper because he is the only one having the competencies to utilise the biometric equipment. Lego education is not subjected to the same economic guidelines as Danish university researchers, where the publication rate is significant. Instead, Lego Education is interested in the acknowledgement associated with the faster creation of improved learning materials and toys when using biometric research. In broad terms, the incentive for Lego Education is to increase profits faster. However, when experimenting, Rasmus uses researchers to ensure compliance with the scientific standards. There are of course many ways of innovating learning materials, but in the perspective of biometric research, Rasmus has experienced the challenges after conducting many projects, and also how the data should be analysed. His experience can help influence Danish university researchers to strive for acknowledgement and economy when using biometric equipment. As well as introducing more researchers to biometric research if more people at Lego Education used it. To interest Lego Education into biometric research, Lego Education needs a financial incentive for increased profit.

8.10 Following process

The actors found relevant to include in the considerations for the program of biometric research, have now been through a moment of problematisation. In the following, we will move towards the next moment of translation, to create a network powered by the intention to embrace biometric research into a more commonly used method. This will be done with the last three moments of translation: interessement, enrollment, and mobilisation. As a summary, each actor and their obstacle for interessement in biometric research is illustrated in table 10:

Actors	Obstacle
Journals	Indispensable publisher of new research, complying with the respective discipline(s) and their own approved methods and theories.
Universities	prestige and focus on economy
Bibliometric research indicator	Distributor of government funds according to a pre-described list.
Paradigms	Does not easily accept the use of other methods and theories outside its frame of reference.
Researchers	Personal and professional focus, and on their perception of the value of biometric research.
iMotions	Platform business model that does not formally pressure highly profiled journals to approve the method, or researchers to conduct more research, or the curriculum to include the method. But with an interest to extent the use of biometric research in academia
Hardware manufacturers	Manufacturer of hardware and software, with an interest to increase profit.
Students	Not aware of the method, is not being taught or driven by personal interest.
Business companies	Not yet competent facilitators with an absence on the potential and limitation of biometric research

Table 10 Overview of the actors found in the analysis, Source:Authors

To get a grasp on how biometric research can most strategically and efficiently interest other actors, while consequently being redefined in competitive ways. We will in the following, identify the most effective interessement device(s), according to the understanding of the practical, technical and theoretical challenges of biometric research, and ascribe actors roles they can accept to undergo an alliance with biometric research. According to Callon interessement is the process of interesting relevant actors, but also to weaken their relation to other actors:

> *"It is in this sense that one should understand interessement. To interest other actors is to build devices which can be placed between them and all other entities who want to define their identities otherwise. A interests B by cutting or weakening all the links between B and the invisible (or at times quite visible) group of other entities C, D, E, etc. who may want to link themselves to B"* (Callon, 1986, pp. 204)

8.11 Interessement

First of all, biometric research needs to be based on an accumulation of trustworthy literature to accommodate the absence of competencies to operate it and create research designs. The literature also needs to be comprehensive enough within the field for researchers and students to acquire information on how biometric research is utilised in a material setting and during an experiment. As noted in the analysis, are some researchers collaborating with scientists from other fields, forcing one to experiment and publish with an offset in another discipline. Furthermore, each researcher has described challenges that have shown to be general across all studies, but also some who are unique for the material setting. This shows how the challenges can be a hindrance for the experienced user, that in the perspective of a newcomer, would result in even more challenges influencing the data. With the small amount of articles available and agreement on proper research using biometric technology. It can be difficult to use an interessement device, besides BFI which could be altered into advocating researchers to embrace new methods more. As a silent actor, BFI decides the researchers economical revenue, also makes it an OPP. Different journals have embraced the method, but still require the method and the particular algorithm to be validated, before any projects can be published using the method and algorithm. Paradigms are concerned about whether the method can scientifically align with their values and beliefs, meaning that biometric research needs to create more explicit and understandable literature regarding the reified theory and research design to ensure researchers that they comply with their disciplines values and beliefs.

iMotions who are already interested in the use of biometric research, could create an interessement device by extending their awareness on the journals guidelines, to also include what level they are on the BFI list.

8.12 Enrollment

In the next part of the story, Callon describes a long series of negotiations that transform the initial construction of interests into actual participation and enrollment. Enrollment is yet another term that is broad and neutral enough to include actors of all kinds. With this term, Callon points to a wide range of techniques in the attempt to ascribe particular roles to actors.

If researchers are to be enrolled, they must be willing to use biometric research when conducting experiments. Doing so requires certain actors to comply with the interest of the researcher. First the BFI becomes relevant when publishing articles resulting in a series of procedures that decides the economic gain, which is challenged by other variables; The list of approved journals demands researchers to be acquainted with the journals approving biometric research and if they are of any interest for the researcher. Additionally is the Ministry of Higher Education and science relevant for the BFI to become suited for researchers to use new methods, that ensures an economic gain. They are also a considerable actor due to their general influence on the university's vision and the content of the study´s curriculum.

Also, the time the researcher needs to find to utilise the method adequately and to locate literature the researcher can understand and accept as valid. To negotiate this with researchers it requires negotiation with the university, because their position can help researchers to be educated and funded. But the researcher needs to deal with other elements besides competencies and economy. A part of it is how researchers find themselves challenged by their discipline´s approval of the available literature and the researchers capabilities to mediate it from one field to one's own.

With journals, the transaction is simple: If the preferred journal has the method and algorithm validated, the researcher can publish. If no method or algorithm has been validated, then the researcher is compelled to validate. The other challenge the journals poses, is if the project's focus already had been published by someone else. This means the economic gain cannot be achieved.

Transactions with the students are non-existent. They wait for the final verdict, and are prepared to accept the conclusion. Their consent is obtained without any discussion. According to Callon, this resembles the negotiating process of the three scientist when discussing what elements challenges the scallops to attach themselves to the towline:

> *"To negotiate with the scallops is to first negotiate with the currents because the turbulences caused by the tide are an obstacle to the anchorage. But the researchers must deal with other elements besides the currents. All sorts of parasites trouble the experiment and present obstacles to the capture of the larvae"* (Callon, 1986,207)

8.13 Mobilisering

Overall, BFI and journals are an important interessement device for the actors previously identified. More importantly, they become a spokesperson of biometric research, as it becomes a representative for biometric research, which the actors agree to negotiate and align with. Thereby, biometric research is able to use the available literature and journals open for biometric research as a spokesperson to enroll other actors. Mobilisation is enabled, when actors use the available literature and preferred journals according to the BFI, while collaborating with a researcher who can mediate the theory and concept behind the method, that is when it becomes a spokesperson of their agenda.

The actors who have not been mentioned, may indirectly become interested and enrolled if biometric research offers these actors to use the journals and BFI as part of their own agenda. These actors include business companies and hardware manufacturers, who already align with the vision of biometric research. Because of that, the solicitation is to promise them to get insights into the data to improve the sensor or make business strategies more precise.

9 Conclusion

Throughout this master's thesis, we have found that there are many practical elements which make it difficult for researchers at Danish universities to produce biometric research. These elements can vary depending on which discipline is being researched within and which personal interests are the main driver. Not only internal factors are decisive, but also external factors can influence if a study in the end reaches its full potential. Fundamentally, a biometric research project needs not only to be thoroughly structured and designed, it also requires that the researcher has the know-how, experience and technical skills needed to work with biometric methods and its equipment. Despite this long list of challenges that biometric research faces, one thing stands clear; universities need to invest more time and resources into biometric research in order to be successful.

A key aspect needed to promote biometric research is to wake up students' interest within this field. Here it is crucial that the universities encourage and support researchers in biometric research as this is the first entry point to capture students' interest. Therefore, universities have to invest more time and resources in educating researchers to have lectures in biometric research. Another key component that needs to be restructured in order to make biometric research more popular is the publication's incentive structure. Today, incentive schemes like BFI encourage researchers at Danish universities to stay within the more traditional research fields as their funding is linked to the number of publications. The guidelines for BFI are defined by the Ministry of Higher Education and Science in Denmark, and they broadly speaking set their scores based on the distribution of publications that are scientific, peer-reviewed and published in channels that are included on the BFI list. Since more unknown subjects like biometric research are, all things equal, less likely to get published in well-known journals, researchers are encouraged to stay within more traditional subjects. By doing this, they increase the likelihood of getting their paper published and therefore ensure funding for their current and future projects. In order to increase the publications of more unknown subjects like biometric research a rethinking of the incentive scheme is thus needed. This is not an easy task, but we recommend that new and innovative subjects are given higher 'scores' somehow, such that they can be more competitive when it comes to research funding.

Another insight that we came across was that the interest for biometric research outside academia is growing rapidly. In some cases it seems to be growing faster than academic research can keep up with, and this has led to frustrations among the actors that believe more evidence-based knowledge would help implement biometric tools or methods in their fields. Examples of this are found within psychiatry, where the development team see potential in using biometry, but need to wait or hold back since more research is needed. More research would entail that the psychiatrists would become more comfortable with the methods and therefore be able to apply them directly on patiences.

Finally, the interviews show that there is a great deal of enthusiasm around biometric research, and that this enthusiasm is also found outside the universities. The prospect for many is that biometry gives many new opportunities and it is unclear at this point what its full potential is. What is clear is that biometry has made it possible to measure new phenomena, which was impossible only a few years ago. This, combined with big-data, machine-learning and artificial intelligence, has made it possible to investigate and monitor completely new areas, and researchers seem to think this is only the beginning. How far biometric research can be applied is of course difficult to judge at this point, but it seems clear that it is a research field that will keep growing. The threat to this development is that private interest grows impatient and starts down-prioritising the quality of the research that is needed. This could lead to misuse of private data and ethical standards could potentially be broken. Therefore, it is of great importance that if a university wants to follow the sociotechnical development that is growing outside and comply with the role ascribed to science in society, it needs to make sure that the quality of their research is adequate at all times.

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11 LIST OF APPENDIX

See appendix document