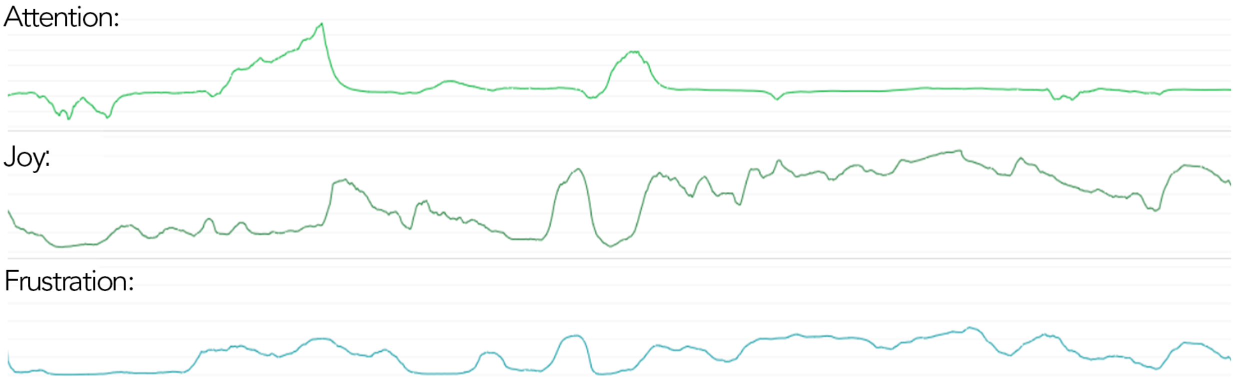
Digital facilitation of biosensor software learning: An exploration of iMotions



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Summary

This thesis investigates and attempts to design a solution for the challenges experienced when learning how to use the biosensor software iMotions. Biosensor software is in this thesis defined as software used to collect data through biosensors such as eye tracking, facial expression analysis, or electrodermal activity. The learning experience of using the biosensor software iMotions is investigated as a case study through interviews with iMotions Customer Success Managers and end-users who have had experience using the software for academic research.

Specifically, the goal is to design a digital and thus a scalable learning solution that does not require iMotions employees to conduct teaching sessions in order to teach new users how to use the software. To investigate the goal, learning theories such as scaffolding and zone of proximal development are applied in combination with didactic theories such as andragogy and self-directed learning. The interviews are analyzed through thematic analysis as a method of breaking down the interview data into themes, providing an overview of the central problems to be addressed. The analysis of these themes is then further synthesized into a series of main findings that list the most crucial problems, which are converted to design principles. Finally, design thinking methods are utilized with the design principles to produce a user-centered design solution.

The key issues identified in this thesis are listed as the following. Firstly, users who are seeking to learn biosensor software must learn many different things at once, both in terms of how to use the software, but also in terms of learning the methodological considerations for biosensor data. Learning biosensor software is a complicated process, which iMotions currently aims to teach by conducting a personal onboarding session, either physical or digital, which often leaves learners overwhelmed with information. Secondly, the technical aspects of utilizing hardware, which users may have never seen before, presents an additional learning challenge. Third, when it comes to the users needing help, the current support strategy relies on the users contacting iMotions directly, instead of being self-directed. Finally, the onboarding approach currently leads to poor information retention due to heavy cognitive load, as users often forget things they had previously expressed an understanding of.

This paper then argues for a design solution to the case study consisting of the following based on a series of design principles. Firstly, a video library displaying how to use the different features in the software and explaining what their use is, allowing users to learn in a digital and self-directed manner without human assistance. Secondly, a new interface was designed focusing on the workflow of the user, constraining information to be only that which is relevant to the user's context, based on their answers to a startup prompt that asks users to select which biosensors they are using. Finally, in-software tips should be added as a means of clarifying what features do, while also providing links to the video library where users can learn more about the features with practical examples.

Keywords: Biosensors, biosensor software, video learning, software learning, complex software, scaffolding, adult learning, self-directed learning, zone of proximal development, cognitive load, User-centered design.

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1. Introduction

Learning new software can be overwhelming. There can be a myriad of menus, features, and different options for users to navigate, and the learning experience can be daunting. Such a process may even be so intimidating that the user will experience difficulty remembering how to use the software. This is problematic, as it can cause frustrations for users, and in a worst-case scenario, the users are not able to use the software.

A relatively new emerging field, which relies on software to gather meaningful data, is the field of biosensors. Biosensors, as defined by Mehrotra (2016, p. 1) are "analytical devices that convert a biological response into an electrical signal". Biosensors can be used in a vast variety of fields, from medical fields to researching user experience". A commonly known biosensor is a heart rate monitor, which can display the heart rate of a person, making the heart rate the collected biometric. However, the physiological information that a user can emit is more than just a heart rate. It can be everything from eye-movement, sweating, brain frequencies, and more. In order to capture such information and examine the data, biosensors need to be connected to biosensor software. Biosensor software is defined in this paper as software that allows for capturing the physiological data and analyzing the gathered data. However, with such software, many complex choices need to be navigated in order for it to be of use.

This thesis investigates the user and learning experience for biosensor software through a qualitative research approach. This will provide the basis for a design solution, in which learning theory and a user-centered design methodology are applied. Using and learning to use biosensor software can be an arduous task, and as such, it is a context that relates to learning new competencies, and the advanced nature of the software provides the opportunity to consider the cognitive load experienced by the user.

Although aesthetics and ease of use are important, it is essential that the user is left with a rewarding learning experience and are able to use the software they are engaging with. As such, this paper aims to examine the user experience of biosensor software to explore the learning experience for the users. To do so, an investigation of the company iMotions and their biosensor software will be carried out, to serve as a case study for biosensor software in general. The investigation will conduct interviews with both Customer Success Managers (CSMs) from iMotions as well as end-users to analyze the learning experience and the context of use, while also investigating the current iMotions software user experience. By combining these results and insights with learning theories, this paper aims at generating new knowledge pertaining to the use of biosensor software, as well as the field of learning theory as it pertains to biosensor software usability. This serves as the foundation for a user-centered design approach, aiming to apply context-specific user data to address problems discovered and designing a positive learning experience. Ultimately, the goal is to research and produce new knowledge concerning the experience of learning and using biosensor software and how to use such research for designing solutions, based on learning theories, aiming at providing an effective learning experience.

1.1 Case Description

In trying to find a case related to the problem of biosensor software and its complexity, several companies that use biosensor software were contacted. One company contacted had a profile that matched. iMotions, a company that specializes in producing a biosensor software that can connect multiple biosensors simultaneously. As such, it is a piece of complicated software with many different options for the user. Not only is it full of options, but it has many different applications, hardware options, and contexts for which it can be used. This prompted a conversation with iMotions, to see if our perceived difficulty of learning their software was reflected in their experiences and practices.

Through communicating with iMotions about problematic aspects of the software, it became apparent that the onboarding process was a sign of how troublesome learning the software can be. Currently, iMotions onboards new clients with a consultant who explains and guides the client through the process of using the software, which is a non-scalable solution. This assumption of a lack of scalability is based on iMotions own estimations considering their resources spent on onboarding new clients (Appendix 10). As such, iMotions wish to find a new non-human introduction to the learning procedures for their complex software. It is for these reasons that we find this case an appropriate fit for exploring the problems outlined here, in the introduction, as it is grounds for designing a learning experience for biosensor software through a user-centric approach. To provide a clear use-case and to also provide different examples of contexts this research approach can be used to explore, studies of the use of iMotions will be conducted with their two primary user groups of iMotions: Academic researchers and commercial clients.

1.2 Specific conditions due to COVID-19 lockdown

As the work of this thesis started in the spring of 2020, it was written under unique circumstances that affected our approach, which must be addressed. In spring 2020, many were heavily affected by the virus COVID-19, which led to almost all of the world being forced by their governments to be quarantined at home, due to the infectious nature of COVID-19. This affected our initial approach of the thesis, and resulted in several reframings of the aim and methodological approach, as the severity of the COVID-19 situation increased.

The basis of the thesis originally intended to investigate biosensor software by using biometrics with users for data collection such as Eye Tracking (ET), Electrodermal Activity (EDA) and Facial Expression Analysis (FEA) to gain insights into their user- and learning experience. The mentioned biosensors would be used to measure the physiological responses that would occur when users are introduced to and have to learn advanced and complex biosensor software. Due to the safety of ourselves and participants, corresponding to temporary government regulations, the opportunity for testing in any non-digital setting was not available. As such, the data collection of this thesis needed to be 100% digitally collected, and therefore the aim of the thesis also needed to be readjusted to these circumstances, which guided the digital data collection approach found in this paper. These limitations and our initial approach will be further reflected upon in chapter 5, Methodology.

1.3 Problem Statement and Research Questions

The previously mentioned research aims and the specified problem areas lead to the following problem statement:

How can a digital learning experience for the use of biosensor software be designed, based on domain insights into biosensor software and the end-users' experience of biosensor software?

Aiming at providing an answer to this problem statement, multiple research questions (RQs) were formed, to ensure a comprehensive and thorough research design:

RQ1: What are the best practices of using biosensors and the best practices for facilitating non-human teaching?

Through the literature reviews, we aim to establish the best practices for both subjects, in order to provide insights into recommendations for utilizing biosensors and to understand the underlying complexity of biosensors. Furthermore, we aim to explore the best practices for presenting information for learning in a digital setting, with a multimedia learning approach, but also how to accommodate different learning preferences.

RQ2: *How do iMotions currently aim to provide their clients with a meaningful and productive learning experience using iMotions' complex software?*

iMotions' current procedure of introducing users to the software and assisting their learning experience is investigated through interviews with iMotions' CSMs and findings from an observed onboarding session. This is done in order for this research to build upon known problem areas and solutions to learning biosensor software.

RQ3: *How do users experience iMotions' software?*

To understand the users' learning preferences, the learning process of the software, and their overall experience with the software, interviews with end-users are conducted.

RQ4: *Based on learning and design theories, how can the participant's insights be synthesized into meaningful solutions for improving the learning experience?*

Through participant insights and theoretical considerations, problems, and possible solutions for improving the learning experience of biosensor software, without human assistance, will be considered.

RQ5: *Through design thinking theory, how can the users' ideas be conceptualized based on learning theories?*

With a user-centered approach and through sensemaking and ideation theory, ideas for solutions based on the findings in RQ4 are discussed and developed.

2. Background

To provide an in-depth understanding of the context for this thesis and its aim, several pieces of background information need to be highlighted, in order for the full context of this research to be understood. In the following chapter, a profile of the company iMotions will be presented. Following this, the technical background of biosensors and what they are capable of is presented. In order to get a clear picture of the possibilities and restrictions of biosensors, a literature review of applied research of biosensors will also be presented.

2.1 Case Background - iMotions

iMotions is a software company founded in 2005, dedicating its resources to creating a biosensor software called iMotions, and they employ roughly 83 people (iMotions LinkedIn People). Their product is a biosensor software, that integrates "and synchronizes Eye Tracking, Facial Expression Analysis, EEG, EDA/GSR, EMG, ECG, and Surveys in one unified software platform." (iMotions LinkedIn About). In addition to developing the platform, iMotions also organizes seminars and webinars related to the newest knowledge and uses of biosensors.

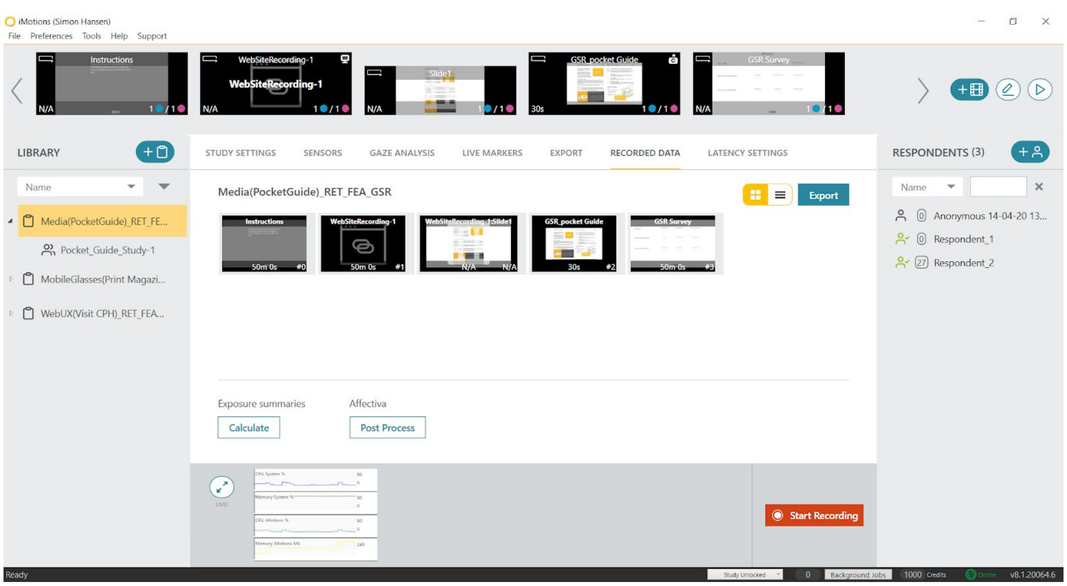

Figure 2.1: Example of a study presented in the iMotions software

As a part of their software, they also conduct onboarding sessions where new clients are introduced to the software and learn its functionalities. This onboarding session is often performed digitally, due to having international clients which adds physical constraints (Appendix 2: CSM 2). The CSMs conduct the onboarding over two sessions. The first session is an introduction to the software and its capabilities and features, with the purpose of teaching the clients to collect data. This normally takes approximately 1½ hours (Appendix 3: CSM 3). When the client has learned the basics and feel comfortable with the software, they go out and gather data by themselves. The second session's purpose is to help the clients analyze the collected data and to extract a meaningful set of results, and this session also lasts around 1½ hours (Appendix 3: CSM 3).

Figure 2.2: Example of a heatmap analysis in the iMotions software

The contact between the thesis group and iMotions started in January, as we sought to find a case for our thesis. The interest of the thesis was especially focused on the use of biosensors and how they and the collected data can be applied to gain greater knowledge of an individual's use of technology. Several companies related to biosensors were contacted, and iMotions was the company that was most related to the use of biosensor technology and had a potential case which this thesis could use as a foundation for investigation. The original case that iMotions presented for us was their problem about the scalability of the onboarding sessions. As it is, the onboarding sessions require an employee to conduct the sessions, which means that as iMotions continuously grows, the onboarding sessions are becoming less and less cost-efficient, as they need more manpower to conduct them. This challenge was presented to us by iMotions, which provided the basis for our research.

2.2 Technical background of biosensors

This chapter aims to provide a technical background for user interaction with each of the three biosensors relevant for this paper ET, EDA, and FEA, but also to provide an in-depth overview of the technology behind each biosensor. This is done in order to provide an understanding and offer insights into the complexity of iMotions' software, and any other biosensor software which accommodates multiple biosensors throughout data collection and a data analysis process where biometrics from each biosensor are entwined. The technical terms described in this section are not necessarily relevant throughout the rest of the paper but are explained to provide an understanding of how biosensors work and to provide domain knowledge regarding biosensor theory. As such, this chapter explains the complexities of biosensor software and aims to provide indicators for considerations relevant to this paper, which will be presented in the final section of this chapter.

2.2.1 Eye Tracking

Though ET devices have been around since the early 1900s, they were intrusive and relying on electrodes being attached near the eyes of the participant (Bojko, 2013a). Since then, advances in ET have focused on reducing the constraints and physicality of the equipment, while increasing the precision and accuracy of its results, leading to the much less intrusive devices of today. Some require users to wear ET glasses, while some only require the user to sit relatively still. But what is the point of ET? As Duchowski (2017a) states:

> ...we move our eyes to bring a particular portion of the visible field of view into high resolution so that we may see in fine detail whatever is at the central direction of gaze. Most often we also divert our attention to that point so that we can focus our concentration (if only for a very brief moment) on the object or region of interest. (p. 3)

In short, ET can be used to study what humans are concentrating on and to follow along the path of attention of the observed subject. Or, as Bergstrom and Schall (2014) states, "Eye

Tracking is a methodology that helps researchers understand visual attention" (p. 3). Duchowski (2017a) suggests that this can provide insight into what the subject found interesting, in observing what drew their attention, and may provide ideas as to how exactly the individual perceived the stimuli they were observing.

One of the first steps in analyzing ET data is usually distinguishing between two primary sources of data: fixations and saccades (Jacob & Karn, 2003). Fixations are eye movements that stabilize the retina over a stationary object of interest, and miniature eye movements that effectively characterize fixations can be considered noise present in the control system in the eye, attempting to hold gaze steady (Duchowski, 2017b). Saccades are when the eye moves rapidly between fixations while looking for information, or looking around moving from different stimuli to stimuli (Purves et al, 2004). In short, a fixation is when the eye is focusing on something, while saccades occur when the eye is moving around, looking for information.

During saccades, there are further small involuntary eye movements, called microsaccades, drift, and tremors (Duchowski, 2017c). As described by Duchowski (2017c. Pp. 196): "Slow drifts curve away from the center of vision, high-frequency (150 Hz) tremor is superimposed on the drift, and microsaccades, are fast flick movements (straight lines) back toward the center". These simply describe the minutiae of how the eye moves as captured during ET, and are useful terminology for describing very specific eye movements when necessary. Typically, when representing these metrics visually, they are done so in the form of scan paths, areas of interest (AOI), heatmaps, or gaze plots, representing the fixations as circles, while the saccades are shown between the gaze plots as straight lines (Bojko, 2013a). AOIs and heatmaps depend on the amount of time a fixation occurs and are a popular metric for understanding what received the most visual attention. As a brief acknowledgment of the limitations of ET technology, it is worth noting that eye trackers only capture gaze data, and not peripheral vision (Maqbali et al, 2013).

A prominent theory within ET is called the eye-mind assumption or the eye-mind hypothesis presents the idea that when we look at something, it is also what we are giving attention to and thinking about (Just & Carpenter, 1980). There are however other points of view regarding this approach. Webb and Renshaw (2008) assert that it is not guaranteed that we are thinking about what we are gazing at, and put forward two theoretical terms to think about cognitive processes going on in our minds while we look at things. The term top-down processes concern visual elements and how they can influence where we look first, such as contrasting colors or sudden movement (Webb & Renshaw, 2008). The term bottom-up processes then revolve around how our goals can influence where we look, which means that although clarity is strived for in task description for ET, participants in ET studies can always interpret or react to them differently. Finally, participants can also think of something completely unrelated than what they are looking at, due to personal associations or ideas. In short, different factors can affect what we look at (Webb & Renshaw, 2008). It is for these reasons that ET data can be considered a catalyst for further inquiry about participant behavior, and not necessarily a tell-all piece of data that is easily interpretable on its own. As such, biosensor software that handles multiple sensors and combines analysis to provide a more in-depth picture of the data is required, as shown below in figure 2.1.

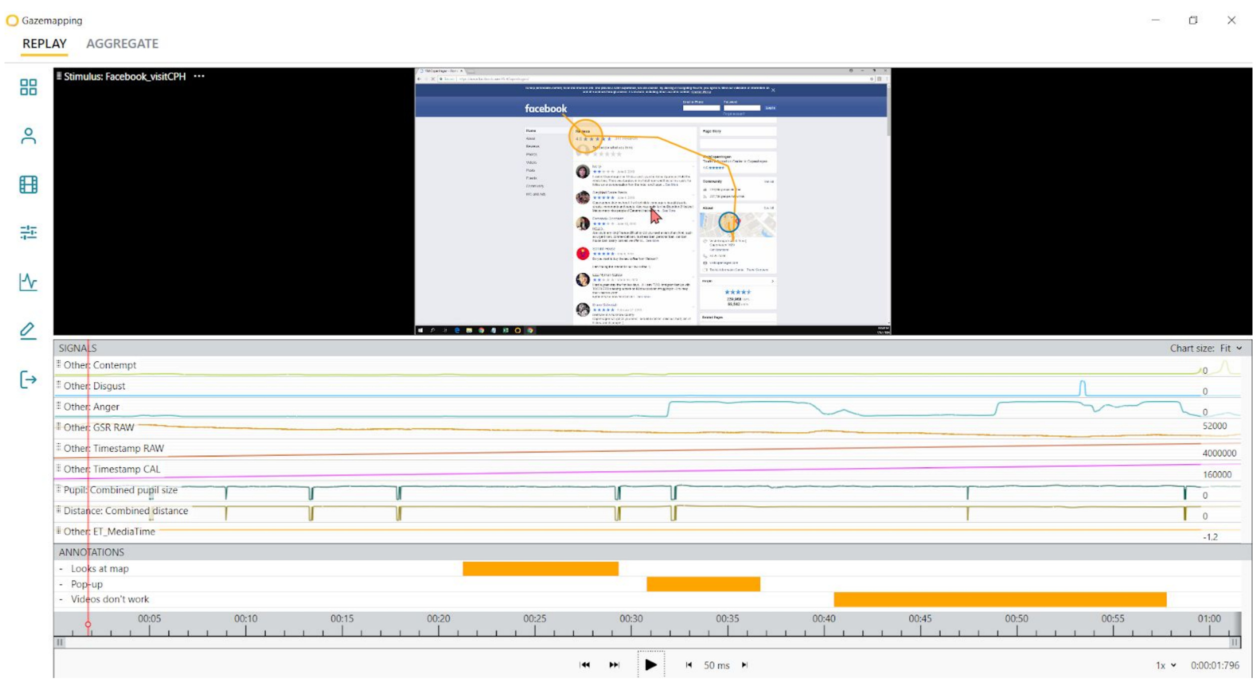

Figure 2.3: Multiple biosensors sources combined for analysis.

It is important to note that these viewpoints may also motivate researchers to use more conventional qualitative methods such as post-task interviews, so as to clarify the thoughts of the participants and to use it as supplement or contrast with the observed objective data of the human gaze. This can be done by asking general questions about the session after it has concluded, or by using parts of the ET data directly after the session deemed worthy by the researchers of clarification or inquiry (Webb & Renshaw, 2008). Interviews are used to understand the point of view of the interviewee, and a post-task interview is a viable option for supplying such depth for ET methods (Kvale & Brinkmann, 2008).

2.2.2 Electrodermal Activity

When conducting research related to users' behavior and feelings, the most common way to report on the emotions and feelings of the user has been through self-reports Carulle, Gustafsson, Shams, and Lervik-Olsen (2019). Self-reports are however limited as it can be seen as only a part of the emotional spectrum and can be classified as heavily subjective for the individual (Carulle et al., 2019). When experiencing emotions or emotional arousal, the first thing the individual experiences is a physiological change, and then the mind perceives these physiological changes and converts the changes to emotions (Carulle et al., 2019). However, the person is often not aware of the physiological changes that happen, but with advances in technology and research, the physiological changes can unveil the user's emotions (Carulle et al., 2019). When conducting research on these physiological changes, EDA is of particular relevance (Carulle et al., 2019).

EDA, though it has gained popularity in the later years, was first used in 1849 where its purpose was to investigate mental stress, such as emotions (Posada-Quintero & Chon, 2020). As many have experienced, when experiencing strong emotions like fear or stress, this can result in an increase in sweat. EDA is a term that refers to the electrical conductance of the skin, as even though sweat consists of several things, such as minerals and lactic acid, it consists mostly of water (Posada-Quintero & Chon, 2020). In most parts of the body, sweat is used as thermal regulation, to cool us down, but at the sole of our feet and in the palm of our hand, the sweat glands are more related to grasping performance. The sweat glands located in these areas are more responsive to psychological stimuli, as they have more eccrine sweat glands (Posada-Quintero & Chon, 2020). EDA measures this conductance, giving researchers an opportunity to objectively assess emotional arousal (Posada-Quintero & Chon, 2020). EDA, therefore, makes it theoretically possible to estimate the time of arousal and its amplitude, when exposed to stimuli, by examining the increase in skin conductance, which happen one to four seconds after exposure to stimuli, and last one to three seconds after (Posada-Quintero & Chon, 2020: Carulle et al, 2019).

The EDA signals are gathered by the position of components. On one hand of the subject, there is a phasic component or the skin conductance response component, which observes the activation of the sweat glands (Zangróniz, Martinez-Rodrigo, Pastor, López, & Fernandéz-Caballero (2017).

Figure 2.4: Picture of EDA equipment.

These signals are most commonly represented through the skin conductance response (SCR) in peaks or several bursts of a peak, indicating the severity of the emotional arousal, depending on the stimuli (Carulle et al, 2019: Zangróniz et al, 2017: Posada-Quintero & Chon, 2020).

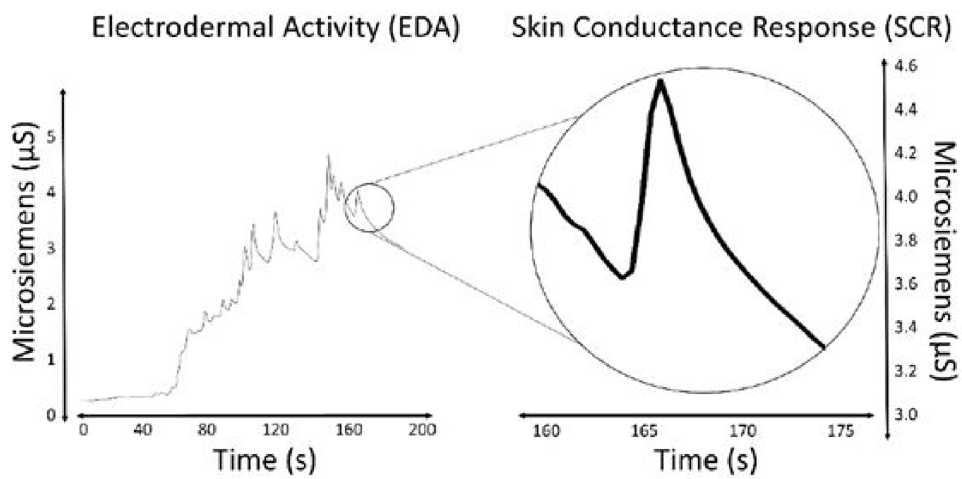

Figure 2.5: Electrodermal activity shown through SCR (Carulle et al., 2019, p. 2).

In the above figure, the overall EDA can be seen and the small peaks in the picture are the SCR to the stimuli. However, as Carulle et al. (2019) mention in their literature review, several studies show that respondents' SCR to stimuli is not instant. Carulle et al. (2019) depict this in the following figure:

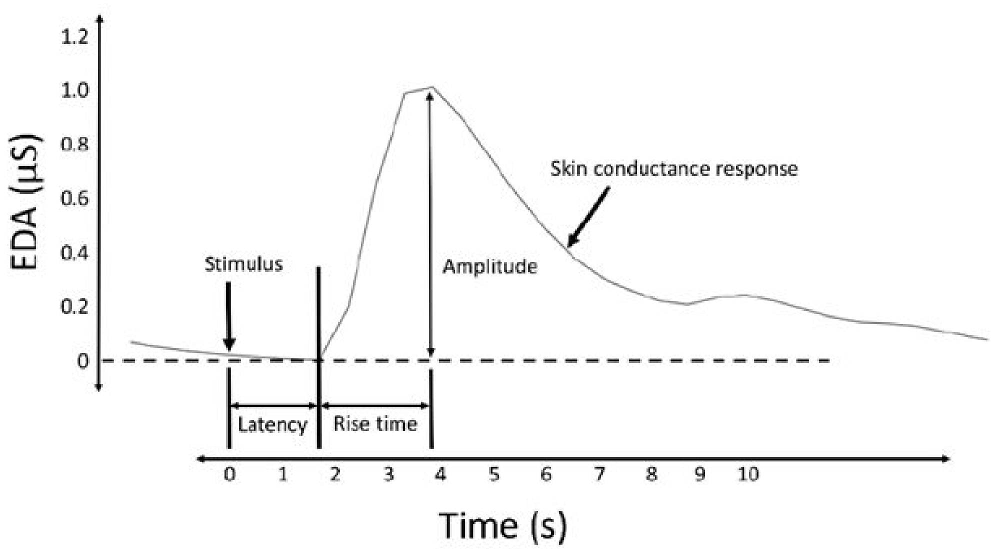

Figure 2.6. Latency and rise time for SCR (Carulle et al, 2019. Pp. 3)

Figure 2.4 illustrates the user's SCR to stimuli within a given timeframe. In this figure, time is relative to when the stimuli are exposed to the respondent, and to the onset peak of SCR, which occurs several seconds after the stimuli have been introduced (Carulle et al., 2019).

Possibilities of EDA

Carulle et al. (2019), lists some of the limitations inherent to self-reporting which EDA deals with. Firstly, they claim that self-reporting has difficulties obtaining a continuous measurement for the individual user. They argue that self-report has to be conducted either before and/or after testing, thus making it difficult to have a continuous measurement of the individual's feelings (Carulle et al., 2019). They argue that EDA can continuously measure and capture the emotional reaction of the respondent. Having continuous measurement causes the process of identifying the effect of particular elements on arousal to be more accurate. Secondly, the article points out the respondent's ability/inability and unwillingness to accurately report the emotions they experienced. Some feelings are more taboo to project and self-report, emotions such as anger and frustration, and due to social desirability bias, respondents can withhold to report true emotions, or they can alter them to fit their narrative of how they want to be perceived (Carulle et al., 2019). By applying EDA to a study, emotions will always be captured, as it measures the root of the emotion, which allows researchers to cross-reference if the participants report that they did not have any emotional reaction.

Lastly, Carulle et al. (2019) highlight that EDA measures the presence of any emotion, also the unconscious ones. Emotions consist of two stages, the unconscious stage, where the emotion is created through physiological changes, and the conscious stage, where the awareness of the changes is reached and therefore awareness of the emotion (Carulle et al., 2019). However, emotions do not always reach the second stage, causing the individual to not be aware of the emotions triggered, but EDA will still be able to capture these emotions (Carulle et al., 2019).

Limitations and challenges of EDA

Despite all the possibilities EDA offers, it does also have several limitations and challenges researchers should be aware of when applying EDA to their research. One of the most prevalent limitations is that EDA can capture the presence of emotions, but not the valence of the emotion experienced (Carulle et a., 2019). It cannot capture which emotion is experienced, i.e if the participant is feeling sadness or joy. Both would be projected the same in the EDA measures, and other methods are therefore needed to specify which emotions are present (Carulle et a., 2019).

As such, EDA does offer advantageous insights about the users' emotions, but despite its uses, it has several limitations that need to be considered, especially the weakness of EDA being used as the sole type of data gathering. As with ET, it is recommended to utilize multiple data points from different data collection methods, especially in combination with other biosensors.

2.2.3 Facial Expression Analysis

Emotional communication in social exchange is primarily interpreted by FEA, and although other body parts respond and react to emotions, facial movement and contraction are how we, as mammals, differentiate between apparent emotions (Rinn, 1984; Ekman, & Friesen, 1975). This is further specified by Rinn (1984) as "Nowhere in the body, however, are the emotions so clearly differentiated from each other as in the pattern of facial muscle tension." (Rinn, 1984. p. 1). Although emotions, as a concept, consist of a wide array of different emotions, such as social, moods/background, and basic emotions, FEA is only concerned with distinguishing between the seven basic emotions, as they are can be detected by only using visual indicators (Adolphs, 2002; Rinn, 1984). These seven emotions are Anger, Contempt, Disgust, Fear, Happiness, Sadness, and Surprise (Adolphs, 2002).

How our face expresses emotions are controlled by what is called the facial nerve, which connects the brain with almost all facial muscles (Rinn, 1984; Adolphs, 2002). These muscles govern our facial expressions, by manipulating the different regions of the face, but some groups of muscles act almost independently of each other, and as such, the face is usually divided into three different regions: (a) the brows and forehead, (b) the eyes, lids, and the root of the nose, and (c) the lower face (Ekman, & Friesen, 1975; Rinn, 1984). Within each different region, multiple muscles control each little part of what is considered a specific expression, and this form of communication is usually not interpreted as a language, but more so as emotions (Adolphs, 2002; Rinn, 1984). As such, these emotions can be utilized in gauging user reactions to an array of stimuli, e.g. usability testing.

The Facial Action Coding System

For automation of the actual understanding or interpretation of these emotional user responses, it was necessary to develop a framework for correlations between each combination of facial muscle activity and the corresponding emotion (Rosenberg, 2005). The Facial Action Coding System (FACS) was published by Ekman and Friesen in 1978 and is still used today since it is purely based on anatomy and consists of 28 main unique visible discernible facial movements, labeled as Action Units (AUs), as shown below in table 2.1 (Ekman & Friesen, 1978; Rosenberg, 2005; Lin et al. 2018; Tan, Rosser, Bakkes, & Pisan, 2012).

AU number	Descriptor	Muscular Basis
1.	Inner Brow Raiser	Frontalis, Pars Medialis
2.	Outer Brow Raiser	Frontalis, Pars Lateralis
4.	Brow Lowerer	Depressor Glabellae, Depressor Supercilli; Corrugator
5.	Upper Lid Raiser	Levator Palpebrae Superioris
6.	Cheek Raiser	Orbicularis Oculi, Pars Orbitalis
7.	Lid Tightener	Orbicularis Oculi, Pars Palebralis
9.	Nose Wrinkler	Levator Labii Superioris, Alaeque Nasi
10.	Upper Lip Raiser	Levator Labii Superioris, Caput Infraorbitalis
11.	Nasolabial Fold Deepener	Zygomatic Minor
12.	Lip Corner Puller	Zygomatic Major
13.	Cheek Puffer	Caninus
14.	Dimpler	Buccinator
15.	Lip Corner Depressor	Triangularis
16.	Lower Lip Depressor	Depressor Labii
17.	Chin Raiser	Mentalis
18.	Lip Puckerer	Incisivii Labii Superioris; Incisivii Labii Inferioris
20.	Lip Stretcher	Risorius
22.	Lip Funneler	Orbicularis Oris
23.	Lip Tightener	Orbicularis Oris
24.	Lip Pressor	Orbicularis Oris
25.	Lips Part	Depressor Labii, or Relaxation of Mentalis or Orbicularis Oris
26.	Jaw Drop	Masetter; Temporal and Internal Pterygoid Relaxed
27.	Mouth Stretch	Pterygoids; Digastric
28.	Lip Suck	Orbicularis Oris

Table 2.1: FACS' 28 main AUs.

Besides the 28 main AUs shown in table 2.1, other AUs are specified, concerning head movement, eye movement, and visibility codes (Ekman & Friesen, 1978). Furthermore, this framework does not only acknowledge activity within a specific AU, or combination of AUs, the FACS framework also allows for coding of the intensity on a five-point scale, in order to provide a more in-depth indication of interpreted expressions analysis (Ekman & Friesen, 1978). It is important to note that the original FACS framework does not aim at categorizing emotions, other and more recent frameworks and software have become accessible, such as iMotions' software (Rosenberg, 2005). Therefore, it is recommended to apply FEA in combination with other data collection methods, in order to provide a more nuanced and complete picture of user reactions and experiences (Ekman & Friesen, 1978; Adolphs, 2002; Rosenberg, 2005).

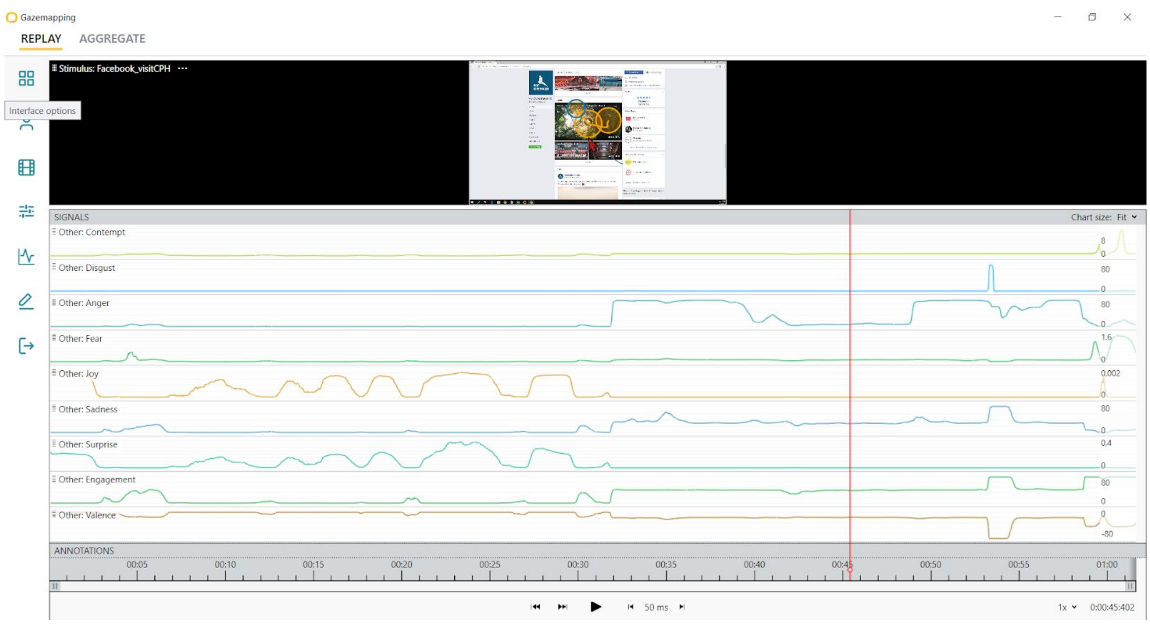

Figure 2.7: iMotions' interface of FEA showing AUs.

FACS has been used in academic research since its publication because of its thorough and comprehensive method of coding facial expressions, early day manual coding with human observers has its limitations since it relies on human capabilities (Cohn, Zlochower, Lien, & Kanade, 2005; Adolphs, 2002). Firstly, the degree of objectivity and comprehensiveness varies from person to person, in regards to interpreting communication through facial expression (Cohn et al. 2005). Secondly, Ekman and Friesen (1978) indicate that more than 7,000 different combinations of AUs can be observed using FACS, and this amount of complexity can often represent faulty findings or sources of error between observers when utilizing slow-motion video recordings (Cohn, 2005).

2.2.4 Technical considerations

To summarize the technical background, the main concepts to acknowledge are that biosensors require adequate hardware as well as software in order to produce a greater and more in-depth picture of the users' experiences. Biosensors are often used in combinations with other biosensors, most commonly ET, EDA, and FEA, and as such, this requires software solutions that can provide adequate tools for simultaneous data collection and analysis (Adolphs, 2002; Wong, Bartels & Chrobot, 2014). Although the software requirements for such a tool can be difficult to gauge at this moment, this chapter aimed to present the complexity of the biosensors and thus shows, through each sensors' capabilities and limitations, that these data collection methods benefit from triangulation by utilizing each other.

2.3 Literature review of applied biosensor research

The following literature review aims to investigate researchers' use of ET, EDA, and FEA in applied research, as this could provide insights into the overall requirements and general usages of biosensor software. This is done to both examine what common uses are in the field, but also to understand how biosensor software can accommodate the applied uses of biosensor research in what kind of data they need to extract from the software.

By understanding the context of how biosensors have been utilized by researchers, this review also aims at gathering knowledge concerning the practical implications of working with biosensor software, in order to produce insights into what a new solution, which facilitates learning, should take into account. Though these papers do not necessarily directly concern the use of biosensor software but rather the hardware, we argue that understanding how researchers use biosensors, in general, will help understand their behavior and needs which can be related to the software from which they must collect and extract their collected data.

For this literature search, a traditional literature review approach was applied (Cronin, Ryan, & Coughan, 2008; Rowley & Slack, 2004). Searches were conducted for each of the biosensors in order to investigate which advantages and limitations there are to conducting a usability test. Keywords were utilized through a block search approach, with multiple biosensor keywords in the first block and the related keywords in the second block (Cronin et al., 2008; Rowley & Slack, 2004). All searchers for applied biosensor research can be seen in Appendix 11.

Block 1	Block 2	Block 3 (2nd search)
"eye tracking" "eye-tracking" "eyetracking"	"Product evaluation" "User experience" "Usability testing" "Re-designing" "Usability" "Onboarding"	"User-centered design" "Behavioral theory"

Table 2.2: Example of block search for applied eye-tracking research.

2.3.1 Eye Tracking

Some common areas which ET has been used to explore are user experience, usability, and design. ET is often used in combination with other methods, to research and evaluate how users experience or think of a certain product or design while using it. These results are often used to point out problems and recommend changes for future redesign, or simply to examine how users perceive the provided stimuli, be it advertisements or software interfaces. By investigating the applied research of ET, contextual knowledge of use is gathered and explores the diversity of uses in the field.

Granka, Joachims & Gay (2004) used ET as a method to investigate how users interact with search result pages and how they browse the page. They observed ocular behavior while users navigated the page and before they clicked on a link, and looked at time spent looking at different elements (fixation time) to explain behavior.

However, more recent studies tend to use more methods than just ET to examine behavior, making use of several different data sources to provide more depth to the user experience analysis and to assist the ET data. For example, Goldberg, Stimson, Lewenstein, Scott & Wichansky (2002) used a post-task questionnaire after concluding ET sessions to evaluate features for a prototype web portal, supplying data beyond what data the ET can collect, such as heatmaps and gaze patterns. They also note that ET research should seek to be replicable in order to create generalizable results (Goldberg et al., 2002). Similarly, Qu, Zhang, Chao, and

Duffy (2017) used subjective qualitative questionnaires to evaluate the user experience of instant message apps, combining objective gaze data with subjective experiential accounts. Wong, Bartels, and Chrobot (2014) wrote about how ET is a productive tool in researching the user experience of e-commerce websites, and note that gaze behavior is among the most effective and informative ways of testing website user experience. As part of their study, they use heat maps to see which areas on an e-commerce web page were the most viewed, but also suggest deploying more methods such as post-task interviews to receive user feedback, leading to triangulation between ET data and user feedback. Wong, Bartels, and Chrobot (2014) conclude that "Analyses such as these have the potential to inform site design decisions and create a more effective medium for communicating product value" (p. 114), showing the usefulness of ET for testing commercial websites or software.

Researchers Wanga, Yanga, Liub, Caoc, and Maa (2014) looked into website complexity in terms of cognitive load, using ET as a method of analysis, with the primary metrics being fixation time displayed in heatmaps. After finishing their tasks, participants were asked to rate the websites in their perceived complexity. Wanga et al. (2014) present many different ways to define complexity in design and websites, but they choose the most commonly used definition, where complexity is defined by the amount of variety in a stimulus chosen for viewing during ET. As they describe it, the complexity of a stimulus (webpages, software, etc.) depends on three factors: number of elements, the level of dissimilarity between elements, and the level of unity between elements (Wanga et al, 2014). In short, how many things are on screen, how different are they, and how connected are they. The more different things are on the screen and the greater volume of content, the more complex a stimulus.

Their study also found that the complexity of a given task can moderate the effect of how users perceive website complexity. Specifically, when users conducted a simple task, fixation count and task completion time were at the highest level on the website with high complexity, while fixation duration was not significantly different on the websites with different complexity (Wanga et al, 2014). However, when users conducted a complex task on a website with medium complexity, task completion time, fixation count, and fixation duration were all at their highest level. Still, when users perform simple tasks, task completion time on websites with high complexity and medium complexity is higher than that on websites with low complexity. They also found that the attention of users is easily distracted as website complexity increases, which increases the fixation count (Wanga et al, 2014). This means that when designing tasks for testing complex stimuli through ET, it is important to consider the complexity of the task as something that can influence the fixation time and general ocular behavior of the participants. This also reflects the importance of task design and how it must be considered when evaluating usability. Is the user simply exploring a page to see what it has, or do they have a specific goal in mind? This may affect how much time they spend on a given page, and what they look for, meaning that the cognitive biases hidden in task design must be carefully considered and reflected upon by practitioners.

Using ocular behavior to explore a given topic

While the previous topic only covered ET as a method for researching UX, usability, and design, this section covers many other applications of ET methods and data. The behavior of the eye, such as fixation and eye movement between elements on a given stimulus, can be used to explore many different research areas.

An example of this is a paper by Karatekin (2007), which looks into using ET measures (tracking eye movements and fixations) to study children and adolescents, analyzing age-related differences in the ocular behavior of these two groups while also evaluating the ET methods used. In pointing out criticisms of ET, Karatekin (2007) addresses that while ET can give an impressively accurate depiction of what we look at, it is worth noting that the laboratory setting may not represent the "perceptually complex environments" (pp. 335) found in the real world. Meaning real-world use cases or scenarios examined by researchers users ET may have more distractions or a less focused context than sitting down a user and asking them to complete tasks in a specific amount of time (Karatekin, 2007). Furthermore, being asked to perform tasks may elicit more proactive and anticipatory eye movements. This does of course not invalidate ET as a method, but as it is a laboratory setting, it is worth acknowledging it is an artificial and constructed setting (Karatekin, 2007).

Tsai, Hou, Lai, Liu, and Yang (2011) examine the visual attention of students while solving multiple-choice questions, and among other things find that students pay more attention to the options they had chosen than the options they had eliminated as answers. Methodologically, they went about this by having the participants think aloud during the ET sessions, after which they performed a content analysis on the transcribed think-aloud data and used it for analysis together with heat maps and AOIs that showed fixation data (Tsai et al., 2011). Beyond their findings on what students paid the most attention to, they also suggest further using ET to explore the field of e-Learning and to evaluate other online systems to ensure a generalizable approach for such studies (Tsai et al., 2011).

ET has also been used to study learning. A study by Lai, Meng-Lung, and Tsai (2013) reviewed ET as a way of exploring learning from 2000 to 2012. This study found that the most used measures for using ET were temporal measures (fixation time), followed by count and spatial measures (number of things looked at and order), although the choice of measures was often motivated by the specific research question (Lai et al., 2013). In their literature review, they found that most applications of ET research are related to research involving information processing, such as reading, scene perception, visual searching, music reading, and typing. In terms of topics covered by ET, cognitive processes, human-computer interaction, and media communications are prominent research areas.

Examining studies centered around instructional strategies, Lai et al. (2013) found that most of the studies focus on how to design multimedia for better learning support. These studies dealt with various cues, guidance, displays, controls, and presentations that were manipulated and examined for the use of multimedia. In short, most ET studies about instructional strategies center around user experience and improving it. The rest of their study focuses on ET studies related to student learning, and the order in which students take in information and how they navigate it (Lai et al., 2013). They conclude that ET methods are a promising way to connect learning outcomes to cognitive processes (Lai et al., 2013).

These examples were provided to illustrate the wide range of subjects one can study with ET. Though much of the literature found during the block search for literature focuses on UX, usability, and design, there are diverse applications of the technology, as long as they involve examining ocular behavior and attention as a method.

Furthermore, as mentioned in the Wong, Bartels, and Chrobot (2014) study, as well as the methodology of other, examined ET studies, it is wise to not just use ET on its own but to include other research methodologies to supply or contrast the ET data with other data types that may add new perspectives or simply corroborate the ET findings and add depth to its validity. As Aga Bojko (2013b) puts it, "Eye tracking is just one method among many, and no single method can provide the answers to everything" (pp. 97). It can, however, help explain why participants failed a given task (they may have been unable to visually locate a necessary element), and provide an opening for further inquiry.

2.3.2 Electrodermal Activity

Through the literature review, several use cases of how EDA has been applied to research were found, varying from assessing stress in work situations, measuring users' trust in automated cars, and combining EDA with traditional usability methods. In the following section, the applied use of EDA will be presented as it gives insights towards limitations and advantages researchers face when working with EDA.

Measuring stress through EDA

Allowing researchers to measure the small physical conditions that change when users are exposed to stimuli can give insight towards how respondents' bodies react to the specific stimuli, which are hard for the user to report by themselves. Liu and Diu (2018) investigated the feasibility of using a single physiological signal (EDA) compared to the currently used approach with multiple physiological signals in the paper "Psychological stress level detection based on electrodermal activity". Currently, several studies on determining respondents' stress levels would use different kinds of physiological signals such as skin temperature, blood pulse, pupil diameter, heart-rate variability, and similar physiological measures (Liu & Diu, 2018). By having several physiological sensors, the researchers are able to have more precise results to assess the stress of the respondent. However, by having several sensors, difficulties of not having the sensors in one small, non-intrusive device arise. Liu and Du (2018) argue that this leads to the problem of minimizing the number of sensors while maintaining high accuracy of the results. They argue that only using one signal would create a more practical alternative for detecting stress. This would allow for easier testing of physiological stress, an increasing condition in today's society (Liu & Diu, 2018).

In their paper, Liu & Du (2018) examine how accurately EDA signals can be used to determine stress, by separating it into three types of stress levels: low, medium and high. They acquired data from an experiment by Healey and Picard (2005), who created physiological data sets about driving stress. Healey and Picard collected data from 24 participants who drove in three settings, resting, highway, and city (Liu & Diu, 2018). They collected data through ECG, EMG, RESP, and EDA, which allowed Healey and Picard to accurately measure stress in participants. From the respondents, they achieved a 90.91% accuracy in low-stress level and 77.27 in both medium and high-stress levels, averaging an accuracy of 81.82%, only through using EDA. As such Liu & Du (2018) present a relatively simple way to predict stress levels of participants within an acceptable degree of accuracy. In addition to this, they also present that EDA is capable of being used as a single physiological measure for emotional stress in the participants (Liu & Diu, 2018). Their use of EDA to measure emotions in the participants is not focused on a single emotion but is rather a general focus on emotions such. Similarly, Walker, Wang, Martens, and Verwey (2019) conducted a study on how EDA can be used to measure trust.

Measuring trust

In the study by Walker et al. (2019) an investigation of drivers' trust in automated cars is conducted, as it affects the intention of their overall use of automated cars. Most studies that investigate trust use self-reports from the participants, but Walker et al. (2019) argue that questionnaires and the like cannot capture real-time changes in trust towards automatization. In order to conduct the study, they worked with the premise of drivers' reliance on automation is primarily based on trust, and assume that if the drivers' trust towards the automation is high, drivers would be more likely to monitor non-driving related tasks compared to when trust is low (Walker et al., 2019).

Their method of approach was to place participants in a "perfect vehicle" and a "poor vehicle" group. The participants were placed in a simulator, with a screen acting the cars front-window, and being equipped with both steering wheel and pedals. The participants were told to imagine being in a fully automated car, and do a specific non-driving related task, but only if they would trust the behavior of the car (Walker et al., 2019).

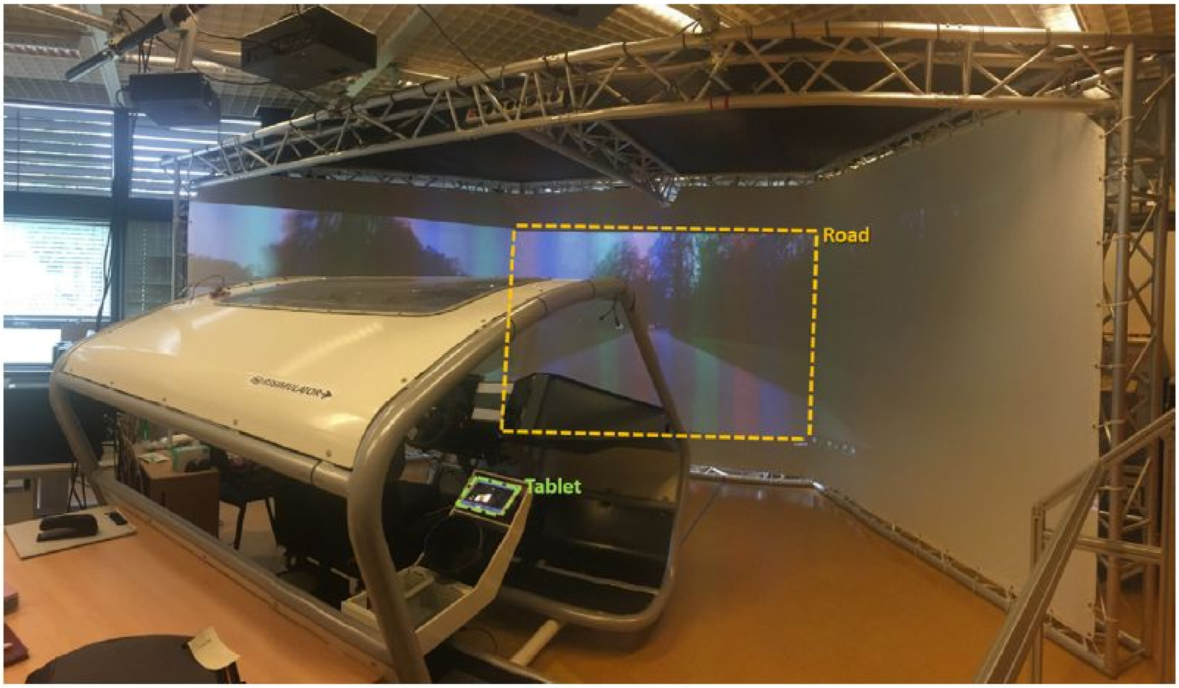

Figure 2.8: The car simulator used. (Walker et al., 2019, p. 4)

The “automated” driving would be divided into three driving phases where the driving would be different for each group, being driven perfectly for the “perfect” group, and poorly in the “poor” group (Walker et a., 2019). For the third phase, the participants would both be shown a video of the car driving poorly. During these phases, the participants were to complete a task on a tablet attached to the dashboard, making it impossible for the participants to both view the road and complete the task (Walker et a., 2019). In addition to analyzing the data gathered from gaze behavior and EDA, the participants were also asked to report their own trust towards the automated driving through a Likert scale from 1-7 (Walker et a., 2019).

From this experiment, Walker et al. (2019) conclude that both EDA and gaze behavior can be used for measuring drivers’ trust in automated vehicles. In addition to this, their results suggest that when EDA and gaze behavior is used in combination, they provide a more accurate result, than each method can provide individually. The ability to measure trust in participants in real-time, with gaze behavior and EDA allows for less reliance on self-reports, which can be affected by subjective biases (Walker et al., 2019).

EDA and usability

As we can deduct from the previously presented studies, EDA can have a positive impact when used for gathering data about users' reactions to stimuli. However, none of these studies research on how EDA can be used in combination with traditional usability methods, which is something that is of relevance for this research.

Foglia, Prete, and Zanda’s (2008) study investigated the combination of Galvanic Skin Response (GSR, another term for SCR) with traditional usability metrics in order to evaluate an animated face assistant on a web interface. In the paper, they argue that GSR is highly subjective from person to person, as people react differently to stimuli (Foglia et al., 2008). Therefore they also find it meaningless to compare the results of participants. Instead, they list six patterns that GSR signals always follow:

1. Learning effect: An already experienced event would have less effect than a new one
2. Summation effect: One single, large event can have a lesser effect that many smaller events
3. Time variant effect: The same event can cause a different effect on the same user at different times
4. Recurrent pattern for emotions: An emotion experienced will typically cause a steep increase in the physiological signal, with a smoother decrease.
5. Subjective effect: Same event causes a different effect on different users.
6. Relaxation pattern: A user who is relaxed shows a trace that decreases gracefully and continuously. (Foglia et al., 2008)

In their paper, Foglia et al., (2008) sought to evaluate the effects of the animated face, and how the GSR signals are related to the users’ attitudes and behaviors during the experiment. They set up an experiment with 43 participants, divided into two groups. Group 1 is exposed to the traditional website interface with the assisting animated face, in task 2, and group two is exposed to the web interface with the assisting animated face in task 1 (Foglia et al., 2008).

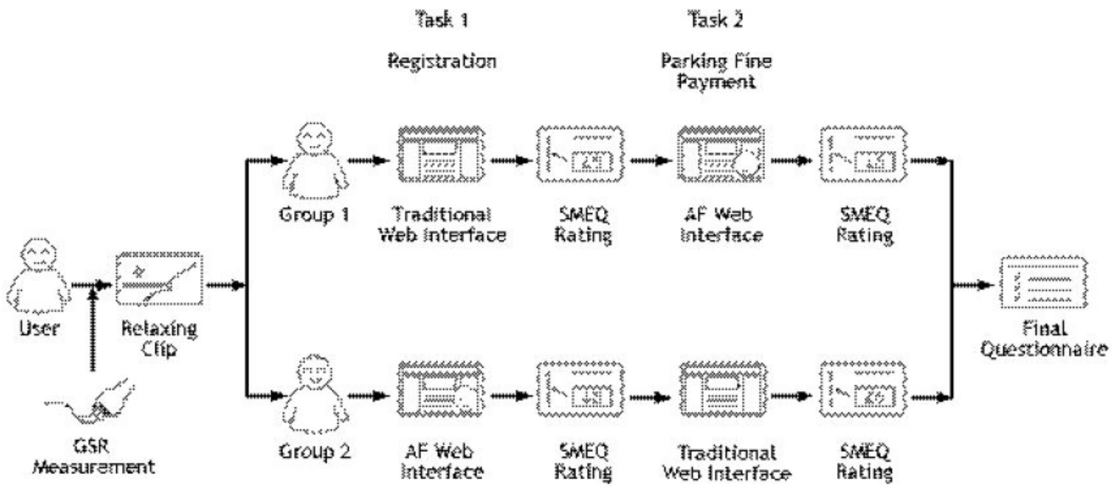

Figure 2.9: The experiment procedure of Foglia et al. (2008).

In the experiment, the participants were first shown a relaxing video to stabilize the GSR signals, before completing the tasks. After that, they were to rate the mental effort they perceived at the completion of the task (SMEQ) (Foglia et al, 2008). Finally, the participants would answer a questionnaire on a 5 point Likert scale.

Foglia et al.'s (2008) takeaways regarding GSR and its use with usability metrics are that, according to them, GSR can be used as a method to quantify the arousal of users. However, they also advocate that in order to specify which emotions that are present in the user, self-reports are necessary (Foglia et al., 2008).

In a similar fashion, O'Brien H. & Lebow M (2013). investigate the use of a mixed-method approach to measuring user experience. They conducted a study with the goal of determining the relationship between three different types of data: Self-report, behavioral, and physiological (O'Brien & Lebow, 2013). The purpose of this was to expand the toolbox of measurement in information interaction, thus broadening the perspective of how to think about conceptualization and measurement of information interaction (O'Brien & Lebow, 2013). In order to do this, they investigated an online news website.

For the experiment itself, the procedure went as follows: First, participants would have their physiological measures monitored before the tasks began, to create a resting baseline for the responses of the EDA. This allows for comparison between before the tasks and during the tasks (O'Brien & Lebow, 2013). Next, the participants would be given a hypothetical scenario, in order to create motivations for the tasks. The participants were then asked to browse the news website for three articles that they would find interesting and read them, which they were given 20 minutes to do. When they had browsed the news website and found the three articles, the participants were to fill out the user-perception questionnaire. Finally, the session was followed by an interview with the participants, discussing the news articles that they chose, and why they chose them (O'Brien & Lebow, 2013).

From the results of the experiment, O'brien & Lebow (2013) found a high correlation between EDA and interest towards the news website, however, they also note that their sample is quite small (10 people), with a short 2-minute baseline, for tasks that only took 20 minutes. Their findings showed that as interest in the news site increased, the participants' EDA decreased, which correlates with earlier reports (O'brien & Lebow, 2013).

O'Brien and Lebow (2013) conclude from this study that having the three types of data, self-reports, behavioral and physiological in combination, allows for a greater understanding of the users' experience. In addition to this, they argue that combining the different types of data can create evidence for criterion validity between the subjective and objective findings (O'Brien & Lebow, 2013). They also argue that EDA is an option for measuring interest in online information interaction, and they implore other researchers to use the triangulation of both self-reports, behavior, and physiological data, in order to understand users' experience completely.

2.3.3 Facial Expression Analysis

Several studies that applied FEA recommend using FEA in combination with other data collection methods (Tan et al., 2012; Tobin & Ritchie, 2012; Cohn, 2005). As such, it is necessary to investigate what others have done within this research area, in order to learn from how FEA has been applied in research.

As previously mentioned, manual coding of FEA, using FACS, has its limitations and as such, it was important to investigate the current landscape of conducting FEA testing. A study by Cohn, Zlochower, Lien, and Kanade (2005), compared FACS coding by human observers with an automated state of the art, of its period, software and demonstrated high concurrent validity amongst the data (Cohn et al. 2005).

Empty coding

The study by Tan et al. (2012) conducted user experience research by utilizing automated FEA coding of participants, while they were playing different video-based computer games. Although their data collection provided what they saw as adequate results, they experienced some difficulties pertaining to what they labeled as empty reading, which was periods within recordings where the software was not able to gather anything meaningful (Tan et al. 2012). This was mostly due to two different problems. Firstly, some participants obstructed the facial view from the camera by touching their faces and as such, inhibited the process of FEA. Secondly, some participants relocated themselves to be positioned out of the camera's view area, either by moving left or right or by simply slouching too far down in their chair, rendering the recording unusable (Tan et al. 2012). Furthermore, the study conducted by Tan et al. (2012) also indicates that participants may be less likely to express signs of certain emotions, such as frustration or anger, as stated by one of their participants "the video recording wasn't affecting me too much. However, I guess I would have shown more frustration/anger if the video recording was not present." (Tan et al. 2012, p. 9).

2.3.4 Main Findings

It has not been possible to use biosensors to test the interaction with and usage of iMotions biosensor software due to the COVID-19 pandemic, which prevented physical data collection. One of the ways to mitigate this was by investigating the applied research of biosensors through a literature review. Furthermore, due to the lack of academic studies regarding the usage of the software that collects biosensor data, this literature review aimed at investigating the three most prominently used biosensors and their processes as a method of understanding what researchers who use biosensor software will need to extract from the system, and for what purpose (Appendix 11). This provided the following insights.

Studies reviewed suggested to use different biosensors to supplement each other during data collection, leading to the collection of many different data types such as heatmaps, heart rate, AOIs, facial expressions over time, fixation, skin temperature and more. All of these are used for vastly different purposes depending on the area of research, whether it be UX research, measuring trust during usage of self-driving cars, or which emotions humans express when reacting to stimuli. The process is further complicated when these types of data collection methods may intersect, and if they are all to be represented in a single piece of software, it may create a heavy cognitive load for users.

These findings provide insight into the usage of biosensors and what kinds of data users may need to extract from biosensor software. Above all else, it illustrates that since it is recommended to use multiple methods and biosensors for data collection, that there is a lot of different biometrics to locate and extract from the software, which could lead to complications for both learning and usage of biosensor software. This warrants further exploration of not just these use cases where researchers need many different data types, but also a questioning of what such required versatility in one piece of software affects both the learning experience and the user experience.

3. Literature Review of Learning Facilitation

This literature review investigates best practices for facilitating non-human teaching and how to accommodate different user types for learning. This includes cognitive load theory, multimedia learning, and using different media channels for learning. The intention is to gain knowledge of learning as it relates to the process of learning software so that such insights could be applied to designing a digital learning solution. This literature review presents different ways in which other researchers have investigated the relationship between learning and technology. For this literature review, a traditional review approach was used, similar to the literature review made in chapter 2. A block search was used with new blocks being added to either narrow or widen the searches. The full literature review search and its blocks can be seen in appendix 12.

Block 1	Block 2	Block 3
Learning* Teaching* Evaluate* Education*	Biosensors Biometric sensor Software Advanced software Technology Multimedia	Cognitive theory Cognitive research Cognitive load

Table 3.1: Second block search for Literature review: Learning

In addition to finding literature through the search, some relevant articles were also found through investigating the journals in which some articles were found.

3.1 Multimedia Learning and Cognitive Load

Mutlu-Bayraktar, Cosgun, and Altan (2019) conducted a systematic literature review about cognitive load in multimedia learning environments, and focused on the research between 2015 to 2019 and reviewed a total of 94 articles. In this article, they review types of cognitive load, types of multimedia learning principles, which dependent and independent variables are investigated, cognitive process, types of multimedia learning environments, and the demographic of the studies (Mutlu-Bayraktar et al., 2019).

Mutlu-Bayraktar et al. (2019) motivate their systematic review by highlighting that multimedia learning is a rapidly developing theory that can grow on par with the increasing use of technology in education and learning. In the article, they define multimedia learning as "Multimedia designs which appeal to different sensing and processing channels are defined as those that present words (narration or text) and pictures (illustration, photography, animation, video, etc.) together" (Mutlu-Bayraktar et al., 2019, p. 1). Related to multimedia learning, they also define their understanding of human cognition, as this must be taken into consideration when reviewing the learning progress through multimedia learning. They write that "learning is accomplished by establishing connections between compatible verbal and pictorial representations" (Mutlu-Bayraktar et al., 2019, p. 1-2). They further elaborate on this by explaining how researchers began to study how the process of selecting and organizing what information is relevant and how it is integrated with prior knowledge that the learner has. Thus, exploring methods which optimize the process of learning through different channels of stimuli (Mutlu-Bayraktar et al., 2019).

Studies revealed that obtaining intensive and complex information through verbal and pictorial channels can be challenging for the learner and hence the concept of cognitive load and the theory of it emerged. The cognitive load theory argues that there are three categories of cognitive load, related to any learning task (Mutlu-Bayraktar et al., 2019). The three categories are the following:

1. The intrinsic cognitive load

   Determined by the complexity of the task. The task becomes more complex, as the intrinsic cognitive load gets higher. Also related to the learners' prior knowledge.

2. The extraneous cognitive load

   The way the information is presented to the learner. Related to the instructional design of the task, and is related to unnecessary elements that need to be processed by the learner.

3. The Germane cognitive load

   This refers to the effort it takes for the learner to create permanent knowledge from the situation. This cognitive load is what is left of the mental capacity after the intrinsic and extraneous cognitive load has begun.
   (Mutlu-Bayraktar et al., 2019)

To summarize the cognitive learning theory, it advocates that the total cognitive load the learner experiences should not exceed their learning capacity, which is why designers should be aware of this and analyze what content is being taught and be aware of the limitations of the learner's cognitive load (Mutlu-Bayraktar et al., 2019).

They conclude that recent studies within this field have a tendency to use subjective measures for assessing cognitive load in multimedia learning research, despite objective measures providing stronger validity and more reliable results (Mutlu-Bayraktar et al., 2019). They advocate that future studies apply objective measures more, such as eye-tracking and physiological measures. However, they also note that combining subjective and objective measures can ensure the reliability and validity of the findings of the study (Mutlu-Bayraktar et al., 2019).

Another study by Rapchak (2017) offered valuable insights for designers who are to create learning experiences. This research highlights multimedia principles applied to online libraries, defining how they can be used, and what online libraries should avoid when creating tutorials. In the study, the principles of multimedia, such as animation, cognitive load, audio, personalization and characters, content to improve learning, and considering the audience, are highlighted (Rapchak, 2017).

Regarding cognitive load, one of the focal points for the study is that designers of learning experiences should reduce cognitive load by removing unnecessary or inappropriate instructional procedures. Designers should carefully consider the number of multimedia effects used to increase engagement, as this can also have a negative effect on learning. As such, the study argues that having animations should be reduced to an absolute minimum if it is possible. To also reduce the cognitive load for the learner, Rapchak (2017) suggests that the learning experience should be divided into several short learning modules, as long tutorials can cause cognitive overload.

In relation to using the duality of multimedia learning, audio is an important channel to use properly for improving learning. Using both channels simultaneously needs to be applied correctly, as otherwise, it can lead to cognitive overload for the learner (Rapchak, 2017). Rapchak (2017) argues to be aware of how audio is applied to multimedia learning and highlights that the most effective use of audio in multimedia learning is in combination with the visual channel. Letting the learner hear a process or task be explained, while the task or process is being shown, allowing for verbal information to be easily synchronized with the visual information presented (Rapchak, 2017). This can lead to deeper learning as the information is more likely to be organized in the working models of the long term memory (Rapchak, 2017). However, the audio and visual channels need to complement each other and not cause redundancy in information, such as reading out loud text on the screen (Rapchak, 2017).

Addressing the learner in an appropriate manner is also an important part of learning. Often academic learning uses a certain tone when communicating, using third-person pronouns, however creating a more personalized tone is advised, according to Rapchak (2017). Talking to the learner in a more conversational tone such as by using first- and second pronouns may be recommended. This is due to studies showing that students had a higher rate of both retention and transfer skills when receiving multimedia instructions that are explanatory, rather than formal (Rapchak, 2017).

Finally, the learning experience needs to be tailored to the learner, as they can have different prior knowledge, according to Rapchak (2017). If learners with a low level of prior knowledge are supported and given information that is easy to process, this will often cause learning to be more effective, however, if the same methods are applied to learners with a high level of prior knowledge, learning can be less effective (Rapchak, 2017).

As mentioned above, it is recommended to look towards more objective measures to understand the cognitive process. Richter and Scheiter (2019) investigated the expertise reversal effect, which refers to the effectiveness of instructional techniques to learners with different levels of prior knowledge. The general understanding of the expertise reversal effect is that instructional techniques should be adjusted as learners acquire more knowledge of the process (Richter & Scheiter, 2019). To investigate this, they used ET as an objective measure to evaluate when the cognitive load was happening, in combination with self-reports about cognitive load (Richter & Scheiter, 2019). The measures from ET they use are focused on the gaze behavior, tracking where participants looked, number and duration of fixations, and pupil dilation. Pupil dilation is a specifically important measure for the study, as pupil dilation grows larger when there is a cognitive load. However, Richter and Scheiter (2019), also highlights that dilation can also be caused by the illumination of the room, so researchers have to be aware of the experiment setting. For the test, Richter and Scheiter (2019) collected data from 73 students. To understand the learners' prior knowledge of the subject, a pretest was conducted, in order to investigate the participants' prior knowledge and their general interest and motivation for understanding the subject. After the pretest, the participants did a knowledge test, introducing them to the subject, and testing their comprehension and performance (Richer & Scheiter, 2019). After the test was conducted, the participants were to self-report on their extraneous cognitive load and their germane cognitive load. To report on their extraneous cognitive load, the participants were asked "How difficult was it for you to understand the contents?", and the germane cognitive load was reported on by being asked, "How much did you concentrate during learning with the digital textbook?" (Richter & Scheiter, 2019).

Richter and Scheiter (2019) could conclude that, much in line with similar studies, integrating different channels of multimedia (audio and visual) by signaling, supports learners with low prior knowledge. However, the study also showed that learners with high prior knowledge were either hindered by the signaling, or unaffected by this. Richter and Scheiter's (2019) final recommendations, based on their own study, are to adapt the design of multimedia learning to learners' prior knowledge, supporting learners to the best extent that is possible.

3.2 Instructional Videos and Cognitive Load

Providing instructional video and other multimedia sources has been used for instructional guidance for many purposes, but this section aims to provide indicators to the best practice of applying cognitive theory to instructional videos.

Pickens (2017) conducted a literature review, in which she investigated the appliances of cognitive load theory to instructional guidance related to library and literature search processes. In the article, she compares static guidance to video guidance, and how they support cognitive load theory. This is also considered in the context of a system that teaches distant learners through non-human guidance, and as such, it is relevant for the aim of this thesis.

The article by Pickens (2017) argues that allowing the learner more control of how information is managed or to segment the learning tasks, will help to reduce intrinsic load, as the learner is more likely to create new knowledge by creating connections between different elements of information. As such, instructional guidance should aim to provide a segmented information overview so the learner is able to navigate content easily and only present desired content so as to not provide additional extraneous cognitive load (Pickens, 2017). Although Pickens (2017) recommends video tutorials for enhancing a learning situation, she expresses the importance of not increasing the extraneous load, which can be difficult for subjects that require multiple elements of information.

The aim of reducing cognitive load for instructional video guidance is also essential throughout Oud's (2009) paper, which aims to provide guidelines for utilizing video tutorials for academic library instructions. She argues that videos should be planned to only show the absolutely necessary elements to understand the learning context and audio should be scripted so the words only appear in one format, either through audio or visuals as to not confuse the learner (Oud, 2009). Furthermore, the article suggests that videos should be short and task-specific, segmented into categories for a better overview of the learning progress, as this would allow the learner to only concentrate on one subject at a time, thus aiming to reduce the overall extraneous load (Oud, 2009).

Another important factor when utilizing video instructions for educational purposes is the component of control (Oud, 2009). Video control should be provided in the form of easily accessible navigation, such as pace and content controls (Oud, 2009). Video pace refers to easy controls for pausing and playing the video and content control should be understood as controls that allow the learner to choose their own sequence of information presentation, thus aiming at minimizing intrinsic load (Oud, 2009). Furthermore, Oud (2009) presents four recommendations for how to present video content:

- Giving an outline of what will happen right at the beginning, to prepare students for what they will encounter;
- Clearly indicating when each part is beginning and ending;
- Explicitly and clearly stating each point; and
- Ending with a summary to help reinforce concepts in student memory
  (Oud, 2009. p. 4)

These recommendations or principles should be applied for each instructional video as it would assist the learner to quickly assess the learning sequence and choose their desired approach, thus aiming at reducing the intrinsic load.

The article by Oud (2009) also expresses the need for understanding the learner, in terms of knowledge level and preferences, as instructional videos offer less teacher interaction than within a regular teacher and learner context. Instructional videos need to be carefully planned in correspondence with the learners' prerequisite skill levels, as stated by Oud (2009), "One size does not fit all when it comes to multimedia learning" (p. 172). As such, the users' learning approaches and preferences are important to investigate and analyze before developing these kinds of videos. Inexperienced learners would benefit from structured, longer, and more explanatory videos, as it would provide a framework for their learning progression, thus presenting what to expect (Oud, 2009). This approach would be counterproductive for the experienced learners, as it might confuse or frustrate them as some of the content might be existing knowledge, as expressed as:

> To allow flexibility in navigating through the content, possibilities include providing a table of contents that allows students to choose which sections they wish to view, or breaking up a longer tutorial into small, focused sections and creating a series instead. (Oud, 2009. p. 9)

As such, videos aiming at providing a better learning experience for iMotions' software should accommodate the different user types, in terms of prerequisite knowledge levels.

Lastly, Oud (2009) states that "Learning is an active, interactive process where learners make meaning from new experiences", which indicates that interactivity within the learning process could facilitate a more efficient learning experience. Providing learners with interactivity in relation to instructional videos refers to the previously mentioned element of content control, but the article also addresses *feedback* as an important factor (Oud, 2009). Feedback is the direct response a software gives the user or learner when they are interacting with it and this feedback helps the learner to know if an answer or choice is right or wrong through immediate explanation (Oud, 2009). Applying interactivity to instructional videos can be a challenge since videos are often only meant to be watched and not interacted with, but Oud (2009) suggests for this interaction to happen alongside the video.

3.3 Main Findings

The study by Mutlu-Bayraktar et al (2019) showed that cognitive load is important to take into account for learning experiences and that there are different types of cognitive load determined by different aspects of the learning experience. Overall, the total cognitive load the learner experiences should not exceed their learning capacity. (Mutlu-Bayraktar et al., 2019).

The study from Rapchak (2017) provided insight into several considerations that designers should be aware of when designing learning designs, such as to adapt and personalize information for the learner and to apply the strength of combining audio and visual channels in multimedia learning. Together, these studies provide important considerations about multimedia learning and the overall experience a learner goes through, as well as what to account for a positive learning experience.

Both articles from Pickens (2017) and Oud (2009) advocates for the minimization of extraneous load through reducing the unnecessary elements shown within instructional videos, as it allows the learner to only focus on a specific task or area at once, thus providing a more efficient learning experience.

The article by Oud (2009) also suggests that learner assessment is essential in order to provide an efficient and meaningful learning experience since learners have different prerequisite skills levels and instructional videos need to accommodate different learner types.

Lastly, the article by Oud (2009) provides indicators on how to minimize the intrinsic cognitive load through two suggestions. First, the article provides guidelines for how to present video content in order for learners to more efficiently understand the learning context and to assess the learning progress. Secondly, providing easily accessible video and content control aims to facilitate the learner to participate in their own learning process by allowing them to skip unwanted or unnecessary content, thus reducing the intrinsic cognitive load.

4. Theory

This chapter aims to provide an overview and explanation of three relevant theories, pertaining to this thesis' research. The theories presented consist of Gibson's (1979) theory of affordance, Vygotsky's (1930) Zone of Proximal Development (ZPD) and Wood, Bruner, and Ross's (1976) theory of scaffolding. Lastly, this chapter will present theories related to didactic considerations.

4.1 Affordance

The term *affordance* was coined by James J. Gibson in 1977, and is defined as the following: "The affordance of anything is a specific combination of the properties of its substance and its surfaces taken with reference to an animal" (Gibson, 1979. Pp. 67). In short, it concerns that which distinguishes a particular object, species, or concept from others, much like how one would distinguish a type of animal from a plant or other species. In a more practical sense, it can be thought of as the combination of properties uniquely related to that which is being discussed, be it an animal, a type of plant, or technology.

Further looking at the technological perspective, Donald Norman (1999) relates the concept to design and technology and sees it as being a way of referring to actionable properties between the world and an actor, such as a person or an animal. Furthermore, he distinguishes the affordance term from what he calls *perceived affordance* (Norman, 1999). As he puts it, a designer would care more about what actions the user perceives to be possible than what is true. That is, the perspective of the user is central, and for that reason, what they believe to be possible based on their perspective on what they are interacting with is also central (Norman, 1999). In contrast, affordances deal more with the physical affordances of a given object, where Norman posits that for screen-based products such as software, perceived affordances play a larger part, as well as cultural conventions, such as knowing that a mouse cursor changing to a hand allows you to click an element (Norman, 1999).

As Norman (1999) puts it, a computer system already comes with built-in physical affordances, such as the keyboard, screen, mouse, and these also come with their own affordances, such as how the mouse affords to point and interact with elements on the screen. Furthermore, he notes that most of these affordances are of little interest to the design process compared to perceived affordances (Norman, 1999). For designers, signaling what users can interact with is perceived affordances, such as putting an icon or other targets for users to click on the screen. An icon does not afford clicking, as the computer and mouse are what afford clicking, rather, an icon would indicate which affordances exist in the system, and create a perceived affordance (Norman, 1999). It is more about signaling what is possible within the system, and not defining what is possible. Possible actions can be indicated with the use of *signifiers*, such as icons or guiding text, as long as they are perceivable, which is explained by Norman (2013a) as the following "In design, signifiers are more important than affordances, for they communicate how to use the design" (pp. 19).

Finally, Norman (1999) touches on other useful terms within the design space, such as *constraints and conventions*. For one, designers rely on conventional interpretations of symbols and their places and rely on users to be familiar with certain conventions. Constraints can be divided into three categories: *Physical constraints*, *logical constraints*, and *cultural constraints* (Norman, 1999).

Physical constraints are similar to affordances, and can be elements such as not being able to move the mouse outside the screen, and so would disabling the mouse when it is not desired for the user to use it (Norman, 1999). Logical constraints deal with reasoning for determining alternatives, such as the user being informed to click five locations while there are four on screen, letting them know that there is a fifth location off-screen (Norman, 1999). Cultural constraints are conventions shared by a cultural group, such as a scroll bar being near-universally known as what allows you to move up and down the page, as well as how clicking and holding the mouse on it allows the user to move it (Norman, 1999). Finally, Norman (1999) concludes that a convention can also be viewed as a constraint in that it prohibits certain activities and encourages others, and is a cultural constraint that has evolved over time. These design constraints help put words to and illustrate the way predetermined constraints or restrictions on a system can shape the behavior of a user, and be useful terms to consider in regards to which aspects of a system should be focused on in order to change or encourage certain user behavior. Ultimately, affordance as a term deals with the relationship between the artifact and the actor engaging with it (Faraj & Azad, 2012). Furthermore, using affordances and constraints can help dictate the level of agency a user has when interacting with a technological system (Faraj & Azad, 2012).

Due to the enormous number of possibilities of handling and collecting data with a biosensor software like iMotions, affordances is a relevant term to apply, as it can give an understanding of both the current affordances that an expert would perceive from the software, but also the users perceived affordances in the software.

4.2 Kolb's experiential learning

The first meeting with biosensor technology can often be an overwhelming task. There are many types, it is advanced, and if you do not have experience with similar technology, it can be a steep learning process. Experience, however, is the keyword, as most new fields of knowledge can be difficult to understand when there is no relatable experience to assess the situation. Kolb's *experiential learning* theory is relevant to both assess and discuss the situation new users of biosensor software encounter, as well as understanding the concept of learning.

The name of the theory, experiential learning emphasizes "experiential" because it highlights the value of experiences in learning (Kolb, Boyatzis & Mainemelis, 1999). The experiential learning theory has a general consensus of its contents, however, there are several models explaining the process of experiential learning, each with its own tweaks. We have chosen to work with the Lewinian experiential learning model, as shown in figure 4.1.

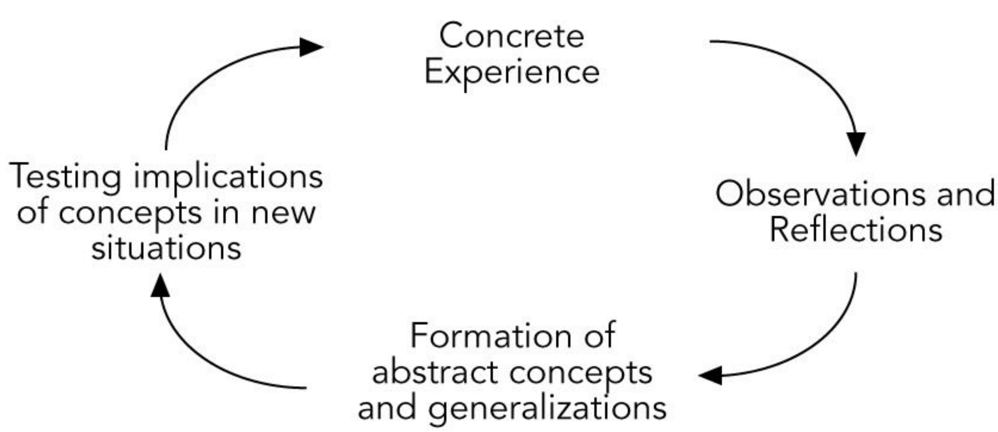

Figure 4.1: Lewinian Experiential Learning Model, own depiction of model based on Kolb (1984), p.21.

The Lewinian model begins with a here-and-now experience, something that the learner gains in the moment (Kolb, 1984). A simple example of this would be if a person touches a hot stove. The learner will immediately experience heat from the stove and experience the pain of touching it. This data, that the hot stove burns when touched upon is reflected upon and a conclusion is made: Do not touch the stove when it is hot. This information, based on the earlier experiences, will modify the learner's behavior and choice of touching the stove. This overemphasized example is a presentation of the four staged cycles that constitute the Lewinian experiential learning model (Kolb, 1984). To put it into a more theoretical view, the first immediate concrete experience is the basis of any observation and reflection. The observations and reflections are then made into "theory" from which new implications for behavior can be deduced. By creating these hypotheses or implications, the action is guided towards new experiences (Kolb, 1984: Kolb, et al, 1999).

The Lewinian model is chosen for the two following aspects. Firstly, it emphasizes the here-and-now experience, the concrete and immediate experience. The immediate experience is a focal point of this model, and it is also a focal point in life, as it is essential for giving meaning to abstract concepts and can at the same time give concrete references, which can test the implications and validity of ideas, and as such create a learning process (Kolb, 1984). As Kolb highlights "When human beings share an experience, they can share it fully, concretely, and abstractly" (Kolb, 1984, p. 21). Secondly, is the emphasis on feedback. In the Lewinian model, it is used to describe "a social learning and problem-solving process that generates valid information to assess deviations from desired goals" (Kolb, 1984, p.21-22). As such, feedback is an essential part of the learning process as well, as it provides a basis for the continuous process of actioning towards a goal and helps evaluate the consequences of the action (Kolb, 1984).

4.3 Zone of Proximal Development

A way to understand how learners can evolve and advance their knowledge is through the theories from Lev Vygotsky, who was a pioneer in researching the relationship between development and learning (Roberson, 2017). Vygotsky coined the term *Zone of Proximal Development*, a term directed at children and their learning experiences. Vygotsky challenged the formal learning of schools and argued that children learn from others prior to school, such as learning from adults. Hence, children will have acquired skills that reflect their own mental abilities, based on their actual development stage or level (Roberson, 2017). That is why Vygotsky argues that teachers should be aware of the individual capabilities of children and that learning opportunities should match the child's development level (Roberson, 2017: Nordlof, 2014). Children have an *actual development level* which is the current capabilities of the child, what the child can do on its own due to its current developed mental abilities (Roberson, 2017: Nordlof, 2014). The second stage is the *potential development level*, referring to what the child could be capable of, if it receives assistance, be it from teachers or other peers. Between the two stages, the term ZPD exists. Vygotsky (1978) defined the term as:

> This difference between twelve and eight, or between nine and eight, is what we call the zone of proximal development. The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky, 1978, p. 86)

In other words, ZPD refers to the distance between different stages in the learning process: The stage at which a learner cannot do something, the stage at which the learner can do it with guidance, and the stage at which the learner can do it unaided.

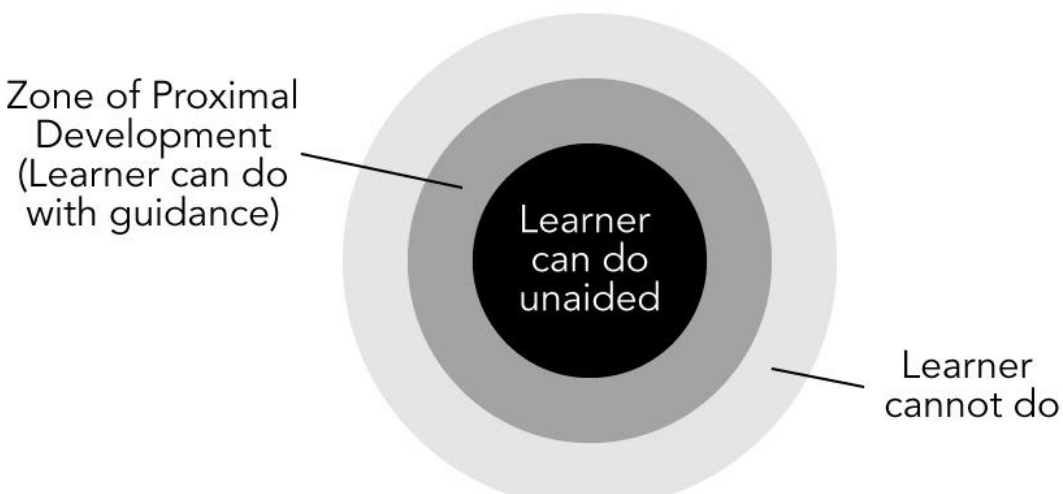

Figure 4.2: Zone of proximal development (Own model based on Vygotsky, 1978)

This is especially why we argue that ZPD is a relevant theory to aid us in our analysis, as this is often the situation of learners interacting with biosensor software for the first time. As the learners need to be assisted to learn and help them take action independently, which leads to another term that is relevant, *scaffolding*, which is often used in combination with ZPD.

4.4 Scaffolding

The term Scaffolding was coined by Wood, Bruner, and Ross in the 1970s, which were inspired by Vygotsky's thoughts (Pol, Volman, & Beishuizen, 2010). Since then, Scaffolding has been used widely in learning institutions to support children's learning. The word scaffolding has two understandings, the literal scaffold that is used to support buildings temporarily until the building can stand unaided and the term scaffold which is a metaphor for supporting learners temporarily to teach them to be independent learners (Pol et al., 2010). Wood et al. (1976). define scaffolding as something that: ".. consists essentially of the adult 'controlling' those elements of the task that are initially beyond the learner's capacity, thus permitting [the learner] to concentrate upon and complete only those elements that are within [the learner's] range of competence" (Wood et al., 1976, p. 90).

Since this definition, the uses have been applied in many contexts and interpreted for different uses (Pol et al., 2010). The extent of the scaffolding is different from each case. Scaffolding is not just supporting the learner, it is a dynamic interaction between the learner and the teacher, and as such, the scaffolding depends on the situation and the type of task (Pol et al., 2010) The thoughts behind scaffolding can therefore highly be related to the thoughts behind ZPD, as scaffolding can be seen as a metaphor of how teachers help learners reach the new zone of their proximal development (Nordlof, 2014). Wood et al. (1976) highlights that for the scaffolding process to be present and effective, "comprehension of the solution must precede the production" (p. 90). This is because without understanding the relation between means and end, there can be no effective feedback, and no markable knowledge of results (Wood et al., 1976).

As such, scaffolding is a relevant term for understanding how biosensor software can scaffold users to better learn the software, but also to understand what users define as effective scaffolding for their own individual needs and contexts. Currently, iMotions employs CSM's that scaffold and assist the learning process for new users, showing that they recognize the difficulty of learning biosensor software and that measures are needed in order to create an effective learning experience.

4.5 Didactic theory

The following chapter will present theories related to the didactic considerations of the learning experience. The basis of adults as learners needs to be investigated and put into perspective, which will be done by exploring *Andragogy* as a framework for understanding learning in relation to biosensor software. Furthermore, the history of *Self-directed learning* will be explained while highlighting specific aspects of self-directed learning which are relevant for the case.

4.5.1 Andragogy

In the early 1970s, Malcolm Knowles introduced the concept of adults learning differently than children, as he introduced his self-proclaimed theory Andragogy, meaning "leading man" in Greek, whereas pedagogy means "leading children" (Knowles, 1970; Knowles, Holton et al. 2005a). Although Knowles (1970) presented his idea of Andragogy as a theory, many critics have refuted the claim of it being an actual theory, Knowles et al. (2005a) have reiterated the concept of Andragogy as such, "It is a set of core adult learning principles that apply to all adult learning situations." (p. 2). Although Andragogy is not interpreted as an actual theory by many, the concept of understanding the many aspects of how learning for adults is facilitated and processed is necessary to investigate, as it relates to the aim of providing a more efficient learning experience of biosensor software.

Andragogy has been researched and examined by Merriam, Chaffarella, and Baumgartner, (2006) since the publication of the term and describes it as the following, "It does not give us the total picture, nor is it a panacea for fixing adult learning practices. Rather, it constitutes one piece of the rich mosaic of adult learning." (p. 92). As such, the concept of Andragogy provides guidelines and assumptions to consider when planning and developing a learning context for adult learners. These guidelines are based on the following six assumptions:

1. As a person matures, his or her self-concept moves from that of a dependent personality toward one of a self-directing human being.
2. An adult accumulates a growing reservoir of experience, which is a rich resource for learning.
3. The readiness of an adult to learn is closely related to the developmental tasks of his or her social role.
4. There is a change in time perspective as people mature— from future application of knowledge to immediacy of application. Thus, an adult is more problem centered than subject centered in learning.
5. The most potent motivations are internal rather than external
6. Adults need to know why they need to learn something.
   (Merriam et al. 2006, p. 84)

Knowles (1970) suggests that adult learners are more independent and self-directing, and as such, they should be more involved in the process of how they are being taught. "Being self-directing also means that adult students can participate in the diagnosis of their learning needs, the planning and implementation of the learning experiences, and the evaluation of those experiences." (Merriam et. al, 2006, p. 85).

Based on these assumptions about adult learners, Knowles (1970) discusses four principles that educators should consider when teaching adults.

1. Since adults are self-directed, they should have a say in the content and process of their learning.
2. Because adults have more experience to draw from, their learning should focus on adding to what they have already learned in the past.
3. Since adults are looking for practical learning, content should focus on issues related to their work or personal life.
4. Additionally, learning should be centered on solving problems instead of memorizing content.

Applying these assumptions and principles in practice can be difficult, as Andragogy facilitates a theoretical framework for adult learning. As such, Andragogy requires an understand and knowledge of the specific learning context and learner, in this case, users of biosensor software, as the teacher is required to reflect upon each of the assumptions and how they fit the situation at that point in time and place (Knowles et al. 2005c).

The teacher or the learning-facilitator also needs to address and reflect on other concepts as shown below in figure 4.1.

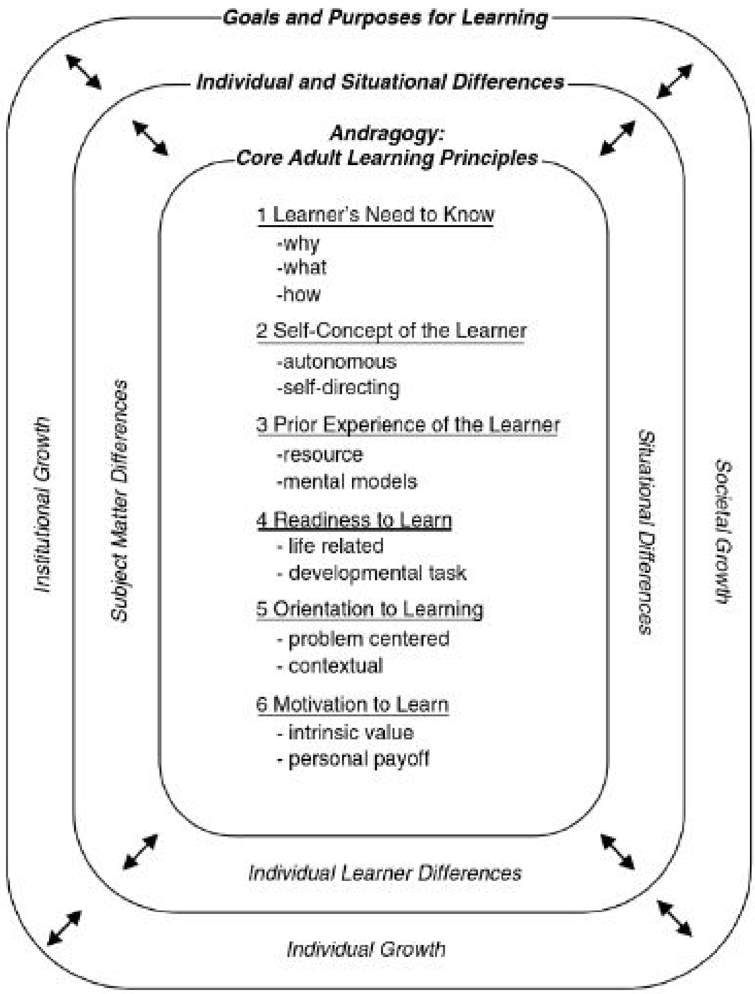

Figure 4.3: Andragogy in practice (Knowles et al. 2005c, p. 149)

The outer ring *Goals and Purposes of Learning* refers to the terms; *individual-*, *institutional-*, or *societal growth*, which constitutes the aim of the learning process (Knowles et al. 2005c).

Individual growth refers to the life skills which adults learn in order to better manage their individual life, whereas institutional growth refers to learning goals which are set in order to improve job or organizational performance. Lastly, societal growth is concerned with the teaching in social transformation contexts, where the aim is to improve their social context and help adults put knowledge into action.

The second ring, in figure 4.3, shows categories of the differences that impact the learning process. *Subject-matter Differences* refers to how different subjects of learning may require different learning strategies since there is a difference in how different subjects should and can be taught (Knowles et al. 2005c). *Situational Differences* refers to the situational context of the learning environment. Does the learning take place in a classroom, individual teaching, or through group activities? Related to this, Knowles et al. (2005c) state: "For example, learners in remote locations may be forced to be more self-directed…" (p. 153). The last category, *Individual Learner Differences*, refers to the individual and personal differences which alters and affect the learning process, as adults do not behave the same, but understanding the differences can help to facilitate learning, as described by Knowles et al. (2005c) "the key point is clear - individuals vary in their approaches, strategies, and preferences during learning activities" (p. 154).

In relation to this research, for biosensor software, it is important to understand the context of learning, in most users' experience, a completely new piece of technology, such as iMotions' software. Knowles et at. (2005d) explains that in situations where the learner is operating within an area where they do not possess any pre-existing knowledge of a specific content area, the learner is very much dependent on the teacher. As such the main differences of approaching a context as the one described, Knowles et al. (2005d) provide the following explanation of how Andragogy differs from a normal pedagogical approach:

> The pedagog, perceiving the pedagogical assumptions to be the only realistic assumptions, will insist that the learners remain dependent on the teacher. On the other had [hand], the andragog, perceiving that movement toward the andragogical assumptions is a desirable goal, will do everything possible to help the learners take increasing responsibility for their own learning. (p. 70)

This difference is important to understand in terms of the correlation between learners of biosensor software and a possible, and purely digital non-human, solution for facilitating a rewarding learning experience for this thesis. As such, the following section aims to provide a more in-depth understanding of how learners can be guided with the goal of facilitating motivation and responsibility.

4.5.2 Self-directed learning

Since the 1970s, adults' learning processes have been subject to more research and interest, as researchers sought to investigate an ever-existing phenomenon of adults learning themselves. As such, one of the terms gained traction was *self-directed learning*. Self-directed learning by itself has never been a new occurrence, as it has been embedded in the everyday lives of adults for so long, that the process has become more or less invisible (Merriam et al., 2006). Knowles (1975) who coined the term, self-directed learning describes it as such:

> In its broadest meaning, self-directed learning describes a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (p. 18)

Knowles (1975) sees self-directed learning as a process where individuals investigate a subject on their own, with or without help from others. Since 1975, Knowles and other researchers have investigated self-directed learning further, including researching adult learning. As the literature of adult learning expanded, Merriam et al. (2006) reviewed the three aspects of self directional learning: the goal, the process, and the importance of personal attributes in self-directed learning. One of the main goals of self-directed learning is to enhance the ability of the learner to be self-directed in their learning. From this goal, the assumption from educators is to help learners in informal or formal learning to be able to develop a plan, execute it and evaluate their process and their learning (Merriam et al. 2006). However, this assumption is not only directed at adults as it is a natural part of all stages of life.

The process of self-directed learning has been widely discussed, as two different processes stand out as especially noteworthy; linear and instructional. The earliest model of the self-directed process is depicted as linear, with Tough (1971) and Knowles (1975) as the frontrunners on the linear process, while both shared similar thoughts about it (Merriam et al., 2006). Knowles (1975) formulated six steps for self-directed learning, which shared similarity to Tough's thoughts: (1) climate setting, (2) diagnosing learning needs, (3) formulating learning goals, (4) identifying human and material resources for learning, (5) choosing and implementing appropriate learning strategies, and (6) evaluating learning outcomes (Merriam et al., 2006). Each step is to be performed linearly, in order to achieve a self-directing learning process for the adult. As the field has expanded, researchers admit that while Knowles and Tough have provided valuable groundwork, it has been conceptualized into different processes (Merriam et al., 2006).

The instructional process aims to be applied in a formal learning situation, and help educators to apply the principles of self-directed learning to their teaching. Similarly to the linear process, researchers have developed different assumptions of approach, and one that is relevant to highlight is Grow's (1991) Staged Self Directed Learning (SSDL). SSDL differs from SDL, as it provides a framework for instructors to help learners become more self-directed.
SSDL divide learners into four different stages:

1. Dependent learner. Learners of low self-direction who need an authority figure (a teacher) to tell them what to do.
2. Interested learner. Learners of moderate self-direction who are motivated and confident but largely ignorant of the subject matter to be learned.
3. Involved learner. Learners of intermediate self-direction who have both the skill and the basic knowledge and view themselves as being both ready and able to explore a specific subject area with a good guide.
4. Self-directed learner. Learners of high self-direction who are both willing and able to plan, execute, and evaluate their own learning with or without the help of an expert. (Merriam et al., 2006, p. 117).

The learners in each stage each have a different level of motivation, and understanding of how to approach the subject, and a different need of an educator. An important consideration of

Grow's SSDL process (1991), is that his model, shown in figure 4.4, is focused on all kinds of students, including both motivated students and apathetic students. That is why in his description of the model, a focal point is how to motivate the learner to gain interest in the subject. This is rarely the case for learners of biosensor software, as they would already have a reason, and therefore, creating motivation for the learner can be excessive or redundant.

The current stage of the learner needs to be considered by the educator, as a mismatch between the two can cause disruption in the learning process. Therefore, Grow (1991) made a figure showing the relation between the need of an educator, and the stage of the learner.

Stage	Student	Teacher	Examples
Stage 1	Dependent	Authority Coach	Coaching with immediate feedback. Drill. Informational lecture. Overcoming deficiencies and resistence.
Stage 2	Interested	Motivator, guide	Inspiring lecture plus guided discussion. Goal-setting and learning strategies.
Stage 3	Involved	Facilitator	Discussion facilitated by teacher who participates as equal. Seminar. Group projects.
Stage 4	Self-directed	Consultant, delegator	Internship, dissertation, individual work or self-directed study-group.

Figure 4.4: Different stages of learners and teachers (Grow, 1991, p. 129).

In figure 4.4 above, Grow (1991) describes each stage of learners to have different needs of an educator, but states every learner, despite their stages "may be temporarily dependent in the face of new topics" (Grow, 1991, p. 129).

Stage 1: Learner is most dependent on an educator. In this stage, the educator needs to be in the role of authority and coach, and give a clear understanding of what the objective is and give straightforward instructions on how to achieve the objectives (Grow, 1991).

Stage 2: Learners of moderate self-direction, are interested and available for teaching. In this stage, learners will often respond positively to personal interaction with an educator, and when they know the motives and purpose of doing different assignments (Grow, 1991).

Stage 3: Learners have some knowledge and skill in the subject, and they are ready to dive in, with proper guidance. These learners are willing to investigate the subject themselves, but will still meet obstacles which will require the guidance of an expert. According to Grow (1991), learners of this stage benefit more from teachings that focus on how to learn, making conscious use of learning strategies.

Stage 4: Learners have a high sense of self-direction. They are independent, and set their own goals, with or without the help of experts. In this stage, learners will pursue their goals on their own. In order to accomplish their goal, they will find help through experts, peers, and other resources that they can find (Grow, 1991).

Considerations of SSDL

The point of SSDL is to create independent individuals, who will take the initiative by themselves to diagnose their learning needs, formulate goals, and obtain those goals, with or without the help of experts. However, Grow (1991) does highlight some implications of the staged self-directed learning model. Grow admits that his thoughts do not represent the learners' perspective, and he stresses that this is a potential fault in the validity of his presentation. He argues that the "model's focus on teacher-facilitated learning further limits its usefulness by excluding teacherless". (Grow, 1991, p. 146). Lastly, he admits that, as any exploratory theory, SSDL is based on "seasoned observations and plausible guesses" (Grow, 1991, p. 147).

Despite these considerations from Grow (1991), the relevance of applying SSDL to the case remains. We argue that SSDL is useful with its focus on developing the learner to be an independent learner. As we aim to investigate how a digital learning experience can be designed for the user, SSDL can serve as guidance when designing a potential learning experience for users to move them to be independent learners. Being able to work as independently as possible with the iMotions software, and advanced software, in general, is an essential aspect of this thesis, which is why applying the thoughts of SSDL could be a beneficial addition to include within a design solution.

5. Methodology

The chapter will present the methodological reflections and approach for this research. First, our research design and framework will be presented. Secondly, the research approach will be argued for. Thirdly, the methods will be presented and expand on the relevance of said methods, while discussing the criteria for the sampling procedure, and the choice of participants.

However, It is important to note that this research was conducted during the COVID-19 pandemic in the spring of 2020, which meant that physical data collection was not a possibility and as such, all, except but one observation and interview was gathered through digital channels. This affected the data collection and what was physically feasible and responsible. The initial research approach, which was still a case study and utilizing user-centered design, revolved around a mixed methods approach of utilizing biosensors with the aim of evaluating iMotions' software. Conducting quantitative biosensor testing in combination with qualitative interviews could have utilized a *mixed methods case study design*, as this approach could provide insights into the complex nature of this case study (Creswell & Plano, 2018a). This approach would have allowed for the comparison of the users' physiological experiences with their perceived experience of the software, and as such, through a mixed method *convergent design*, aimed at further improving data triangulation (Creswell & Plano, 2018b).

Although this approach was not possible, we were able to conduct an onboarding observation with an interview of the corresponding CSM, who conducted the session, before the pandemic caused limitations to data collection. Despite these limitations, it opened up the possibility of recruiting participants which did not have to be physically available for us, since we no longer needed to apply participants with biosensors, we were able to interview people from around the world, who possessed user insights into iMotions' software. As such, a new methodological approach was formed.

5.1 A case study

The research design of this paper utilizes a case study approach. A case study pertains to a detailed and intensive analysis of a single case (Lazar, Feng & Hochheiser, 2017). Though there are often concerns regarding the external validity or generalizability of results found through analysis of a single case, it does not mean it is impossible to generalize based on a case study (Bryman, 2016a). However, it is important that this generalization is done in a context-specific manner, such as when utilizing what Bryman (2016b) has labeled a "Representative, typical or exemplifying case" (p. 62). With a representative case, the point is to capture the circumstances and conditions of an everyday situation, exemplifying a broader category under which it is a member (Bryman, 2016b). From the results found through such a case, a generalization can then be made to similar contexts or examples.

For this paper, the case study of the use of iMotions software is established as a representative case that illustrates the usage of biosensor software. The case is chosen not because it is unusual or extreme, but rather because it is an ordinary case for users of biosensor software, as all users have to go through first-time use at some point. This establishes the iMotions biosensor software as being typical and representative of its genre of biosensor software, and a basis from which results of tested aspects not unique to iMotions may be generalized to the use of all biosensor software.

Furthermore, though all of the results gathered through our case study may not be directly transferable to other or even similar contexts, there are still aspects of the research approach that may be generalizable to other cases and replicable, provided they share some criteria and context. The methods used to collect data may still be appropriate for researching problems for similar software, given how many criteria the different software share. As such, to replicate the usage of the methods displayed in this paper, it would require a subjective evaluation and comparison of the software by the researcher to assess whether or not the same research approach would be relevant or appropriate.

The case study will be approached with a focus on the user, and center around how the users experience iMotions and their software. That is why a presentation of the research framework is needed.

5.2 Research Framework

This paper utilizes the combination of User-centered Design and Design Thinking, in order to provide a research framework which facilitates the nature of our case study. The following two sections will explain how these serve as a framework and provide guidelines for this thesis.

5.2.1 User-Centered Design

As the name suggests, user-centered design is a design approach that focuses on making the users an integral and participatory part of the design process (Blythe, 2001). For this paper, it has been deemed an appropriate fit due to the heavy involvement of user feedback gathered as part of the research process, through insights found through qualitative feedback found in interviews. As these insights help inform the designed solution to the problem, much of the designed solution is based on the experiences and needs of the users.

User-centered design consist of the following steps (ISO, 2017):

1. Identifying the needs of the users, as well as their surrounding context.
2. Specifying requirements for the relevant stakeholders, such as users and businesses.
3. Conceptualizing and designing potential solutions
4. Evaluating the designed solutions

Identifying the needs of users allows the researcher to understand which pain points to address in the design, and understanding the user's context can help further illuminate use cases and what the process the user goes through looks like (Blythe, 2001). It is important to ask who the user is, what their problems are, and what the experience of the problems they face is like (ISO, 2017). For this paper, interviews with iMotions' employees are conducted, as well as interviews with iMotions' clients, all to generate insights into the users, their problems, and their context.

In order to make these insights actionable, requirements for relevant stakeholders are established (ISO, 2017). As this paper is first and foremost academic and ultimately not written for the gain of a company, business requirements are not factored in. Instead, the focus is on user requirements, identifying which problems a potential design would solve, and what it would ideally result in.

After identifying the needs and requirements for the design, a solution must be conceptualized and designed (ISO, 2017). This will be achieved through design thinking methods such as brainstorming, ideation, and sketching. This serves as a method of designing a solution founded both in theory and data, combining creative methods and user perspectives.

After designing a solution, in order to assess its quality, it and the process must be evaluated against the established requirements to see if it fulfills what was planned (ISO, 2017). This allows for critical reflection that may provide insights into what shortcomings there are, and what should be focused on for redesigns in the future. It also serves as a method of reflection for the work process, allowing for important insights into where one might run into problems and how to avoid them in future iterations (ISO, 2017).

This user-centered design approach was also critical in directing the next methodological choice of design thinking, which focuses heavily on user insights and empathizing with the user.

5.2 Design Thinking

Design thinking as an approach describes designing solutions to problems as part of moving between different spaces. More specifically, *inspiration*, *ideation*, and *implementation* spaces. Though each of these spaces are clearly defined, they are each quite broad and can be moved between freely (Brown & Wyatt, 2010). This specifies which part of an overall process the designer is in, but in order to further specify the exact steps taken, the *Double Diamond* model is used as well to provide more of a structural overview of the diverging and converging steps taken when designing a design solution (Clune & Lockrey, 2014). In short, design thinking provides an overall explanation of which spaces designers are moving between, whereas the Double Diamond model can specify the exact steps designers go through when designing a solution.

Throughout this paper, we as researchers move into the inspiration space by immersing ourselves in and analyzing the data (Brown & Wyatt, 2010). Through synthesizing that data and converting them into insights towards the end of the analysis, the process moves into the ideation space, to an extent. That is to say, the point of collecting and analyzing data may have been to better understand the problem from the perspective of end-users, as is the case for the inspiration stage. However, through working with and analyzing that data, some ideas for possible solutions can begin to take form amongst the researchers (Brown & Wyatt, 2010). This can be related to Jon Kolko's (2010) perspective on design thinking and his idea of abduction and abductive thinking. This is a process through which a form of hypothesis may be adopted as suggested by the data, where a form of inference occurs internally within the mind of the researcher. This is a part of the process, which is further described in chapter 7 regarding sensemaking and brainstorming for idea generation.

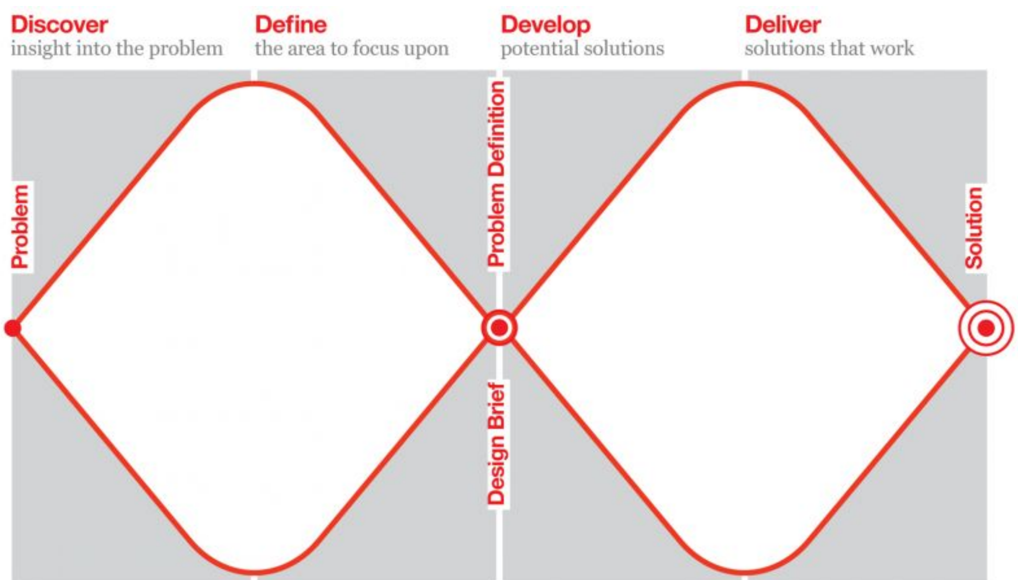

Figure 5.1: Double Diamond Model (Design Council, 2019)

In relation to the Double Diamond model, it can also be explained as the data gathering process being the *discover* step (Figure 5.1), in which a divergent approach is employed in order to better understand and gain insight into the problem (Clune & Lockrey, 2014). Then, towards the end of the analysis, a convergent approach is taken as main findings are established, defining areas to focus upon for the development step (Figure 5.1), which is further described in chapter 7. This paper's design presentation, in chapter 7, also focuses on the development step, and the methods employed to come up with design ideas that can be used for the final step of the Double Diamond model, the delivery step (Clune & Lockrey, 2014).

With a focus on the users' experience and needs, there is an emphasis on understanding the users' perspective with great detail. This forms the framework for our qualitative approach, as further explained in the following section.

5.3 Qualitative approach

This paper aims to investigate the use of biosensor software based on domain and user insights through a case study, followed by a proposed design solution. In order to understand how users are currently taught to use iMotions as well as understanding the perspectives of the users, detailed insights from those closest to this process of learning the software are required. Investigations of which efforts iMotions have put into place are required, and most centrally for this paper, exploration of how users experience this learning process as well as using the software in general. To discover and attempt to solve any problems related to this process, it is important to engage with the primary stakeholders related to the use of iMotions' software and to allow them to express their experiences and frustrations.

When working qualitatively, the focus is primarily on the interpreted meanings of words and sentiments, as opposed to the quantifications of data (Bryman, 2016a). Utilizing a qualitative approach, researchers are able to go in-depth with a case and perform what is referred to as thick descriptions, which are detailed accounts and descriptions of a culture or context (Bryman, 2016a). For this paper, the qualitative paradigm offers a methodological and analytical approach focused on understanding the perspective of the users through their own words, using qualitative methods such as ethnographic studies and interviews.

With this approach, the current context of biosensor software use can be investigated through the perspectives of the end-users who have to learn the software. Even though the perspective of iMotions employees will also aid in clarifying the current context, the primary focus is on the end-users and the problems they face, as they are the ones a solution will be designed for.

Ultimately, the objective of this paper is to delve deep into the details of the context and problems experienced by biosensor software users, as exemplified by a case study on iMotions users. The qualitative approach helps to provide the kind of rich data needed to understand these perspectives and to turn the insights gained into data needed to support design decisions.

5.3.1 Qualitative research criterions

With our chosen qualitative approach to this thesis, some considerations and reflections of the quality and robustness of the findings need to be highlighted. This will be done through an assessment of *reliability* and *validity* (Lecompte & Goetz, 1982). These terms can be viewed differently, whether or not a quantitative or qualitative approach is taken.

Reliability in a qualitative perspective which refers to two aspects, *external reliability* and *internal reliability* (Lecompte & Goetz, 1982). External reliability refers to the degree that the study can be replicated. This is a difficult criterion to meet, as social settings and situations are interchangeable, and the same circumstances are almost impossible to replicate (Lecompte & Goetz, 1982). Internal reliability is much more relevant in this case, as it refers to the internal researchers' agreement of findings (Lecompte & Goetz, 1982). This is a criterion that researchers need to be aware of during the whole process of collecting and analyzing data, in order to gain meaningful and synthesized findings.

The second essential criterion is validity which is similarly split into two aspects in the qualitative perspective, *internal validity* and *external validity* (Lecompte & Goetz, 1982). Internal validity refers to the correspondence between the data collection and the findings generated from this. This is one of the qualitative approaches strengths, as we in this thesis need to work closely with the participants to understand their social context and understanding of biosensor software. This allows for congruence between what is observed, and what information the observations have given (Lecompte & Goetz, 1982). External validity refers to the degree of which the findings can be generalized to a larger context, a point that is often weak in qualitative approaches, as case studies have difficulties proving that findings are generalizable over a vast area. In addition to this, qualitative studies often have a considerably smaller sample size than quantitative studies, making the argument of generalizing across a large population weaker. These criteria will be further reflected upon in chapter 8.

5.4 Methods

In the section to come, the used methods for this thesis will be presented. The aim of the presentation is to give a clear picture of how each method is of value to answering the problem statement and research questions, while also highlighting the strengths and values of each method.

5.4.1 Participant Observation

In order to learn about the current experience of being onboarded to the iMotions software, the method of participant observation is relevant. The focus of this method is to observe the interactions and conversation between the two participants and noting it through field notes (Bryman, 2016c). The purpose of the observation is to observe a natural situation of the participant doing the requested action. The researchers will often have the choice to do this either covert or overt, with strengths and advantages of each (Bryman, 2016c). Covert observation adds to a more natural situation, but also crosses with several ethical considerations. An overt observation, however, allows researchers to record the situation, and take field notes, and therefore acquire thorough observations and notes that can be re-experienced later. As the observation of the onboarding process would require consent from iMotions, the overt observation is the more attractive option to apply.

With consent from iMotions, an overt observation allows to take tedious field notes, which purpose is to capture key observations during the moment they occurred, from the perspective of the researchers, and as described by Bryman, are also key in capturing initial analytical thoughts about observed behavior and interactions (Bryman, 2016c). In addition to the method of participant observation, the method of a qualitative interview was utilized.

5.4.2 The Qualitative Interview

In order to gain a deep and meaningful understanding of the users' thoughts and behavior, the qualitative interview is a viable method, as it provides insight into the subject's point of view

(Brinkmann & Kvale, 2015). An interview can be conducted in many ways, depending on the focus and purpose of the interview. It can be conducted as an informal conversation. It can be conducted structured and answered rigorously. It can be a combination of both (Brinkmann & Kvale, 2015). The different types of procedures offer different kinds of qualities. Having a combination of the informal conversation and a structured interview is referred to as a semi-structured interview (Brinkmann & Kvale, 2015). A semi-structured interview is classified as an interview, with several already chosen questions that serve as a guide for the interviewer (Brinkmann & Kvale, 2015). By having a pre-made interview guide, the interviewer has several topics that need to be covered for the purpose of the interview but can dictate the interview, by letting the interviewee speak freely and choose to rephrase the questions, as the interview continues (Brinkmann & Kvale, 2015). The strength of semi-structured interviews lies in the procedure, as it allows the interviewee to open up and answer the question freely, while the interviewer has the freedom to dive into the answers from the interviewee, allowing some answers to be elaborated further and explored (Brinkmann & Kvale, 2015). By conducting interviews with users who have experience with biosensor software, and the iMotions software especially, we aim to gain insights about several aspects of the learning experience. Furthermore, we aim to get insights about how users first experienced the meeting with iMotions, and also gain an understanding of what they expected and wanted from the software.

However, due to COVID-19 and the necessary quarantines, face to face interviews are not possible, meaning we must resort to only conduct online interviews to collect data from the users' point of view. With this approach, some considerations are made. Bryman (2016d), presents how an online-interview can be conducted in two ways, either as an asynchronous interview, which is often conducted through mail or other text mediums or as a synchronous interview which is conducted in real-time with a video-communication software (Bryman, 2016d). Each approach has some limitations and strengths, which will be highlighted below.

Having an asynchronous interview allows for more flexibility, as users can answer the questions when it fits their schedule. In addition to this, such an interview also requires a greater commitment and motivation from the interviewee, which can be harder to gain from the interviewee, but it can also lead to more descriptive and more considered than a face-to-face interview. However, as Bryman (Chapter 20, 2016) also highlights that this is not necessarily a strength as spontaneous answers can also offer valuable insights. Synchronous interviews give the advantages of a face-to-face interview to some extent, as it allows the interviewer to follow up on answers from the interviewee. Additionally, the face-to-face interview can easier maintain the focus and motivation of the interviewee to a greater extent, than an asynchronous interview (Bryman, 2016d). Finally, a major potential fallacy that Bryman (Chapter 20, 2016) highlights for the synchronous online interview is the dependency of dependent internet speed on both parts of the interview, which can heavily affect both video and sound quality. To proceed with the method of interview, we conclude that for this project, having a semi-structured online synchronous interview is the most optimal path we can choose, given the circumstances.

5.4.3 Thematic Analysis

In order to analyze the qualitative interview data, thematic analysis is employed. Using thematic analysis, the qualitative interview data will be split up into themes, after which the qualitative data is to be analyzed (Bryman, 2016e). This allows a systematic and thorough analysis of the qualitative data and its content. To follow a systematic approach, Braun and Clarke (2006) suggest a series of guidelines, broken up into six steps:

1. The researcher must familiarize themselves with the data, such as by reading and transcribing the data if necessary, and writing down initial ideas they get from immersing themselves in the data.
2. Following this, the researcher must generate the initial codes of the coding process, looking for interesting features of the dataset with an open and systematic approach. This leads to a grouping of the data as it pertains to each code, in an open coding approach.
3. At this stage, the researcher creates themes by taking the codes and grouping it along with the relevant data into potential themes.
4. After creating themes, the researcher must review them as a method of evaluating if they work with the initial codes and the data set, double-checking what is to be analyzed.
5. Before the report is produced, the themes must be clearly defined and named.

6. Finally, by taking compelling examples from the themes, they will be analyzed and related to the overall analysis of the research question, a report and analysis of the data are carried out.

This systematic approach by Braun and Clarke (2006) will serve as a set of guidelines on what steps a thematic analysis consists of, and guides the approach taken in this paper. It serves as a method of analyzing and understanding the experience and point of view of interview participants, while also providing a systematic analytical approach to gain an overview of the data and its most important elements.

Data coding and themes

The initial codes were generated through open coding which, as Blair (2015) explains, deals with establishing codes that appear from text or a dataset. The open coding for this thematic analysis was carried out by going through the interview data and choosing both words and concepts that would appear multiple times throughout the interview, creating a pattern of which subjects and ideas were most common and most important. This provided both an overview of the data but also identified patterns within that data. Furthermore, as the size of each interview data is quite large, word-by-word coding (Benaquisto, 2012) was performed on important excerpts from the interview as determined by the researcher, so as to not require full word-by-word coding on the entirety of the large datasets. As Braun and Clarke (2006) claim, researcher judgment is important in determining themes. This word-by-word approach examined repeated words and concepts throughout the data, as a means of getting an overview of central ideas and concepts discussed throughout excerpts from the interviews. It is worth noting that the most frequent concepts may have been guided by the interview question to some degree, as despite it being a semi-structured interview that allows the interviewee some freedom, the interviewer ultimately frames the discussion through questions.

For themes, Braun and Clarke (2006) note that the researcher must clearly state how they measure prevalence, requiring researcher judgment to make that determination and transparency to make it clear what that determination is. Prevalence is in this case measured both by the quantity of the mention of a concept or term, but also in how related it is to the overall research question, requiring a judgment call on whether data is relevant to what is being investigated. There is no set number of times a concept or idea has to appear to make up a theme in this paper, however, it must be at least more than once (Braun & Clarke, 2006).

As mentioned earlier, the themes are to some degree at least framed or guided by the interview questions, meaning that despite the freedom interviewees have in semi-structured interviews, the starting question determines a large part of the direction of the interview. These factors influence and help determine what makes a theme in this thematic analysis (Braun & Clarke, 2006).

5.4.4 Personas and scenarios

In the following section, the use and development process of personas are described. Personas are fictional characters that serve as archetypes of users for a product (Liedtka, Ogilvie & Brozenske, 2019). The purpose of the persona is to understand the user, and "gain a sense of familiarity and empathy for your users" (Goodman, Kuniavsky & Moed, 2012, p. 492). However, creating personas to gain familiarity with the users is not only to gain insights about users' interaction with the software but also their attitudes and beliefs (Nielsen, 2013; Nielsen, 2004). Goodman et al. (2012) argue for using internal interviews with the company who meet the user in their work, to gain the employees' insight into the user, such as their understanding of the users and the users' motivation. However, as Goodman et al. (2012) emphasize, the main data used to create personas should come from the users themselves. For this thesis, the data for the personas be based upon the qualitative interviews with the users and be cross-referenced with the data gained from CSM interviews.

Yet, when working with IT-systems, personas are mostly relevant for understanding how people navigate and interact with the system, and not what information or content that should be shown, according to Nielsen (2013), as users do not have that kind of knowledge about systems. In this vein, personas are in this paper used to establish learner types. This means that the personas will be used to illustrate certain types of learners with specific learning preferences, based on the findings of the data collection and analysis. As such, these personas are a type of practical synthesis of findings and data. With this, a clear use scenario for the proposed designs can be established, relating its use to different learning preferences and needs (Goodman, 2012). Though these learner types may not cover all existing learner types or learning preferences, they serve as an example of how user data such as that collected in this paper can be used in order to consider potential user scenarios. This can help exemplify an ideal user scenario, but may also be useful for considering potential problems users can face by attempting to empathize with such user types (Goodman et al., 2012). Furthermore, it provides a more practical and less abstract understanding of how the designs might assist users. One of the ways to do so, is to use the personas in scenarios.

Scenarios are used to describe the interaction between the product and the user, detailing how a person behaves or thinks about the activity or situation. (Goodman, et al., 2012). Scenarios have several uses, depending on what the researcher wants to do with them. They can be used to tell a story, captivating what the problems are and the details of the problem, and setting a context for the user (Goodman, et al., 2012; Liedtka et al., 2019). They can also be used to provide a scenario, where the purpose is to guide the implementation and can give a shared vision of the direction of the design (Goodman, et al., 2012). Design scenarios, which will be used in this section, is a scenario that aims to envision the ideal outcome of using the design. In this type of scenario, designers recreate how users would approach a situation, the problems they encounter, and how the design ideally solves these problems (Goodman, et al., 2012). When creating the scenarios, Goodman et al. (2012) have produced a list of content a design scenario can consist of.

- Actors: Who are the actors in the scenario?
- Setting: What is the context of the scenario?
- Actions: What do the actors do?
- Events: What happens in response to the actions?
- Evaluation: How do actors evaluate the events, and how do they make decisions based on that?
- Plot: What outcome do the sequence of actions and events produce?
  (Goodman et al., 2012).

By using the above checklist, a scenario can design to depict what challenges the users face and how the design can help them overcome it. The use of personas and scenarios will later be presented and utilized in chapter 7 as a use case example of users using the design.

5.5 Population, Participants, and Sampling

This project aims to understand and improve upon the user- and learning experience of biosensor software, which pertains to the end-users of iMotions. Furthermore, there are employees at iMotions that hold key information and experiences when it comes to teaching users how to utilize their software, so although they may hold some bias in that they are representing the company whose software is being investigated, they are still holders of vital information. This makes the population for this research consist of two sets of key stakeholders: iMotions employees and end-users.

The recruited iMotions' employees were all working as CSM's, a job that dealt with client interaction and teaching usage of iMotions software. This means that they were all in positions to have observed and participated in multiple scenarios in which users were first-time learners and experienced users of the software, as well as having great amounts of experience with both learning and usability problems.

The end-users are, according to iMotions (Appendix 10), primarily either academic researchers performing various research, or private companies conducting product testing. As the focus of this thesis lies in the learning experience and not the specific uses of biosensors, we argue that potential participants should have some degree of experience with the iMotions software. That is why as a criterion for being a relevant participant in this study, the potential participant needs to have experience with iMotions, be it academic or commercial.

Though an effort was made to contact both of these subsets of users, academic users were the only group of users who responded to contact and were ultimately recruited. Having only one segment of the end-users represented in the participants does have some implications for the data collected. One of the implications is that insight gathered will be focused on a certain point of view. Thus, some of the data that are collected might highlight points and views that are not present to the same extent in commercial clients' points of view. By having only academic clients, this project, its analysis, reflections, and conclusion will not be able to give a clear picture of all of iMotions' users.

The sampling methods employed were convenience sampling and snowball sampling (Bryman, 2016f). In order to recruit iMotions employee participants, iMotions were contacted and internally asked for available employees that would be interested. For users of iMotions, initially, iMotions clients were asked through iMotions own channels, however, there were no respondents. Instead, personal contacts were used initially to recruit participants and then asking those participants to reach out to others who would fit the participant profile.

In total ten participants were recruited for interviews, seven users of iMotions of various experience, and three iMotions CSMs were interviewed. Of the six users of iMotions, three were professors, teaching at universities while the remaining participants were master thesis students. To give insights about the background of knowledge each participant has, there is a need to elaborate on the different participant education, and how they got to know the iMotions software.

Customer Success Managers

First of all, three of the participants interviewed were employed at iMotions as CSM's, as they are experts in the software, dealing with clients and the problems they face. All three have done the same training courses for the software, and as such their expertise in the software varies little. However, they have different backgrounds and different education, and such different approaches and preferences of teaching the biosensor software. These will be referred to as CSM 1, CSM 2, and CSM 3 when quoted or mentioned in this project.

Users

In total, 7 users were interviewed. Three of the users were university professors. These professors study different fields and have also been introduced to the software differently. Two professors, referred to as Professor 1 and Professor 2, attended an iMotions' academy, which is a week-long course that teaches about all the different uses of biosensors along with other scholars in a group of 15 people. Hence, they have not had the usual onboarding process with completely individual introduction and support from iMotions. Instead, it was several iMotions CSMs that taught the software. The third professor, referred to as professor 3, did receive a normal onboarding session with a single CSM, and therefore had more intense support for the sessions.

Additionally, four master thesis students were interviewed. None of these students have had an actual onboarding session with iMotions or an academy session. Two of these students, Student 1 and Student 2, learned of iMotions through classes and have not done any research with the biosensor software, and as such, they had limited experiences with it. That is why the interview with Student 1 and Student 2 was done together, so they could support each other and discuss their experiences. That is why a total of ten participants were recruited and only nine interviews were conducted. Student 3 has done research with iMotions and has worked intensively with the software for half a year but has had no contact with iMotions directly, and therefore had to solve challenges by contacting his teacher who has contact with iMotions. Student 4 also has experience with the software as it is being used to collect data for research, but Student 4 did not have an introductory course to iMotions. Instead, she had repeated contact with iMotions every time an unresolvable problem occurred. However, two of the university students, Student 1 and Student 2, who were in the same class, had limited experience with the iMotions software, which is why the interview with them was done together. A participant overview will be presented alongside the results from the thematic analysis in chapter 6.

As mentioned, no commercial company users were included in the study. This was due to the lack of availability of such participants despite efforts to contact them. In reflecting on what such participants could have added, it is possible that a more market and product-oriented research approach to using biosensor software may create different user needs and user requirements for navigating and using the software, and such users may have different priorities for what is important. For the sake of transparency and reflecting on a lack of generalizability, it is therefore important to acknowledge that the research carried out in this paper is primarily based on the perspectives of academic end-users.

In addition to this, despite the representation of academic end-users, iMotions noted that use cases vary drastically depending on what the user intends to investigate, what hardware they intend to use, and what metrics they intend to collect (Appendix 3: CSM 3). It is for this reason that we acknowledge that our current sample size of 6 academic end-users cannot possibly be representative of all use cases, even for the academic segment, as use cases can vary. Further reflections on this can be found in Chapter 8.

5.6 Procedure

The following section will describe the procedure of the two primary research methods of this paper, observation, and qualitative interviews. Each method's procedure will be explained and reflected upon, in order to highlight if there were circumstances that could affect the data to any extent.

5.6.1 Participant Observations

For the observation of the onboarding session, a video camera and an audio recorder were present in case it became relevant to review the data. Field notes were written by two writers of this thesis sitting about one and a half meters behind the two participants, who were sitting next to each other in front of a computer on a table (Appendix 13). Another iMotions employee was also in the room behind the onboarding participants, and the onboarding manager would occasionally ask her questions, meaning her presence had some effect.

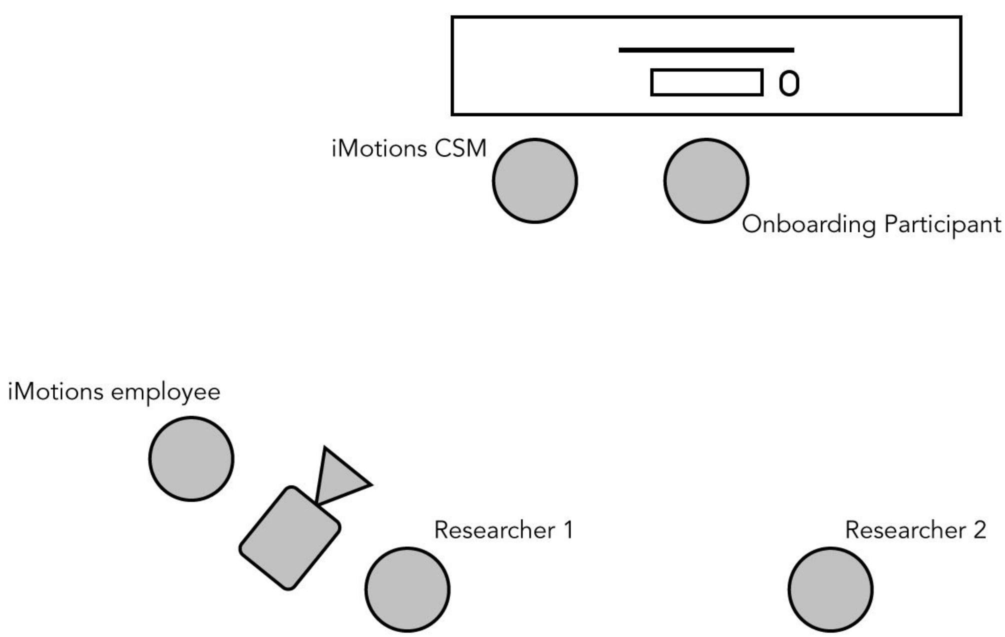

Figure 5.2: Onboarding observation setup.

Following the onboarding sessions, both the onboarding manager and the learning participant were interviewed using interview guides and a semi-structured approach.

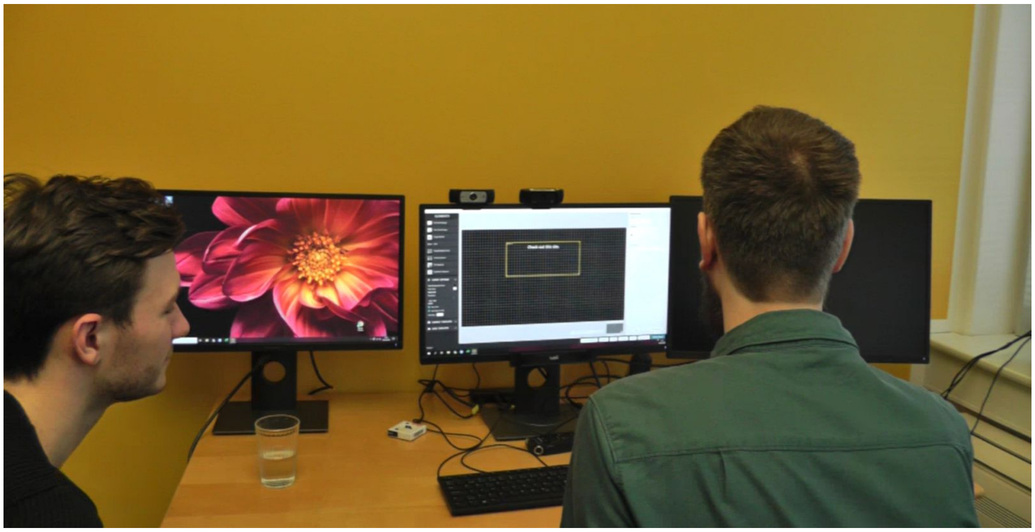

Figure 5.3: Photo from the onboarding session

Due to time constraints, the onboarding manager had to go through three hours of onboarding in slightly over an hour, meaning the process moved faster than it typically does. This will be kept in mind throughout and reflected upon at the end of the key findings. During the onboarding session, the onboarding participant was first shown an existing completed biosensor capture session to see what a recorded project looked like, after which a new project was started as per the instructions of the onboarding manager in order to walk the participant through how to start a new session.

From here, the onboarding participant was shown the different kinds of biosensors that can be connected to the software, and how to load stimuli that participants of biosensor experiments will react to. Throughout this process, the onboarding participant was allowed to and did ask questions regarding what was being explained and walked through. Following this, the participant was walked through how to start and record a session, and the different ways one can analyze the data using the iMotions software, such as AOIs and heatmaps. The onboarding manager noted that he only went through the most frequently used aspects, and not every single aspect of the software.

Finally, the compressed nature of the session may have had an effect on how understandable instructions were for the onboarding participant, as they would likely have had more time to process information during a longer session. This does not mean the data is worthless, but for the sake of transparency, it is worth recognizing.

5.6.2 The Qualitative Interviews

As mentioned earlier, a total of nine interviews were conducted. All, except one, were done digitally using the online video calling software called Zoom in a synchronous manner. This required the participants to have a webcam and microphone, with the same requirements being set for the researchers. The single interview which was not conducted digitally were part of the participant observation of the onboarding session, which was before COVID-19 restrictions were placed. All of the interview sessions were carried out with one participant and two researchers, with one researcher conducting the interview and the other writing down notes and interjecting with additional questions if they had any. For the interviews, two interview guides were created, one for the clients of iMotions and one for iMotions' employees. Below in table 5.1, is the interview guide for the clients of iMotions. The interview guide for the employees of iMotions can be seen in Appendix 14.

Questions	Corresponding research aim
1. How did you learn to use the software? Did you get any help, tutorial, onboarding? (iMotions onboarding steps)	Aims to provide insight into understanding what kind of a user they are. It's essential to assess the participant in relation to their preexisting knowledge.'
2. When you used iMotions for the first time on your own, what was it for?	To get an understanding of what their first-time use context was to understand the potential situations of use and what the background of the interviewee is.
3. What was the first time use process like, was it difficult, any major problems or struggles?	Understand what problems (if any) they faced when trying to use iMotions for the first time. Aims to find out what the first experience was, and furthermore, in correlation to the previous question to investigate the effect of Q2.
4. How many times have you used iMotions? Did it get easier as you used it, or did you need to contact iMotions?	Aims to understand if there was a learning curve for the user, as they tried the software, or if they met steep challenges that could only be solved by expert knowledge.
5. What are the biggest challenges or problems you've had with using iMotions?	Looking at their all-time history with iMotions and seeing if there are any major problems that have persisted or seem unintuitive, to gain insights into their experiences and learn about them as users.

6. Is there anything in particular you like or dislike about the software, in a general sense?	Trying to see both positives and negatives based on their experience, to learn more about them as users. Highlight specific aspects and why these were positive or negative.
7. Reflecting on this, is there anything you would want from iMotions in terms of either teaching you the software or helping you when you face problems? What could have made it easier for you to master the system?	Exploring if they have any current ideas on how to improve the user experience of iMotions, to see how they think about their problems and how they believe they can be alleviated.
8. Have you used any other software similar to iMotions, and is there anything you liked better in comparison? What about advanced software in general?	Seeing if they have past experiences that could inform potential solutions to problems, and learning about their experience with similar software to understand how they may want to be assisted.
9. Have you previously tried to learn new software, purely based on digital guidance (articles, video, etc)?	Investigate the participant's former learning experiences through non-human teachings, to provide indicators as to what worked. Aiming at providing new insights into the target audience's preference for learning.
10. Any concluding comments, anything on your mind?	Wrapping up the interview and making sure nothing is left on the participant's mind before concluding.

Table 5.1: Interview guide used for clients of iMotions

To produce the interview guide, the aim of the different aspects we wanted to investigate, was reflected upon, and the questions were then developed. The end result of this process is seen in the above interview guide.

Every interview would start by providing the participant with a brief introduction of the interview's purpose, the research aims of this thesis, and highlight why their participation was important for the thesis. The interview guide was constructed to be semi-structured, and often the questions would be asked in the order that the interviewer seemed fit, as one answer to a question may have led to answering another. Lastly, each interview session was finished by asking if the interviewee had any additional thoughts, questions, or comments.

5.6.3 Thematic Analysis

In order to process the large amount of data the qualitative interviews yielded, the thematic analysis were applied. After the interviews were conducted, all of the interviews were to undergo selective transcription, highlighting anything that we deemed relevant or interesting. This process was done individually, and as such, each interview would have three selective transcriptions, one for each researcher. By doing so, some transcriptions might overlap, but it served to diminish the likelihood of missing quotes that are relevant.

After the selective transcriptions were done, each researcher would write down codes they would find relevant for the different participant types, iMotions employees and academics. As such, two types of codes were created, codes from the interviews with the CSMs and codes from the interviews with users. The codes created were then to be revised among the researcher and examined to see if there were identical codes or codes that overlap in content or if they needed to be renamed.

This procedure was chosen to reduce individual bias in the codes, by openly discussing the relevance of each, and what their purpose is. With the base of the reviewed codes, themes were created. However, some themes also consisted of sub-themes that are used to frame the theme as a whole, but that is not the case for all themes. With the codes, sub-themes, and themes established, the data is able to be analyzed.

5.6.4 Reflections of Procedure

In relation to the procedure of the applied methods, some reflections have been made regarding participant observation and interviews. During the onboarding session, there were circumstances that did differ from a perfectly natural onboarding session. First of all, as mentioned earlier, the participant who was subject to the onboarding session was a part of the thesis group, and therefore not a real client for the CSM who conducted the session. This could have affected the iMotions employee's behavior as not only was it not a real client, there were three observers, examining how the CSM performed his job. In addition to this, one of the observers was iMotions' UX designer. The presence of a coworker, a person that you know and see frequently, might have a different effect, compared to a researcher who will be there once.

Related to the presence of a third party during data collection, we argue that our interviews were not affected to the same extent by the presence of an observer. These, were conducted digitally, and the observers were taking notes related to the interviewer's questions and the interviewee's answers. Normally, the physical presence of an observer can be intrusive, if the notetaker at certain points starts to type or write excessively (Bryman, 2016c). During an interview conducted digitally, the notetaker can be both muted and not use a video camera, reducing the presence to a bare minimum, and to some extent obtain the presence of a ”fly on the wall”.

6. Results and analysis

The following chapter will present all of the results collected through the interviews, through a thematic analysis. The last section of the chapter will present a summarization of the main findings. For transparency and to provide context for each of the participants' occupations and how they were introduced to iMotions' software, they are presented below in table 6.1.

Participant descriptor	Occupation	Introduction to iMotions
CSM 1	Customer Success Manager	Employed at iMotions
CSM 2	Customer Success Manager	Employed at iMotions
CSM 3	Customer Success Manager	Employed at iMotions
Professor 1	University Professor	iMotions Academy
Professor 2	University Professor	iMotions Academy
Professor 3	University Professor	Onboarding session
Student 1	Master Thesis Student	Introduction through classes
Student 2	Master Thesis Student	Introduction through classes
Student 3	Master Thesis Student	Self-taught
Student 4	Master Thesis Student	Self-taught with contact to iMotions

Table 6.1: Overview of recruited participants.

As the table shows, participants were introduced to the iMotions software through various means. Some were self-taught by interacting with the software, while others attended the iMotions Academy, a week-long course that teaches all of the different biosensors that the iMotions software affords.

In this chapter each theme will be presented with a table, displaying themes, sub-themes (when relevant), and codes, with corresponding examples of raw data, in the form of quotes from both CSMs and users. The themes will then be analyzed and perspectives from both samples of participants will be highlighted, facilitated by the theories and relevant literature, presented in chapters 2, 3, and 4. This thematic analysis is performed with the goal of understanding which problems occur during the learning and onboarding process, utilizing both the perspectives of those that are in charge of teaching and those who have to learn the software.

6.1 iMotions' onboarding process

As the case description explains in chapter 1, iMotions requested ideas for how onboarding could be provided without any human assistance from iMotions. As such, domain knowledge of the onboarding process and the aim of this introduction to biosensor software needs to be investigated, since this knowledge is needed in order to provide a solution which accommodates an efficient learning experience. The below table, 6.2, displays the codes with examples of raw data, which form the theme iMotions' onboarding process.

Codes	Quotes
Use the software by themselves	"The goal is clearly to get them to use the software by themselves…" (Appendix 1: CSM 1 - 00:05:04)
Standardized structure	"That's sorta like the standardized structure as we have. an hour and a half for the first onboarding ... And then we do the second half, which is the analysis and we're going to process the data and that sorta stuff. So that usually is another hour and a half." (Appendix 3: CSM 3)
Recorded training sessions	"It's quite often I record the training sessions and send it to them. So I get less feedback now, so they already know that if they forget something they can just go to this recording and it's there." (Appendix 3: CSM 3)

Table 6.2: "iMotions' onboarding process" overview, with codes and raw data.

Although the overall aim of the onboarding sessions is for the clients to be able to work with and use the software themselves, as shown in table 6.2, these sessions are very customized for each specific client and their wants and needs, as stated by one CSM: "It's more like consulting about what the project is and then when we have that sort of information we make the training aim towards that." (Appendix 3: CSM 3). As such, a big part of the initial onboarding is to recognize and determine the important functions and features of the software and then plan around those, in order for the clients to be able to use it for their specific project or research (Appendix 13: Field Notes). As such, there are some thoughts of andragogy present in the quote, as the aim is also to understand what the internal motivations for working with biosensors are for the clients, relating to the aspect of andragogy that aims to understand learner motivation (Merriam et al., 2006). By having a concise understanding of clients' motivation for working with biosensors, the CSMs are able to personalize the onboarding session with the biosensors that are relevant for them. Hence, the clients have an understanding of why they need to use specific biosensors.

The practical process of the onboarding sessions was described by one of the CSM as "... the standardized structure as we have an hour and a half for the first onboarding. Going through the interface, designing the study within it, getting all the sensors hatched, up until they would collect data." (Appendix 3: CSM 3). After an individual amount of time, where the clients would collect their data through the initial study design, a second session follows with the CSM where exploration and processing of the data is the main focus (Appendix 3: CSM 3).

As the first session revolves around setting up a study design with the client and making them capable of collecting the data themselves, there is a big focus on getting it right the first time. This was explained by one CSM as "If you create a study [design] which makes sense and if you collect the data, well, then the data is there. Then you are able to manipulate and analyze it as you want, but if garbage [data] goes in, then you also get garbage out of it" (Appendix 1: CSM 1 - 00:06:05). It is essential for the study design to be correctly set up, so it makes sense, meaning that it is capable of collecting the required data which the client aims to use. This is further emphasized by the same CSM "... initially make them [clients] able to set up a study which makes sense. I think that is the most essential part of it all." (Appendix 1: CSM 1 - 00:05:34). In this case, "the study makes sense" is viewed in regard to the client's sensemaking. Without having a proper design study set up for the client, they will have difficulties collecting data that can represent what they want to investigate, which indicates that this is the most essential part of the CSM's job.

This also relates to Vygotsky's idea of reaching the ZPD, where a learner can learn something with assistance that they could not otherwise learn, and the idea of scaffolding, the process of a teacher aiding a learner to learn (Pol et al, 2010; Roberson, 2017). The initial session is where the CSM is aiding the new learners to expand their capabilities of what they can do unaided. The function of the initial session is to move clients between three zones in order to improve their learning process, as is similar to the ZPD (Vygotsky, 1986). This means that they must be moved from the zone where they are not able to collect data to the zone where they can collect data with help, and finally to the zone where they can collect data without guidance

(Vygotsky, 1986). Furthermore, the first onboarding session functions as the process of making the learners able to understand the solution before they can start the production, which in this context relates to unaided data collection.

The second session of the onboarding process takes place after the client has collected their data and is ready to process it. Considering this in relation to the ZPD, the process of the clients conducting their data collections unaided reveals problem areas and issues where they are not able to proceed unaided. As such, the second session comes as a natural step where the CSMs are utilizing scaffolding to expand the client's capabilities and knowledge. An example of this is stated by a CSM as such, "It is also for this reason we want to split it up into two sessions, because then [clients] are like able to sit with it themselves and then this results in, how do you say it, more relevant questions in the second session. And it is exactly because they get it under their skin…" (Appendix 2: CSM 2 - 00:15:47). The practical side of the second session revolves around how to process the data, in terms of export of data and analysis, which kind of analysis is appropriate for this setup, and how is the data exported to datasheets for further analysis (Appendix 2: CSM 2 - 00:02:38).

The aim of the onboarding sessions is for clients to learn how to collect data and analyze it unaided. The way that iMotions provides a scaffold to move the client from what they "cannot do", resembles experiential learning theory, in the divided structure of the onboarding session (Vygotsky, 1986). Experiential learning (Kolb, 1984) explains how one can learn through what Kolb calls a "concrete experience", reflecting on it, forming thoughts and concepts about it and ultimately using that knowledge moving forward for learning. The clients experience a guided first-time use with the software, making them able to gain concrete experiences on their own, which they can reflect upon themselves, until the next meeting (Kolb, 1984). During the second session, the clients are able to receive feedback on their own reflections and receive guidance from the CSM. As a result of this, the clients should have a foundation of experiences that they can rely upon when collecting and analyzing data by themselves. However, as the results and analysis chapter will show, this is not always the case. The CSMs have observed the same, as despite the session being a thorough introduction to help the clients to use the software independently, there are still several questions about using the software post-onboarding. As a solution, iMotions have started to record the sessions, and send it to their clients afterward, as their impression is that it helps their clients re-experience the session, and retain some of the information they were given during the session (Appendix 1: CSM 1 - 00:13:41). This helps iMotions' CSMs as they experience they receive fewer questions from clients post onboarding (Appendix 3: CSM 3). As such, this can be interpreted as the clients finding the recorded sessions helpful, and therefore contact iMotions less, after the recording of the sessions was introduced.

6.2 Learning preferences

This section explores and analyzes some of the different preferences and attitudes the users expressed for learning how to use iMotions' software. Furthermore, general learning preferences for the process of learning how to use software expressed by the participants are also examined and analyzed.

Codes	Quotes
Just start the project	"I usually don't look at tutorials, I just messed around with it myself ... I just basically started doing what I need for the project, and along the way I kind of learned what I can do." (Appendix 8: Student 3 - 00:09:40)
Ask an expert (if you know the question)	"The expert is okay if you know what to ask the expert, but if you don't know what to ask the expert, then maybe the tutorial is better."(Appendix 4: Professor 1 - 00:52:48)
Good tips in iMotions	"A good example of good tips in iMotions is when calibration fails. Then some pretty okay tips show up, saying sit down at a hand's distance.. ..Then six or so pieces of advice show up, as far as I can remember, on the screen, so they were very good." (Appendix 6: Professor 3 - 00:26:09)

Table 6.3: "Learning Preferences" overview, with codes and raw data.

One approach to learning that was discussed by several participants was the idea of learning by doing. This came up in two different forms, through users talking about independently exploring and interacting with the software, and through users discussing learning in a supervised situation in which they were working on a project of some kind.

The idea of learning the software by exploring it and looking for options was expressed as part of the code "Just start the project" by Student 3, who stated he "messed around with it", and that he "just basically started doing what I need for the project and along the way I kind of learned what I can do" (Appendix 8: Student 3 - 00:09:40). Similarly, Student 1 expressed a clear preference for this learning approach, stating "I would definitely prefer to learn it myself by just jumping into it and throwing something in that I haven't tried to work with before and then understand it that way" (Appendix 7: Student 1 - 00:22:05). This can also be related to experiential learning (Kolb, 1984). In this case, attempting to use iMotions is a concrete experience, and in seeing what happens upon interacting with it and exploring it, users can reflect on their new knowledge and use it as a means of informing what the software is capable of and what it cannot do. In short, some users had success with and prefer to learn through experiential learning, where they can interact with the software and get to know it by themselves (Kolb, 1984).

Though this is a theoretically founded approach, there can also be some problems. For example, if users become stuck and cannot progress further, or simply cannot figure out how to use it, their learning experience is put to a halt, which can be related to the ZPD (Vygotsky, 1986). Meaning, if there are no scaffolding efforts in place at all, which are meant to assist users when they experience challenges in their learning, it may be more likely that users will fail to learn the software, or will miss key information and not be situated in such a way that their learning conditions are optimal (Wood et al., 1976). Student 1 claimed that "..when something wouldn't make sense I would find a video and Google search" (Appendix 7: Student 1 - 00:22:05), though since there is not much information available outside of the iMotions help-center which is only for clients, and since iMotions does not have instructional videos, this approach may prove to be fruitless. To sum up, Student 3 had success achieving what he set out to do with the software by learning experientially on his own, and Student 1 expressed a preference for this experiential learning approach. However, without sufficient scaffolding or assistance, it is more likely for the learner to run into barriers blocking their way to the ZPD than it would be if an expert was able to assist them (Roberson, 2017). As this paper argues in chapter 2, the likelihood of running into barriers of learning, such as these, is high for biosensor software, due to the complex nature of the required knowledge for understanding how to use it. Furthermore, if materials that could provide scaffolding such as instructional videos were available for independent experiential learning, it could alleviate potential learning problems (Wood et al., 1976).

This idea of learning by doing but being supported to reach the zone of proximal development and achieving the necessary learning goals was also brought up by Professor 1. Whereas other users talked about learning on their own, Professor 1 talked about learning under supervision in relation to an iMotions learning seminar he attended: "And then there could have been, like let’s say morning, where they just gave us a basic overview and then explored what we wanted to do, particularly ourselves and then start to develop the project … That would have suited me.” (Appendix 4: Professor 1 - 15:08). He expresses a preference for a style of learning which is experiential in that he gets a concrete experience by exploring his area of interest through a project in the software, while still remaining in an environment in which he could seek help from experts. Similarly, Professor 2 felt that those who attended that same iMotions seminar with a project and goal in mind so that they could test the software seemed to have a better learning experience, saying “..they were definitely getting much more [than] Professor 1 and I who came to see what it was about” (Appendix 5: Professor 2 - 34:51). This indicates that a goal-oriented experiential learning approach may be beneficial to learners with similar preferences to these users.

The code “Ask an expert (if you know the question)” provides insight into the different ways and preferences there are for scaffolding when learning to use iMotions, as expressed by the iMotions users. As stated by Professor 1:

> The expert is okay if you know what to ask the expert, but if you don’t know what to ask the expert, then maybe the tutorial is better I suppose, when i am using survey software, I start with a short course, download the manual, found the things in the manual I wanted, things got stuck or went going wrong, contacted the producer of the software so it's a combination of all three. (Appendix 4: Professor 1 - 52:48)

This suggests that the specific learning context the learner finds themselves in is important and that the user may need different methods of assistance or scaffolding in the learning process depending on the user's prior knowledge regarding biosensors, and how used the user is to navigate the software. This also suggests that his learning experience involved both exploring the software, but also learning about it by reading through materials explaining what the software can be used for, and also being helped by an expert. Student 2 stated “I think I would ask a colleague first or some form of tutor ... I don’t think I would go about it without some knowledge about what there should be or what you can do with it” (Appendix 7: Student 2 - 22:35). This exemplifies that learning needs can depend on the individual user, with Student 2 expressing that if he had no prior knowledge of the software, a tutor or a more experienced colleague would be essential for assistance. This was in the context of a hands-on experience, where he could also learn by interacting with the software. Experiential learning is an approach that seems to be desired by several participants, however, if left entirely unassisted and without scaffolding efforts, it may lead to obstacles within their learning process.

The code “Learning is personal” sheds light on different learning preferences. As Professor 1 expresses: “Learning is a very personal thing, different people are going to learn in different ways.” (Appendix 4: Professor 1 - 00:53:43). In short, as indicated by the analysis found in this section, there are many different preferences for the learning process, as different individuals learn differently. This may be worthy of reflection for eventual design decisions when designing a digital onboarding process, to consider that there are different use case scenarios from a learning perspective and that different use cases may also independently have different preferences to consider.

Finally, a learning preference expressed by Professor 3 was regarding an existing approach to scaffolding in the system, which occurs when calibration fails: “Then six or so pieces of advice show up, as far as I can remember, on the screen, so they were very good” (Appendix 6: Professor 3 - 26:09). This is an instance where the system clearly knows the user is making a mistake, which may be a reason as to why scaffolding has been implemented in the software. However, the idea may be transferable to other aspects of the system, by providing advice to the user depending on what they are interacting with, and depending on what their use case is.

6.3 Academic and commercial requirements

In this section, some of the differences between academic and commercial clients will be covered, as well as some considerations for self-directed learning as it relates to the learning motivation of different users, as part of analyzing the sub-theme “Different goals of utilizing iMotions’ software”. The sub-theme “User needs for academic research” displays user needs, such as a desire to have greater control over the software, which will be analyzed. This will also be related to perceived affordances, which regards what the user perceives to be possible within the software rather than what is actually possible, whereas an affordance represents what is actually possible within the software (Norman, 1999).

Sub-themes	Codes	Quotes
Different goals of utilizing iMotions' software	Academic clients	"I would say that the idea of publishing [academic research] needs to be explained and gone through. If you want to publish this, then you need this type of eye tracker with this many respondents. So in that way there's a difference between academic and commercial customers." (Appendix 2: CSM 2 - 00:14:26)
	Commercial clients	"Sometimes it happens, definitely in the commercial world, but maybe also sometimes in the academic world, that sometimes it is not quite as hypothesis-driven. They have not set some clear goals [for their study]." (Appendix 1: CSM 1 - 00:10:43)
User needs for academic research	Customized metrics	"What I really liked about Tobii studio was that you could really customize the metrics, but I don't think you can do the same here [in iMotions], as I remember." (Appendix 8: Student 3 - 00:31:57)
	Ogama compared to iMotions	"I was used to using Ogama, which is an open source software … you can adjust pretty much anything and when you've been able to do all kinds of things.. ..then iMotions can seem … It is sometimes a bit limiting, sometimes I want to do what I could do in Ogama." (Appendix 6: Professor 3 - 00:04:55)

Table 6.4: "Academic and Commercial Requirements" overview, with codes and raw data.

For the codes "Academic clients" and "Commercial clients", accounts were given of certain problems academic and commercial clients encountered, but from the perspective of the interviewed CSMs CSM 1 and CSM 2. These insights can be related to self-directed learning, and more specifically, Grow's (1999) perspective on SSDL, as both the theory and the data explores the needs of the users for learning under supervision.

Based on the account of CSM 2, academic clients can be seen as often being in the second stage of SSDL, being an interested learner. As Grow (1999) explains, these learners are interested, moderately self-directed but still unknowing of the subject matter to some degree, with iMotions being the subject matter in this case. As CSM 2 explained it, academic clients are often in need of practical examples as related to their research purposes: "I would say that the idea of publishing [academic research] needs to be explained and gone through. If you want to publish this, then you need this type of eye tracker with this many respondents" (Appendix 2: CSM 2 - 00:14:26). This indicates that they show an interest in the software and the practical application of it, but due to a lack of experience with the software, they are still in need of assistance through experts showing practical examples related to their potential study. However, how much knowledge these users possess regarding biosensor software is subject to change, and will impact the level of assistance needed to further their learning process and move to a higher stage of learning. Practical examples of use, through video or otherwise, may be able to move such users to stage 3 of SSDL, making them involved learners, with less assistance from experts (Grow, 1999). Through existing examples of researchers exploring similar topics to their own, they may be able to reach a basic level of knowledge as held by involved learners, without needing assistance from an expert (Grow, 1999). More time spent with such learning materials could then expand that basic knowledge to the fourth stage as a self-directed learner, providing the information they need to be able to plan, execute and evaluate their own learning, all without assistance from experts.

Commercial clients may require more assistance as they, according to CSM 1, base their projects less on a hypothesis and less of a clear goal when it comes to learning iMotions: "Sometimes it happens, definitely in the commercial world … that sometimes it is not quite as hypothesis-driven. They have not set some clear goals [for their study]" (Appendix 1: CSM 1 - 00:10:43). This suggests that commercial clients may be more prone to be dependent learners, requiring more direction from an expert as learners in stage 1 of SSDL require (Grow, 1999). Although this paper does not include commercial users in its sampling and design considerations, this insight may prove valuable for future research regarding users trying to learn how to use iMotions' software with less of an objective in mind.

The code "Customized metrics" contains Student 3 presenting a perceived affordance based on his experience with another system, Tobii Studio. Since a perceived affordance is a feature the user would expect to be in the system, it is in this case represented by the participant basing his perceived affordances of the system on his experience with other biosensor software (Norman, 1999). He expected to be able to interact with and tweak the metrics options more than the software currently affords, recalling "What I really liked about Tobii studio was that you could really customize the metrics. I remember when I wanted to export the gaze plots, then you could really define the color, the shape, the line width, and really play around with the data." (Appendix 8: Student 3 - 00:31:57). In a similar vein, the code "iMotions compared to other software" dealt with how a different system afforded more options than iMotions, and comparatively, iMotions feels limiting. As Professor 3 argues "Ogama is a kind of German engineer's dream, there are levers for everything, you can adjust pretty much anything and when you've been able to do all kinds of things, then iMotions can seem … It is sometimes a bit limiting" (Appendix 6: Professor 3 - 00:04:54). Both of these examples display two types of users, those who draw on prior experience to inform their use of iMotions, and a type of user who wants to get in-depth with options that either are or aren't offered by iMotions. This indicates a difference in users related to what they expect from the software, and although this is not as relevant for the learning process of the software, a potential design should be very explicit regarding its affordances.

6.4 Learning challenges

This theme covers challenges related to the prerequisite skill levels of iMotions users, as well as challenges related to learning and retaining information for learning how to use biosensors and its necessary software. This includes both the technical skill levels users may already have, as well as language barriers that can cause difficulties when communicating across countries. Furthermore, the difficulties of learning how to use the software along with biosensors are explored, giving way to discussion related to other ways of learning. Combined, these aspects provide insights into both the challenges users face, as well as their ideas and suggestions for how to have a better learning experience.

Codes	Quotes
Technical skill levels	"..you have a lot of people that are very technically skilled or that have a lot of skills with computers in general, but maybe don't know the like theoretical side of sensors or why they are using them. Or it can be the flip opposite" (Appendix 3: CSM 3)
Putting things into practice & asking the right question	"...with any software you've got to have a chance to explore, you learn through exploring, and you've got to be putting things into practice, but so often you see someone else doing something, "how were you doing that?" and they show you, and so, you incorporate it. And very often you don't know what the question to ask is. because you don't know that it can do it." (Appendix 4: Professor 1 - 00:51:38)
Learning preparation	"..instead of having less than two weeks to prepare for it. If we had three months to prepare for it, and if we have been advised to read the books, read the book, read the tutorials in advance, but even then, reading the tutorial without having the equipment doesn't make a lot of sense". (Appendix 4: Professor 1 - 00:42:08)
Multiple directions of learning	"… So there were several things, learning in different directions at the same time. And then one direction of learning interferes with another." (Appendix 4: Professor 1 - 00:46:11)
Practical knowledge not represented in software	"When it comes to very specific tasks, then what you basically learn when you were working on your task in Copenhagen is very precious information, it's enormous value. But when we were doing this in so squeezed time interval, we lost much of that information unfortunately. That was the most valuable experience we should have kept, stored very well. I don't get this information from the menus, it's not there." (Appendix 5: Professor 2 - 00:29:53)
Hands-on experience and online learning	"But usually what you see is just like really requiring some hands-on experience and you don't have it, you just watch people doing things. They do it very fast professionally and it leaves you a little bit puzzled. That was my experience with the (inaudible) webinars." (Appendix 5: Professor 2 - 00:10:42)

Table 6.5: " Biosensor learning challenges" overview with codes and raw data.

In the code “Technical skill levels”, CSM 3 addresses that prior knowledge related to technical skill levels can be a factor for learning how to use iMotions, though not necessarily in such a way that those who are more technically experienced are able to understand it more quickly. As CSM 3 expressed “It depends because you have a lot of people that are very technically skilled or that have a lot of skills with computers in general, but maybe don’t know the like theoretical side of sensors or why they are using them” (Appendix 3: CSM 3). This means that although a user may have experience with learning complex software or using computers, the added learning barrier of understanding what the different biosensors and their individual analytical outputs are used for, can still make for a challenging learning experience. Additionally, CSM 3 points out that an opposite case can also happen “Or it can be the flip opposite, where it’s a professor who's been doing this for ages, but haven’t touched a computer at all in their life” (Appendix 3: CSM 3). This suggests that the learning obstacle can be the technical aspects, where the user may know a great deal more about the theoretical implications of biosensors and its data., They will need some level of guidance to understand the more technical aspects of the biosensor software. This once again highlights that the context of the learner is important to consider not just for a digital onboarding solution, but for learning in general. In order to allow the user to move between the ZPD, the context of their learning situation is important to keep in mind to ensure that the right scaffolding or general assistance is employed (Nordlof, 2014: Pol et al., 2014).

For the code “Exploring & asking the right question”, Professor 1 brought up the idea of learning through exploring the software and stated “... with any software you’ve got to have a chance to explore, you learn through exploring, and you’ve got to be putting things into practice” (Appendix 4: Professor 1- 00:51:38). This suggests that he places value in experiential learning, with the concrete experience of being a user going through the software and exploring its options. However, the second half of the quote addresses a different aspect of experiential learning: “..but so often you see someone else doing something, "how were you doing that?" and they show you, and so, you incorporate it. And very often you don't know what the question to ask is, because you don’t know that it can do it” (Appendix 4: Professor 1 - 00:51:38). Though users may learn through reflecting on their exploration of the software and testing out what it can do as Kolb (1984) claims, it also requires users to have some existing knowledge, otherwise it is possible that the users will miss important aspects of the software they are exploring because they, as Professor 1 expressed, “don’t know what the question to ask is" (Appendix 4: Professor 1 - 00:51:38). It is in this context where some level of assistance, be it scaffolding built into the design of the software or human actors assisting new users through the ZPD, helps ensure that crucial aspects of the software are not missed.

Similarly, as part of the code "Learning preparation", Professor 1 touches upon the idea of studying relevant knowledge before going through hands-on sessions with the software: "I think my learning experience would have been much better if … we had three months to prepare for it, and if we have been advised to read the books, read the book, read the tutorials in advance" (Appendix 4: Professor 1 - 00:42:08). This indicates that gaining a certain level of prerequisite knowledge before trying iMotions' software in a practical setting, would remove some of the barriers mentioned under the analysis of the code "technical skill levels". This would help users dealing with the challenge of understanding the theoretical and practical aspects and leaving only the technical elements to be learned. There may be some merit to the idea of understanding exactly what the system affords before having to learn how to use those affordances in practice, however, he also recognizes that "reading the tutorial without having the equipment doesn't make a lot of sense" (Appendix 4: Professor 1 - 00:42:08), acknowledging that engaging in understanding the software without the equipment and clear, practical examples can be a fruitless endeavor (Gibson, 1979). As such, there may be a balance to uphold, enlightening the users to the theoretical and practical implications of using the software, but doing so with examples where the users can see the process of using the software.

In the code "Multiple directions of learning", Professor 1, Professor 2, and Professor 3 each note that learning iMotions' software is challenging because there is more to it than simply understanding the functions of a piece of software. In the context of exploring and learning what the software can do, while also having to get to know the different biosensors, Professor 2 mentioned that "The most difficult thing is to learn to do new things" (Appendix 5: Professor 2 - 00:24:40). This means that simply learning one new thing on its own is difficult, making it particularly difficult to have to familiarize yourself with and learn to use multiple new concepts and aspects of biosensor software. Professor 3 made a similar comment, by mentioning that he does not remember all the different features because there are so many, stating "I do not use all of the shimmers [EDA sensor] many different features and I can't even remember them" (Appendix 6: Professor 3 - 00:03:34). In short, as the iMotions' software affords many different options through different hardware types and different data types to be extracted from them, there is a large variety of things to learn depending on your existing knowledge, making learning the software a long and complicated process. The amount of affordances present in the software makes it difficult for users to know what it actually affords (Norman, 1999). As Professor 1 argues:

> … it wasn't just learning the software it was also learning the thing that the software was doing, like connecting up to the technology, so we were learning about the hardware, but we were also learning about the whole notion of biosensory measurement. So there were several things, learning in different directions at the same time. And then one direction of learning interferes with another. (Appendix 4: Professor 1 - 00:46:11)

It is a multifaceted piece of software to learn, which means learning the biosensor software is situated in a greater context of learning biosensors and their capabilities. The software not only affords to connect a biosensor so that its data type can be collected, but it also affords some parts of data analysis. Each biosensor type has different data types that can be collected, such as AOIs and fixation for ET, or different emotional states for FEA. As presented in Chapter 2, biosensors provide the strongest results when used in combination with each other (Walker et al., 2019). As such, in order to gain the full use of biosensor software, the users need to learn the different biosensors, and not just a single one (Goldberg, et al, 2002; Tan et al, 2012). Beyond simply being able to understand the affordances of collecting and analyzing data, users must also understand the theoretical implications of what this data can actually be used for. These dimensions are what contribute to the multifaceted and complicated nature of learning to use iMotions' software, as was depicted in the above quote from professor 1 (Appendix 4: Professor 1 - 00:46:11). Furthermore, all of this is situated in a technological context of using a computer, a keyboard, and a mouse, as well as becoming familiarized with hardware that users may never have seen before.

As a potential solution to this learning challenge, Professor 1 suggested focusing on learning and becoming familiarized with one biosensor at a time, eye tracking in his case, in order to focus his learning and allow him to be better acquainted with one aspect as opposed to losing track of the many different options and their possible ways of intersecting: "... because we were introduced to so many things, it felt like we gotta explore all of these things … rather than okay, all I'm interested in is the eye-tracking and I think if I'd done that, I think I would probably still be using it now" (Appendix 4: Professor 1 - 00:32:35). In short, it is difficult to ensure that users are receiving the guidance they need to be situated in the ZPD if their learning path constantly steers in many different directions, instead a design solution could provide them with options for what to learn first and then focusing on one thing at a time.

Returning to experiential learning as an important aspect for some learners as part of the code "Practical knowledge not represented in software", Professor 2 said the following: "..what you basically learn when you were working on your task in Copenhagen is very precious information … I don't get this information from the menus, it's not there." (Appendix 5: Professor 2 - 00:29:53). In short, this suggests that the concrete experience of working on specific tasks and learning experientially was very important to him and his learning process, and it is not something he feels the software and its menus currently provides. Such knowledge should, therefore, be considered for the design of a digital onboarding process

Finally, for the code "Hands-on experience and online learning", Professor 2 talked about how a webinar he attended failed to provide him with the knowledge he needed because it was not something that provided experiential learning as an option, and because of its fast pace, saying: "But usually what you see is just like really requiring some hands-on experience and you don't have it, you just watch people doing things. They do it very fast professionally and it leaves you a little bit puzzled" (Appendix 5: Professor 2 - 00:10:42). This illustrates that while users can watch someone else carry out a task and potentially learn from them if the pacing is not suited to the users' individual needs, it may move so fast that retaining the information the users learn is not possible. In relation to Knowles' (2015d) assumptions regarding the adult learning process, the user's capabilities for the context-specific learning situation needs to be assessed properly in order to facilitate an adequate learning process. As such, the learner is very dependent on the teacher's ability to adjust this process to the learner's skill level.

6.5 Software challenges for biosensors and usability

As stated in chapters 1 and 2, we argue that biosensor software is used for a variety of complex tasks and as such, can be labeled as an advanced software in the sense that it forces the user to consider multiple feature-rich interfaces throughout the process of working with the software. This was also reflected in the interview data, which featured both CSMs and users alike detailing learning difficulties and problems related to learning and using iMotions. In order to understand this theme "Software challenges for biosensors and usability", table 6.6 below displays the sub-themes and codes which make up the theme.

Sub-themes	Codes	Quotes
Complexity	Many things can go wrong	"... there are actually a lot of different options in relation to setting up a study … there are many things which can go wrong" (Appendix 1: CSM 1 - 00:17:42)
	Complexity is an obstacle	"I clearly think that it is a big obstacle that the software is quite complex to use, so just figuring out how to set up a study and collect the data, that is a big hurdle." (Appendix 1: CSM 1 - 00:09:58)
	Complexity in options	"... what I think that makes it complex is the options you can choose between, there are a lot and you can not filter anything away." (Appendix 2: CSM 2 - 00:19:04)
UX problem areas	Expert systems don't account for user stupidity	"I have to say I'm very skeptical about so-called expert systems because expert systems are created by experts and they don't account genuinely for my stupidity." (Appendix 4: Professor 1 - 00:38:31)
	Integrated support adds complexity	"I think the more that was put into the software, like, the more support they had integrated into the software, then the more complex the software becomes." (Appendix 4: Professor 1 - 00:37:33)
	Visual noise	"... this visual noise that you get, it can be kind of distracting. I didn't like that too much." (Appendix 8: Student 3 - 00:26:32)
	Workflow	"I think it would definitely help if they could clear up the UI in a way so its more logical, and not just everything together in one place, kinda of like dividing the UI into the stages of the workflow, because now if they put more functions and features and functionalities into the interface it's just getting more cluttered." (Appendix 8: Student 3 - 00:40:43)
	Usability errors	"If they [iMotions] sat down and conducted a completely ordinary usability test with some task, and some users would go through something and talk aloud, then they would discover a lot of them [errors]." (Appendix 6: Professor 3 - 00:34:20)

Table 6.6: "Software challenges for biosensors and usability" overview, with sub-themes, codes, and raw data.

As seen in table 6.6, above, this theme does not revolve around one specific software area itself, but pertains to the general usage and complexity of the software, as this was a shared sentiment amongst the participants.

The first sub-theme "Complexity" pertains to the main software issue mentioned by the CSMs in relation to the software's level of complexity, which derives from the amount of options presented to the user, and was regarded as a big obstacle (Appendix 1: CSM 1: Appendix 2: CSM 2). These amounts of options, spread out over multiple interfaces of the software, is exemplified in figure 6.1, below.

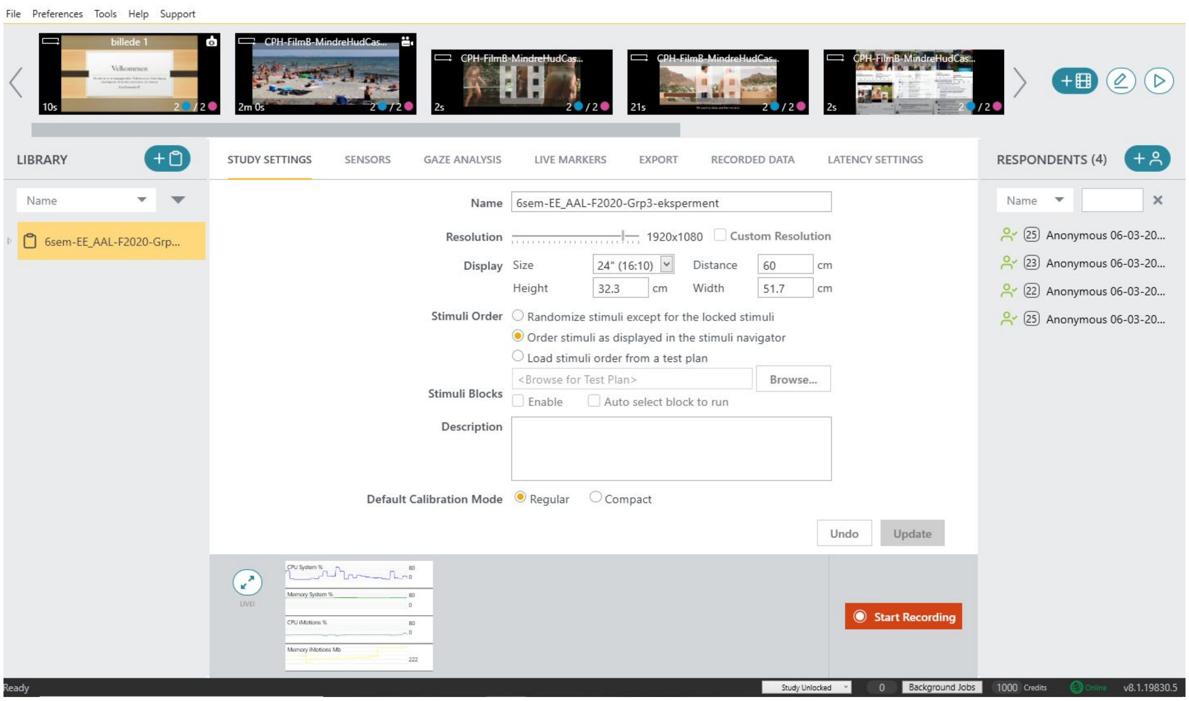

Figure 6.1: Example of iMotions' initial interface for study settings.

Figure 6.1 only shows one of the many settings menus, in the center of the picture, which users need to go through in order to set up a study design, where even the slightest incorrect settings can result in unwanted results, as stated by CSM 1 "Study design, it is especially this thing with all these different options, which cause problems when trying to set it up correctly … there are often many steps to go through" (Appendix 1: CSM 1 - 00:21:45). As such the amount of options and initial steps to go through presents obstacles for the users. Viewing this in relation to Gibson's (1977) theory of affordance, the software possesses the necessary affordances to correctly utilize the product, but participants expressed concerns for systems being developed by experts and as such does not account for the users' inabilities. This means that users would not be able to understand the systems properly and not perceive the necessary affordances which the software actually contains (Appendix 4: Professor 1 - 00:38:31). Furthermore, another participant stated the following "Internal developers have difficulties with always recognizing it [obstacles]. They know where to click, so it's difficult for them to discover it [obstacles] and don't find it troublesome. After all, they made it [the software], maybe." (Appendix 3: Professor 3 - 00:34:48). This indicates that the software contains some discrepancy between the actual affordances, what the systems can do, and the perceived affordances, what the users experience as possible (Norman, 1999). The data indicated that the users are often not being directed or guided by the software to where these available actions can take place and the software might need signifiers to visualize for the user where a specific action takes place and which action is possible (Norman, 2013a).

An indication to the differences of the software's actual affordances and the perceived affordances could be found in a statement made by one of the CSMs "... what I think that makes it complex is the options you can choose between, there are a lot and you can not filter anything away." (Appendix 2: CSM 2 - 00:19:04). The CSM was expressing that every option within the software is present at all times as nothing can be filtered away, and as such, regardless of the user's aim for utilizing the software and which biosensors are employed, all options are displayed, which adds to the software's complexity through an increase of extraneous cognitive load (Oud, 2009).

Another subject to consider, regarding users experiencing obstacles in the initial process of using iMotions' biosensor software, is the difficulties of learning multiple areas within biosensor research, mentioned in the previous section. This sentiment was also touched upon by a participant who expressed the following when asked about her own experience of learning the software on her own "I didn't find it easy, everything I understood, I understood from the conversation with a CSM" (Appendix 9: Student 4 - 00:14:04). As such, this points out the importance of assisting the users through proper scaffolding in one way or another, in order for them to at least understand the technologies and software specific terms related to the software (Pol et a., 2010).

Several participants expressed frustration with the general usability of the software, best exemplified by one participant who said: "If they [iMotions] sat down and conducted a completely ordinary usability test with some task, and some users would go through something and talk aloud, then they would discover a lot of them [errors].” (Appendix 6: Professor 3 - 00:34:20). Another participant provided additional insights when asked if he had tried other biosensor software and if there were some differences which he liked, “They split up the interface in a way that is logical from a workflow point of view … That was something I kind of missed.” (Appendix 8: Student 3 - 00:37:39). The same participants continue to explain how the general workflow could accommodate the user in a more logical way by separating the menus into stages of use so they would follow a chronological approach to setting up a study and going through all the necessary steps (Appendix 8: Student 3 - 00:40:43). These statements can again be seen in comparison to Norman’s (2013c) emphasis on designing for activities, rather than individual tasks. In the case of biosensor software, activities should be understood as the overall goal of using the software, producing reliable data/results either for academic or commercial usage, and tasks should be understood as the small different stages that make up the total process. Furthermore, Norman (2013c) states the relevant benefits of designing for activities as:

> Design for individuals and the results may be wonderful for the particular people they were designed for, but a mismatch for others. Design for activities and the result will be usable by everyone. A major benefit is that if the design requirements are consistent with their activities, people will tolerate complexity and the requirements to learn something new: as long as the complexity and the new things to be learned feel appropriate to the task, they will feel natural and be viewed as reasonable. (p. 233-234)

This indicates that when designing for activities, complexity would be less of an issue since the users would be more comfortable with the software and be able to understand the overall process of working with the software. Furthermore, Norman (2013c) adds that “The most important principle for taming complexity is to provide a good conceptual model, …”. The term *conceptual model* should be understood as an integrated explanation of how the software works, as such the iMotions software should aim to provide a more simple and activity-based interface to accommodate for this complexity (Norman, 2013c).

6.6 Processing the data

One of the essential parts of any data collection is the processing of the data and it is no different when using biosensors. When processing the collected data some general steps need to be accounted for. Exporting the data from iMotions' software into excel sheets of raw data, then analyzing it by examining, comparing, manipulating the data, and lastly the process of visualizing the data. As such, this is one of the most challenging aspects of the iMotions' software, according to the CSMs and the users, as the below table 6.7 shows.

Codes	Quotes
Data export and visualization	"It provides a lot of challenges because there are so many exports [of data-set] as there are. And that is something, which I think our clients really struggle with. How do I get the data and visualize it in an easy and manageable way" (Appendix 1: CSM 1 - 00:23:17)
Data analysis	"... we see most problems occur when they have to export the data and compare it. You have to actually compare it yourself. And this is where I believe that most of them actually just want some form of something finished." (Appendix 2: CSM 2 - 00:29:47)
Assumptions about competencies	"I had never used pivot charts, pivot tables, in the past. I've done a lot of work with excel sheets, but not with the amount of data that those excel sheets were working. And trying to, they [CSM] were making assumptions about the competences with the excel sheets, where I was getting lost." (Appendix 4: Professor 1 - 00:13:26)
Analysis preview	"Intuitively it [iMotions] works really well. What we had difficulties then, was when people started asking specific questions and they wanted to see like kind of preview of analysis. How can we show those things, like heatmaps and whatever. And there, you need fluidity there. That was the impact of our inefficient use of the software." (Appendix 5: Professor 2 - 00:14:04)
Start the analysis	"One of the first problems was like, how to find areas of interest, or how to start analyzing the data ... but how to start analyzing the data was very challenging." Appendix 9: Student 4 - 00:07:14)

Table 6.7: "Processing the data" overview, with codes and raw data.

The above table, 6.7, shows that the CSMs acknowledge that processing the data, collected through iMotions, can be difficult for their client, an indicator which is also depicted throughout the user interviews.

The code "Data export and visualization" is based on the many challenges the CSMs experience related to exporting the data. As CSM 2 highlights "It is there where most get satisfaction of iMotions, and also that we see problems when you are to extract the data and compare it (Appendix 2: CSM 2 - 00:29:23). Extracting the data is both an important and necessary part in order to analyze the data, but it can be an excessive task, which is also expressed by our participants, as exemplified by Professor 1:

> The main struggle was getting around the excel sheet. Because I had never used pivot charts, pivot tables, in the past. I've done a lot of work with excel sheets, but not with the amount of data that those excel sheets were working. And trying to, they [the CSMs] were making assumptions about the competences with the excel sheets, where I was getting lost. (Appendix 4: Professor 1 - 00:13:26)

The quote addresses two important issues. He struggled on his own with the process of understanding and exporting the excel sheets and furthermore, a need for adequate guidance when manipulating the data. The first issue can be seen as an affordance issue of the iMotions software, as it affords not only a single export file to be made, but multiple. Presenting all the affordances embedded in the software to the user causes challenges, as there are too many options for the users to handle, meaning there may be cause for implementing constraints within the design, as to not overwhelm and confuse the user (Norman, 2013d). The second issue is related to what was discussed in section 6.4, the users' prior knowledge level concerning specific areas, and how to best assist that user through scaffolding. The participant expresses concern regarding that the CSM, during his introduction to iMotions, did not account adequately for his competencies for working with excel sheets, and as such, the learning process was problematic. Optimally the CSM would have assessed the participant's actual development level regarding data export and excel and thereby would have been able to plan the learning experience around this, and as such provide adequate guidance to support the potential development level, where the participant was unable to complete the tasks themselves (Nordlof, 2014; Roberson, 2017).

The next obstacle when processing the data was expressed as the task of analyzing the data. Analyzing the data is where most of the problems occur for the users. CSM 1 highlights that "... there are some analysis tools which are really hard to navigate for the clients" (Appendix 1: CSM 1 - 00:22:50). This indicates the complexity of the software in terms of utilizing the different tools, but furthermore, the issues of scaffolding the onboarding session to the right extent, enabling the clients to be able to analyze the data. In addition to this, often users would need to utilize several biosensors software, to yield strong, quality data that can be analyzed and compared (Goldman, 2012; Walker et al., 2019). As seen in table 6.7, Student 4 expressed that just the initial steps of starting the analysis was a difficult task (Appendix 9: Student 4 - 00:07:14). Another participant stated "... but it would have been because of the methodology. Like how do you conduct the analysis." (Appendix 8: Student 3 - 00:15:48). This indicates a lack of understanding of the overall process of the analysis, and if viewed in conjunction with scaffolding, the user is not able to understand the solution to the problem (Wood et al., 1976). As such the actual production, in this case, the data analysis is not feasible. Furthermore, this calls for a learning design to support the methodological considerations of using biosensors. An example of this could be the finding from chapter 2 that while biosensor data is a useful catalyst for further inquiry about participant behavior, it is not a tell-all piece of data that is easily interpretable on its own (Bojko, 2013b). Providing users with such methodological knowledge regarding best practices for getting quality insights out of biosensor data could make them better equipped for using the software effectively and provide an overall more informed experience.

In addition to the challenges of analyzing the data, both the CSM's and the users also experienced difficulties when visualizing the data and transforming the data into something meaningful for them (Appendix 1: CSM 1 - 00:23:17; Appendix 5: Professor 2 - 00:14:04). This could also indicate some issues concerning scaffolding, in terms of the users not being assisted properly to understand the actual solution to the problem, in this case, data visualization. Another possible cause to this issue can also be found in the capabilities of the software itself, as explained by CSM 2 when asked about the users' preferences concerning data visualization "... and this is where I believe that most of them actually just want some form of something finished" (Appendix 2: CSM 2 - 00:29:47). This indicates that users in general prefer the software to be able to provide some form of finished data visualization. Although this was not expressed by the user sample of the participants for this research, they express frustration and confusion regarding the approach and execution of analyzing the data. Furthermore, as earlier mentioned in section 6.3, iMotions' different client segments, academics, and commercial, often want different solutions, which could also be the case in terms of data analysis and visualization. According to CSM 2, many academic clients prefer to have the raw data which they can examine and analyze closely, while most of the commercial clients prefer a quick overview of the data, "So we have two camps, some who would like to have the raw [data] and some who want the polished" (Appendix 2: CSM 2 - 00:33:42). This indicates a need for software improvements to be made in terms of additional features, a subject which will be explored further in the next section, as it pertains to different suggestions for improving iMotions' biosensor software.

6.7 Suggested software improvements

Through our interviews, both the CSMs and the users expressed some ideas or thoughts about how to improve on iMotions' software, which is shown in figure 6.8 below. This is a relevant aspect to analyze in order to assess the participants' solution in relation to the paper's proposed design presentation for a non-human onboarding experience.

Sub-themes	Codes	Quotes
Customization	Default settings	"I had to set it up in each of the stimuli, what kind of metrics these sticky-notes should show, so maybe if the system would remember what kind of metrics, what kind of data I need. Then it would just make it as a default and it could just apply to every single stimuli." (Appendix 8: Student 3 - 00:22:10)
	Software tips based on user level	"And then you could do, as you sometimes have in Office … show tip, or how to show tips and if you think there's too many and if you know them, then you are able to turn down the level of tips or have three to four levels of tips, for beginners where there is a lot." (Appendix 6: Professor 3 - 00:27:32)
	Personalized workspace	"I think that a good idea. I think Adobe also does that, like in illustrator and photoshop. You can set your user interface based on what you want to do, like, do you want to make digital art, animations, do you want to make logos, whatever. And that instantly creates a workspace for you, which is much easier for you to reach all the functionalities for your work." (Appendix 8: Student 3 - 00:41:53)
Integrated software assistance	Guided process	"I think there is a need for a rethinking of the study design editor … maybe some kind of guided process, where the users are asked some questions, what do you want?" (Appendix 1: CSM 1 - 00:32:48)
	Quick overview	"I actually think that most of our clients want something that is a bit fast. A quick overview. So we have to somehow gather some data in some kind of report." (Appendix 2: CSM 2 - 00:33:42)

Table 6.8: "Suggested software improvements" overview, with sub-themes, codes, and raw data.

In connection to the previous section, regarding data processing, a CSM indicated a need for an easier and faster way of providing a quick data overview, maybe through a preset report feature (Appendix 2: CSM 2 - 00:29:47). As the users also expressed in the previous section, 6.6, there exists an issue regarding the overall process of how they handle their data. This is a problem for which a CSM suggested a quick and easy data visualization overview as a possible solution (Appendix 2: CSM 2 - 00:33:42). Although this was not an expressed sentiment by the user sample of our participants, it is important to note that all of the users involved in this research were academics and as such did not approach the software from a commercial point of view. This was indicated to be the user segment of iMotions' software who usually preferred a fast and easy data overview, as previously explained in section 6.6. Although this could be viewed as a simple functionality to implement within the software, the same CSM provided some insight into an issue concerning this otherwise easy solution, "... basically it [iMotions' software] is just a tool to collect data and then you have to make your own analysis. And it is of course always dangerous to provide some pre-analysis with other people's data, but in reality, this is probably what is most sought after (Appendix 2: CSM 2 - 00:30:01). As such, this solution of implementing a software-generated analysis overview should be approached with caution, since the contexts and aims of conducting biosensor research are such a diverse area, this solution could provide unwanted results.

Another suggestion which was made by Student 3 concerned the general levels of customization or personalization. Student 3 drew on his experience with another complex software package, Adobe, when he suggested implementing a form of personalized workspace, as it is available within Adobe's applications (Appendix 8: Student 3 - 00:41:53). This personalized workspace would result in a customized interface depending on your goal and tasks within iMotions' software, as such, filtering away all the unnecessary options and features, aiming at providing a simpler and more straightforward interface. A very similar idea was also expressed by CSM 1, who expressed it as such "I think there is a need for a rethinking of the study design editor … maybe some kind of guided process, where the users are asked some questions, what do you want?" (Appendix 1: CSM 1 - 00:32:48), thus making the software a more active part of the general user experience, but also aiming at filtering away the amount of options presented to the user based on the user's answers. These similar ideas of improving the software draw very accurately on the same idea of setting up constraints for the user, meaning that by filtering away unnecessary and unwanted options, the user is thereby eliminating possible wrong actions and only displaying desired actions (Norman, 2013b). General constraints in relation to design are exemplified by Norman (2013b) as the following "Constraints are powerful clues, limiting the set of possible actions. The thoughtful use of constraints in design lets people readily determine the proper course of action, even in a novel situation" (p. 125). This indicates that implementing some constraints in the form of a "guided process" or "personalized workspace", would aid the users in utilizing the software in a more productive way. Furthermore, these forms of constraints would help in the reduction of extraneous cognitive load as it would allow the user to only focus on relevant information or actions (Oud, 2009).

In continuance of the user setting up constraints for themselves, based on their overall goal and tasks at hand, this idea was also proposed for more in-depth tasks, as expressed by Student 3

> I had to set it up in each of the stimuli, what kind of metrics these sticky-notes should show, so maybe if the system would remember what kind of metrics, what kind of data I need. Then it would just make it as a default and it could just apply to every single stimuli. (Appendix 8: Student 3 - 00:22:10)

This indicates a need for even further customization of the default settings, in order to provide a more efficient usage, but at the same time minimizing the risk of errors, by setting up constraints that remove unwanted actions.

Lastly, Professor 3 suggested an integrated support feature in the way of providing assistance based on users' knowledge level, which was expressed as the following "And then you could do, as you sometimes have in [Microsoft] Office … show tip, or how to show tips, and if you think there's too many, and if you know them, then you are able to turn down the level of tips or have three to four levels of tips, for beginners where there is a lot. (Appendix 6: Professor 3 - 00:27:32). This idea of in-software support, based on user knowledge level, can be seen as providing context-specific scaffolding for the learner, for them to be able to approach new tasks that they might not be able to complete on their own (Wood et al., 1976). Although this non-human scaffolding could assist the user in taking on otherwise approachable tasks, the theory of helping learners through scaffolding is seen as a dynamic interaction between the learner and the teacher, and as such, this non-human guidance would need to be researched further in order to understand the specific contexts and tasks where such an implementation could be useful for iMotions' software (Pol et al., 2010). Further investigation and discussion of how iMotions currently support new learners will be presented in the following section.

6.8 Support

As it was described earlier in 6.1 iMotions' onboarding process, iMotions still have to support their clients and assist them when they encounter problems as they use the biosensor software unaided, despite the in-depth onboarding session. When interviewing both the CSMs and users, it became apparent that there were many nuances regarding the need for support and the degree of available support. This resulted in the sub-themes and codes shown below in table 6.9.

Sub-themes	Codes	Quotes
Post-onboarding support	Help-Center	"... sometimes they aren't able to find something on our help-center, which actually could be better search-wise, and then I just tell them straight away to just contact me if there is something they need or can't find." (Appendix 2: CSM 2 - 00:17:22)
	Different support needs	"And then it's just, every person has different needs. It can vary from, I don't hear from people for 3 months, to I hear from them like 3 times a day." (Appendix 3: CSM 3)
iMotions support	Advanced guidance	"But I guess this, advanced guidance, is what we miss" (Appendix 5: Professor 2 - 00:50:14)
	Only basic information within iMotions' help-center	"Actually I have been reading a lot in the iMotions page [help-center], but it wasn't that helpful, it gives like the basic instructions, but not like, specific ones. ... So the only way that I could use it was by asking help from [an iMotions CSM], so he has helped me a lot with understanding how everything works." (Appendix 9: Student 4 - 00:03:49)
	Necessity of onboarding or CSM assistance	"I didn't find it easy, everything I understood, I understood from the conversation with [an iMotions CSM]." (Appendix 9: Student 4 - 00:14:04)
	Google search when facing problems	"… if something didn't make sense, then I would probably find a video, do a quick google search or then find some text or video regarding the subject or problem I'm facing." (Appendix 7: Student 2 - 00:22:08)
	Improving support	"I could imagine that it would be beneficial to open the support sites, because then you can at least search in Google, or my experience is that their searches work better than whatever little searching machine they have bought to their local pages." (Appendix 6: Professor 3 - 00:32:05)
	Lack of manual	"It's not like you can just grab a manual and then learn everything. You almost need to contact them [iMotions] once in a while" (Appendix 6: Professor 3 - 00:05:59)
	Case study as example	"It would be beneficial, because that was also in the case of Tobi studio. What they did is, they presented basically a case study. They showed an example of how you could use Tobi studio through a very specific case study. It was in a Youtube video." (Appendix 8: Student 3 - 00:27:21)
	Lack of information overview	"In relation to mastering it [the software], then a [need for] manageable process and there is probably a lot in the FAQs and the questions in the forums, and such, but you don't get any overview like that, there are all kinds of relevant system specific stuff. Getting an overview of what it is capable of." (Appendix 6: Professor 3 - 00:23:40)
	Immediate CSM	"I am not used to working with experts that in that way answers immediately".

	support	(Appendix 6: Professor 3 - 00:33:24)
	CSM support and less help-center	"So in that way it's more based on paying for high level support and then it's that which solves the problems rather than [iMotions] being a piece of well-coded software and really nice support pages and help pages." (Appendix 6: Professor 3 - 00:06:39)

Table 6.9: "Support" overview, with sub-themes, codes, and raw data.

iMotions provides an online help-center where clients can find frequently asked questions and information about the software, only accessible to paying customers (iMotions help center, 2020). Through the CSM's interviews, it became clear what role the help-center has when it comes to users trying to learn iMotions' software. Though the help-center is the first thing iMotions encourages users to visit before onboarding, as it somewhere they can learn how to get started or get answers to basic questions, a CSM mentions that "..there is something called getting started. Most people don't use it" (Appendix 2: CSM 2 - 00:05:52), which she speculates is due to users expecting to learn how to use the system during onboarding anyway. It is of course also available after users have been onboarded and have some experience with the software, and though it is used, a CSM notes that "..sometimes they aren't able to find something on our help-center, which actually could be better search-wise, and then I just tell them straight away to just contact me if there is something they need or can't find." (Appendix 2: CSM 2 - 00:17:22). This shows that iMotions are aware that the webpage cannot properly scaffold the clients' learning, and chose to work around it, rather than working with it.

However, as the users highlight themselves, different users will experience different problems or have different questions, and a static list of frequent answers can either only cover so many of those possibilities or have not been adapted to enough possible specific problems. As Student 4 mentions, "Actually I have been reading a lot in the iMotions page [help-center], but it wasn't that helpful, it gives like the basic instructions, but not like, specific ones." (Appendix 9: Student 4 - 00:03:49). Student 4 emphasizes the basic level of information in the online help-center which leads to the user not being able to overcome the obstacles of her learning process, thus needing specific guidance. iMotions are aware that different users have different needs, because the level of support needed varies from user to user, as CSM 3 mentions "..every person has different needs. It can vary from, I don't hear from people for 3 months, to I hear from them like 3 times a day." (Appendix 3, CSM 3). If the users do not get adequate information from the help-center, this can result in a hindrance in the experiential learning process the users go through. Users will often experience problems that they did not encounter when they had an expert guiding them. These problems are not always solvable in an unaided context, and as such the process of experiential learning is not possible. In this situation, the user can reflect on what they did wrong but do not have the necessary experience to make conceptualizations on how to fix the problem (Kolb, 1984).

The lack of information within the help-center can be related to a missing overview of content according to Professor 3, who states:

> In relation to mastering it [the software], then a [need for a] manageable process and there is probably a lot in the FAQs and the questions in the forums, and such, but you don't get any overview like that, there are all kinds of relevant system specific stuff. Getting an overview of what it is capable of. (Appendix 6: Professor 3 - 00:23:40)

The quote brings out one of the issues of the help-center. Despite that the help-center might have the information needed to overcome the problems that the clients are facing, not being able to find the information is also an issue. Not being able to find information on how to solve specific problems is an obstacle for users becoming self-directed learners of the software, as most users will start at the level of "interested learners'' as they want to become users of biosensors and biosensor software (Grow, 1991). As such, the users will need a personal guide that they can rely upon to help them learn (Merriam et al., 2006). After the onboarding sessions, hopefully, the users should be able to work more independently, and become "involved learners'', who are willing to investigate problems themselves, but occasionally require the assistance of an expert (Grow, 1991).

Furthermore, Professor 3 mentions that the current process seems like it is "more based on paying for high-level support, and then it's that which solves the problems rather than [iMotions] being a piece of well-coded software and really nice support pages and help pages. (Appendix 6: Professor 3 - 00:06:39). Based on this quote, Professor 3 has the impression that in order to solve a problem he is facing, he needs to contact iMotions to solve the problem, rather than independently get help from their online help-center. Hence, the user is not going through the experiential learning cycle as they will be stuck at the stage of observations and reflections (Kolb, 1984). Without the necessary amount of scaffolding, the clients are not able to gain a learning experience that will make them able to solve the problem, should they face it again (Pol et al., 2010). Thus, the aim of making the user a self-directed learner is diminished to an extent, as the user rarely has the opportunity to overcome challenges unaided (Merriam et al., 2006)

In response to their current experience with learning iMotions, there were several ideas from the users on how to provide support to more specific cases. One user had experience with another biosensor software called Tobii, which focused mainly on ET software. The user highlighted the way Tobii presented an introduction on how to use the software, "What they did is, they presented basically a case study. They showed an example of how you could use Tobii Studio through a very specific case study. It was in a youtube video" (Appendix 8: Student 3 - 00:27:21). In this quote, Student 3 highlighted the way the Tobii Studio software shows how applied use of the software helped him become a user of the software. The video showed applied practice of a specific case, and through it, the user could deduce how to apply the Tobii software to the participant's own project. Despite that the video did not necessarily have great relevance for the study which Student 3 was carrying out, the information given in the video was able to direct him into a path that helps him with his project, giving him a learning experience he can reflect upon, and as such, became self-directed (Grow, 1991). Furthermore, according to Oud (2009), instructional videos can function as good examples of specific tasks or challenges, and aid the user in transferring these solutions to other contexts.

6.9 Main findings

In this section, the main findings from the above analysis are presented in two subsections, current problem areas and Improvements and new ideas. These findings will be important considerations for the design chapter, serving as the basis for a user-centered design approach.

6.9.1 Current problem areas

- The aim of the onboarding session is to turn new clients into self-directed learners of the software. However, despite the current onboarding sessions, users are still having difficulties using the software, as much information on how to use it and its many options is not retained.

- As the iMotions software affords many different options through different hardware types and different data types, there is a large variety of things to learn depending on the existing knowledge of the user, making learning the software a difficult and long process. While the user may understand the theoretical implications of biosensors and its data, they may need some level of guidance to understand the more technical aspects of using biosensors, or vice-versa.

- Both CSMs and users expressed a need for scaffolding in relation to data processing, as it is currently difficult and intimidating for users, which is evident by how users often feel unable to proceed unaided.

- The current support strategy is often based on contacting the experts at iMotions, and iMotions experts themselves advocate for writing directly to them rather than utilizing the online help-center. As such, the current help-center offers limited support for self-directed learning, and the users are forced to contact iMotions directly.

- Retaining information after onboarding is a problem for the users. However, recording a video of the onboarding sessions and sending the video to clients improves knowledge retention, according to the CSMs. For this context, being able to re-watch the session allowed them to rewind and skip around to parts they may not have immediately understood in the moment, or relearn things they simply forgot over time due to the overwhelming amount of information.

6.9.2 Improvements and new ideas

- Accounting for the learning context is important for an effective learning experience, which can be elements such as how much prior knowledge of biosensors the learner has or how experienced they are with the software. Furthermore, making users aware of the theoretical and practical implications of using the software, and doing so with examples where the users can see the process, is important. Taking all of this into account and providing the scaffolding needed for individual types of learners is paramount for an effective learning experience, due to learning being a highly personal experience.

- Signifiers could be utilized to change the user's perception of the software's affordances, by communicating where to perform task-specific desired actions. Thus providing a less confusing interface, but also aid the user in becoming more self-directed.

- Setting up constraints in relation to the software's functionalities, based on the user's overall aim for utilizing biosensors, would allow for designing for the activities instead of smaller tasks. As such, this could potentially reduce the effects of how the software's complexity limits the user.

- User chosen constraints within the software, in the form of a "guided process" or "personalized workspace", would limit the perceived affordances, thus reducing confusion. Furthermore, this would provide users with options for what to learn first and then focus on one element of the software at a time, which could reduce the amount of information users are exposed to and have to assess.

- Providing context-specific tips within the software could act as a scaffolding method and aid the user in attempting tasks that are difficult to approach. These tips should be based on the user's own skill level which is chosen by the user themselves and should be used as a guidance that can scaffold the user's learning development.

7. Design Presentation

This chapter will present a design aimed at providing solutions for this paper's research question and case description and furthermore reflect on those design choices. Nonetheless, it should be noted that through our case study approach, we are aware that the design produced is a solution that is relevant to the case and not a generalized solution for all biosensor software. As such, we will also highlight the design principles that are generated from the findings throughout this research and which serve as a foundation for the proposed design solution. While the design is not a generalizable solution, the design principles are directed towards the general field of biosensor software, aiming to help us answer our problem statement. With that said, the following sections will first introduce the design process and be explained in-depth to provide transparency for our procedure of the ideation and sensemaking process, which resulted in six core design principles. Section 7.2 and 7.3 will present and discuss the main aspects of our solution. In section 7.4 user personas will be introduced, which will be used as actors for scenarios, to provide context for the design. Lastly, a discussion of design reflections will be presented in section 7.5 to acknowledge design challenges and considerations.

7.1 Design Process

This section describes and discusses the creative process from which ideas for design solutions were generated, based on the understanding and findings established in chapters 2, 3, 4, and 6. Furthermore, design thinking and the Double Diamond model are related to the creative process undertaken for designing solutions and work as a framework for idea generation and solution design. This explores the sensemaking processes and how the methods employed allowed us to reflect on our own ideas and gradually reach a common vision that could then be further developed into design prototypes, both conceptually and visually.

By collecting and analyzing data in the inspiration stage, we as researchers naturally moved into the ideation stage as familiarizing ourselves with the data caused us to have ideas for what a solution may look like, even if it was premature. In order to externalize those ideas and to try and get a shared understanding of what thoughts we each had regarding potential design ideas, a brainstorm was carried out using Google Docs to write down ideas in a shared document. This can be seen as the beginning of what Kolko (2010) views as being synthesis, which he refers to as being "..an abductive sensemaking process" (p. 19), meaning that it allowed us to make sense of general ideas and concepts we had each thought of. Four ideas were written down as a result of this process: A video library of tutorials on how to use iMotions software, tips within the software that could assist users in understanding how it works, a start setup that would hide certain features if the user did not need them for their use case and a forum on which users could ask questions and interact. All of these ideas were briefly explained, after which the next step of this process began.

In an effort to continue this synthesis and sensemaking process, Google Jamboard was used as a method of getting a common understanding of how we each perceived and understood the different ideas (Kolko, 2010). Google Jamboard allows users to create several different slides on which they are able to add post-it notes with text on them as well as adding images, allowing a visual overview of different thoughts users may have on different subjects. This was used as it allowed collaboration over the internet, which was particularly useful due to COVID-19 not allowing for physical meetings at this stage.

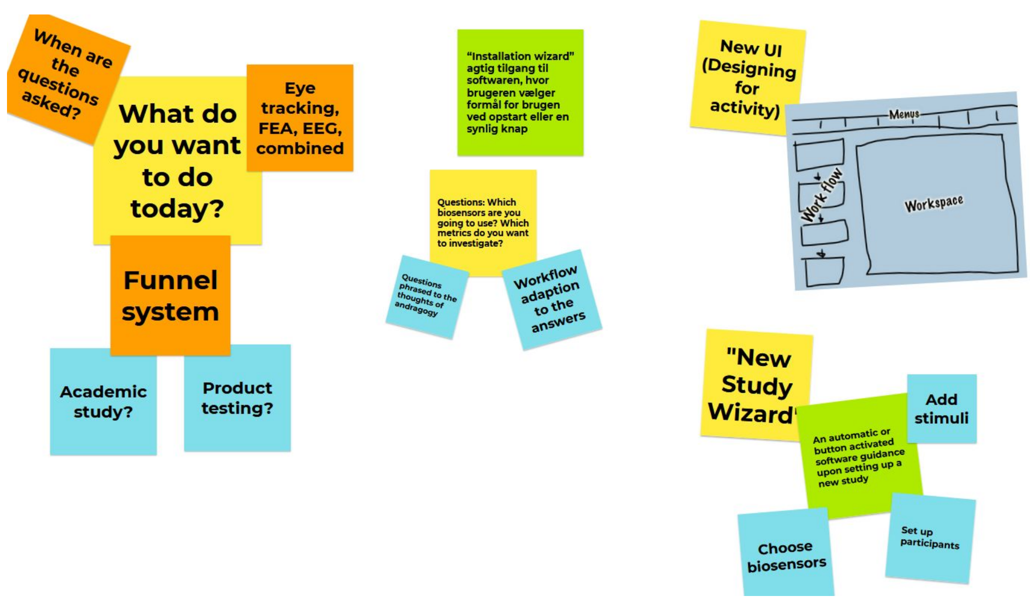

Figure 7.1: Use of Google Jamboard to illustrate thoughts and perspectives on ideas

It also allowed the three researchers of this paper to individually write down our thoughts, which we could then discuss in a meeting once we had all had a chance to individually reflect upon the ideas. Relating this to Kolko's idea of sensemaking (2010), it allowed each of us individually to make sense of our internal concepts and ideas, after which we were able to collectively reach a common perspective. This resulted in the idea of adding a forum being eliminated, as it faced scrutiny from the three of us for not being adequately represented in our data compared to the other design ideas, and thus not being central enough of an issue.

Upon reaching a common conceptualization of the ideas, sketching methodology was applied in order to compare and contrast how we might visualize and design the ideas listed. As Buxton (2010) argues, not only are sketches quick and easy to make but also function as an aid to the thought, allowing a tangible visual representation of ideas. Furthermore, sketches are typically used to suggest and explore, rather than confirming ideas (Buxton, 2010), which allowed the three of us to explore how these ideas could possibly be visually represented. As such, we each sketched a visual representation of the three ideas (video library, software tips, and the start setup), with examples being shown below in figure 7.2.

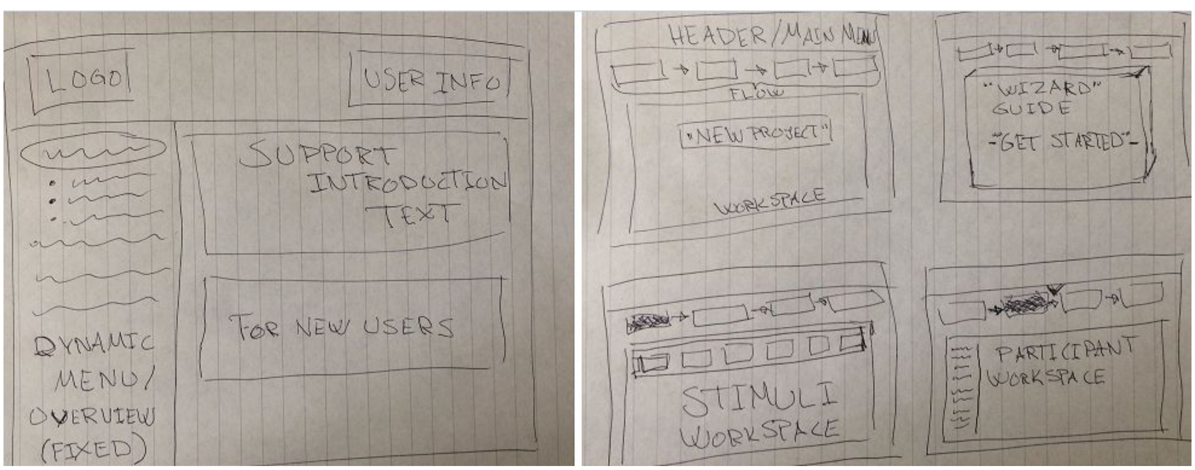

Figure 7.2: Two sketches used for discussion of visualizing design ideas

These sketches allowed for discussion of the visual design for the proposed ideas, which will be further specified and explored in sections 7.2 and 7.3. This concluded what can be seen as the development step (figure 5.1) in the Double Diamond model (Clune & Lockrey, 2014), as we grew increasingly convergent by settling on ideas for design solutions, that then needed to be moved closer to the deliver step of the Double Diamond model in order to finalize design ideas. However, fully realizing and completing the delivery step is a step beyond the scope of this paper, but will be reflected upon in chapter 8 as part of reflecting on how a final design might be developed.

This design process, along with the main findings presented in chapter 6, Results and Analysis, formed design principles for the solutions. The term design principle is borrowed from Kanstrup and Bertelsen (2011), who state what these principles should be "...based on the analysis of insights and visions and the work with sketches." (p. 91). As such, this design process of generating design visions through sensemaking and sketch work, combined with the main insight, described in the previous chapter, provided the necessary knowledge to produce the following table, 7.3, which shows correlations between main insights and design principles. However, it should be noted that through the sensemaking process and a synthesization of the findings, some findings are deemed more relevant for a design solution and principles than others, and as such, some findings are not present in the design principles and the design. As such, the design principles represent a synthesized version of the main findings, which were a synthesized version of the user data. This means that the design principles ostensibly represents the user data in an operational form.

Main findings	Design principles
Users are required to learn multiple new knowledge areas, in order to utilize biosensor software, as biosensors yield most accurate results when combined.	Design principle 1: Software guidance and assistance should be integrated within every step of the design.
The current help-center offers limited support for self-directed learning	Design principle 2: Online support options should facilitate self-directed learning.
Users are required to contact experts directly in order to solve problems, rather than being able to solve problems themselves.	
Both CSMs and users indicated a positive effect of using videos within the learning context for biosensor software	Design principle 3: Videos should be utilized for providing non-human, self-directed teaching and scaffold the learning process of biosensor software.
Video teaching utilizes both audio and visual channels, reducing the cognitive load for the learner.	
Videos allow for independent learning and can support users in being self-directed.	
Users learn differently and as such have different learning preferences.	Design principle 4: The design should accommodate users' prerequisite

Users possess different levels of knowledge regarding biosensor and software knowledge	knowledge levels regarding both theoretical and technical knowledge about biosensors, and practical aspects of biosensor software.
The iMotions software interface lacks clear instructions	Design principle 5: The design should communicate the process of using the software in a simple and understandable way, while assisting the user through each step of the necessary tasks.
Users found difficulties of how to proceed through the different steps of the workflow in the iMotions software	
Imotions software can be overwhelming in terms of the amount of interface options.	Design principle 6: The software should be able to set up constraints, limiting the amount of affordances and the corresponding information that the user is exposed to.
Information can be overwhelming in the level of required theoretical knowledge.	

Table 7.3: Main insights translated into design principles

As such, the design principles shown in table 7.3, provided the framework for the two design solutions, which will be presented in the two following sections. Design principle 1 is not necessarily directly related to a specific design decision but is instead kept in mind for each of the design solutions listed in the following sections.

7.2 Onboarding and support through video-assistance

In the following section, the first part of our design solution will be proposed. This part of the solution is related to the iMotions online help-center, a support page where clients can read about functionalities of the software and get online support from CSMs, and how it can be used for providing digital onboarding sessions, and in general, make it easier to navigate. This also relates to the case description, which required a digital and non-human reliant solution, and as the data shows is not the case currently, as was clearly conveyed by student 4 "So the only way that I could use it was by asking help from [an iMotions CSM], so he has helped me a lot with understanding how everything works." (Appendix 9: Student 4 - 00:03:49).

The proposed design will be presented, which revolves around using video formats to teach and explain the different functionalities, features, and the entirety of the iMotions software. The design we present will accommodate a non-human onboarding video solution, but the video format should be used for all support content, and not just for the onboarding. The current help-center is primarily focused on text, and has few visual elements, such as pictures and videos, to represent the software.

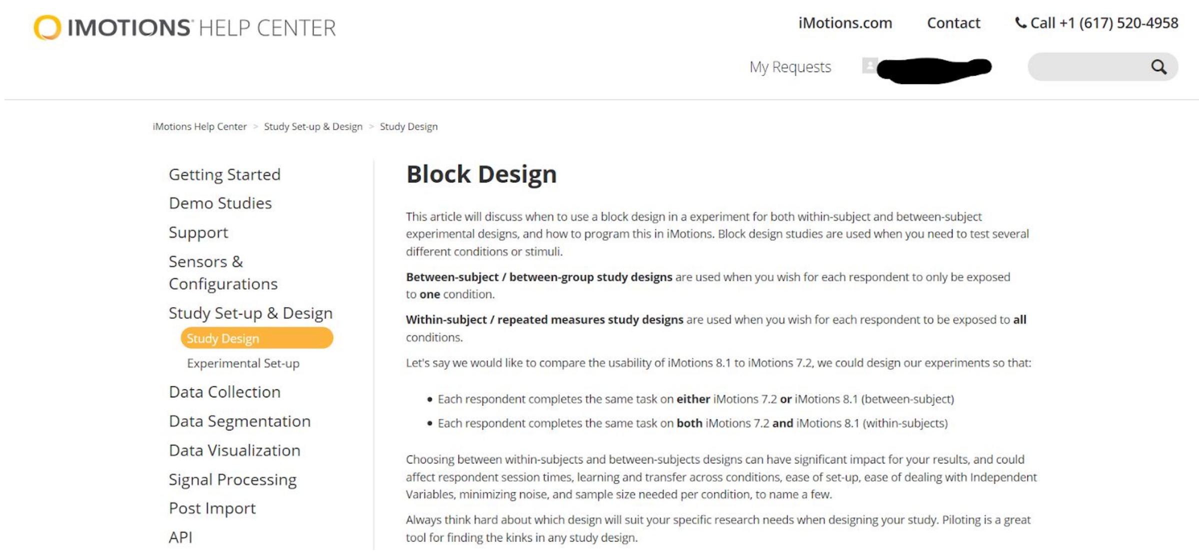

Figure 7.4: Current help center design

One of the primary problems of the current help-center as discovered through CSM and user interviews was that it suffered from a lack of overview, with professor 3 clearly stating "there is probably a lot in the FAQs and the questions in the forums, and such, but you don't get any overview like that" (Appendix 6: Professor 3 - 00:23:40). In short, in its present state, the iMotions help-center fails to provide users with a clear overview of its content, which must be addressed in the design. Another problem was that the help-center consists mainly of basic information which was not applicable to the specific cases for the users, as was visible through student 4 saying "Actually I have been reading a lot in the iMotions page [help-center], but it wasn't that helpful, it gives like the basic instructions, but not like specific ones. And I needed very specific ones" (Appendix 9: Student 4 - 00:03:49). This notion was shared by a CSM as they also advised clients to contact them directly, instead of referring them to the help-center, which was expressed as "... sometimes they [clients] aren't able to find something on our help-center, which actually could be better search-wise, and then I just tell them straight away to just contact me if there is something they need or can't find." (Appendix 2: CSM 2 - 00:17:22). That is why rethinking the design and purpose of the current help-center is necessary for achieving a digital and scalable non-human solution.

We propose to convert the current help-center to keep the role of providing information to users in need of help, but also for it to be used as a digital onboarding experience for new users. The following low-fidelity prototype proposed in figure 7.5 is a combination of ideas based on the findings presented in section 3, Literature review, theories presented in section 4, Theory, and the findings from section 6, Results and Analysis, as well as the developed sketches described in section 7.1 Design Process.

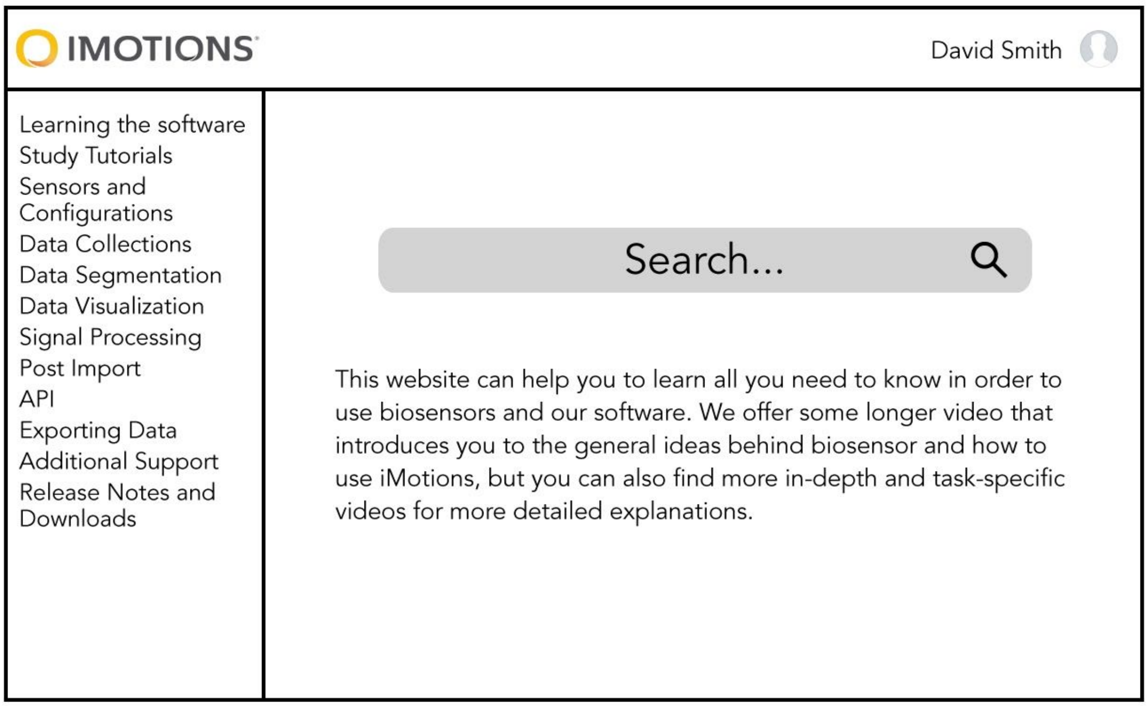

Figure 7.5: Prototype example of the frontpage for a video-assisted learning site.

Presenting specific examples of the content for this new solution is something that needs to be investigated further, as it was challenging for this research to do in-depth software testing, but we have still attempted to provide some examples of how a low-fidelity prototype could look. As described in the main findings of chapter 6, Results & Analysis, instructional videos should especially be provided to assist and scaffold the user through the complex process of handling the biosensor data. This was exemplified by student 3, who mentioned he had a positive experience with video tutorials while learning a different biosensor software "It would be beneficial ... They showed an example of how you could use Tobi studio through a very specific case study. It was in a youtube video." (Appendix 8: Student 3 - 00:27:21), while student 2 clearly showed a preference for learning through video, saying "… if something didn't make sense, then I would probably find a video." (Appendix 7: Student 2 - 00:22:08). As such, the idea of learning through video is adopted for this solution based on the main findings produced in chapter 6, Results & Analysis, but also theoretical considerations regarding multimedia learning, found in chapter 3, literature review. Furthermore, the complex nature of biosensor software, due to its many options, makes it difficult to find the exact features, and video examples of someone carrying out the desired actions showing detailed examples of where to go and how to use the system (Pickens, 2017; Oud, 2009). As our user data shows, users currently rely on expert assistance for learning the software, and additionally, the participants also expressed that being able to see someone use the software in action was particularly helpful as a way of learning by example. As such, the video tutorials would essentially replace the human actors as part of the current biosensor software learning process, assisting users in learning this uniquely complex software type. This also tackles the problem of scalability mentioned in chapter 1, allowing iMotions to help the users where needed, but without requiring human assistance.

When a user enters the proposed design, they would be presented with the visuals from figure 7.5. According to the interview participants, the help-center did not currently provide a clear overview of what content there is, and that it was difficult to find task-specific content, which one user stated as was mentioned in a quote from professor 3 earlier in this chapter, the help-center did not currently provide a clear overview of what content there is, and that it was difficult to find task-specific content (Appendix 6: Professor 3 - 00:23:40). Hence, we propose to give the user an immediate overview of task-specific content, such as, how to set up a new study, how to add stimuli, and especially, how to process the different kinds of data. Placing the search function centrally, with explanatory text to provide the users with an idea of what to search for, aims to motivate the user to make specific searches, as it was a common need for the users, to find specific information, rather than general. This common sentiment was expressed by Student 4 as "Actually I have been reading a lot in the iMotions page [help-center], but it wasn't that helpful, it gives like the basic instructions, but not like specific ones." (Appendix 9: Student 4 - 00:03:49).

In order to create a potential design, that can serve as a solution to our problem statement, we argue that the proposed design should strive to become an alternative to the onboarding session. This could be done by embracing the strengths of multimedia learning, as presented in chapter 3. In the chapter, we described Rapchak's (2017) arguments for the importance of using both the visual and audio channel for creating learning experiences, and furthermore, we presented Pickens' (2017) and Oud's (2009) studies regarding the benefits of instructional video. Based on this, and design principle 3 presented in table 7.3, using the video format as the main communication tool is advisable for this context. One of the reasons for why the video format is beneficial is that it allows for combining the benefits of the visual and audio channels. Allowing the learner to see the visual presentation of the subject with an auditory explanation of the visuals, can provide the user a deeper learning experience, and the information is more likely to be organized in the long term memory (Rapchak, 2017). In addition to this, several of the users also referred to the video format as a viable learning experience, showing that the participants have similar experiences, with Student 2 noting "if something didn't make sense, then I would probably find a video" (Appendix 7: Student 2 - 00:22:08) and student 4 saying "if I could do like a video, to explain everything that I have been going through and how to do this, that would help another person" (Appendix 9: Student 4 - 00:25:13.)

As such, setting up an online onboarding session with the use of videos allows users to work with the software independently. According to Rapchak (2017), it would be favorable for the learning process, if the learning videos are divided into relatively short videos with limited information, in order to reduce the cognitive load of the learner. Additionally, providing the users better opportunities to learn through online environments can assist the learners to become more independent as they are able to find information that they need themselves, making them more self-directed (Grow, 1991). This form of content segmentation supports design principle 2, as shown in table 7.3. That is why we propose the following solution for an online onboarding session.

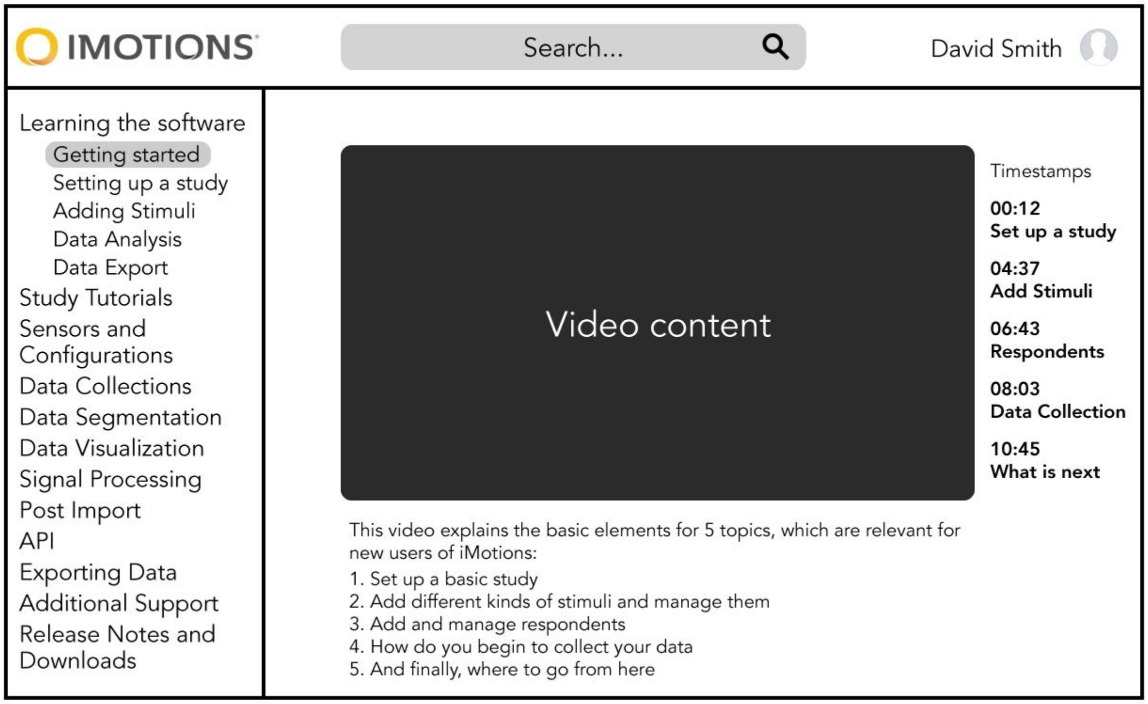

Figure 7.6: Example of "getting started" with a corresponding video and description.

In figure 7.6 above, one of the steps of our proposed online onboarding session is shown, where the user is presented with the first step of the onboarding session. The video is of a longer nature, depending on the specific topic, showing each step of creating a new project, with a CSM explaining each step; study setup, adding respondents, adding stimuli, analysis (data processing), and data export, and as such, explaining why these steps are necessary. An example could be a video explaining how to add stimuli to a study and which considerations the user should be aware of in the process. In this context, considerations should be understood as the best practices of working with biosensors, which would be a video providing an in-depth explanation of the methodological considerations the users need to take while learning to process biosensor data. A lack of these additional methodological explanations was expressed by Student 3, who claimed his confusion in learning the software would stem from the methodology, saying "it would have been because of the methodology. Like how do you conduct the analysis." (Appendix 8: Student 3 - 00:15:48). On a practical level, these videos would also provide visual examples of how the best practice for utilizing biosensor hardware, e.g. to make sure that the room is sufficiently illuminated when collecting data through ET.

A description of what the video contains is placed below the video, detailing specifically what the purpose of the video is and how the user can proceed with their learning, aiming at minimizing the intrinsic cognitive load (Pickens, 2017; Oud, 2009). To the right of the video, timestamps for the video is shown, allowing the user to be aware of the different steps, but also able to jump to the step that the user finds relevant for the learning experience, accommodating users' different prerequisite skill levels (Oud, 2009).

In figure 7.6, one of the focal points of structuring the page is the overview as that is something participants found lacking in the current help-center, as expressed by Professor 3 "In relation to mastering it [the software], then a [need for] manageable process ... but you don't get any overview like that, there are all kinds of relevant system specific stuff" (Appendix 6: Professor 3 - 00:23:40). When a user selects content from the menu, they are taken to a new page which contains a clear description of the selected topic, along with timestamps for the video, allowing the user to skip to the parts that they find relevant for their project (Figure 7.6). Furthermore, we argue that the onboarding sessions should be split into several videos, going through every step needed to be able to work with the iMotions software. iMotions should be aware of the length of the content they produce, as Rapchak (2017) highlights that videos that are too long can cause cognitive overload in the user. However, some videos might have to be longer, as they have to show a certain amount of content to cover the specific topic, without confusing the user by splitting the video up in too many segments. Longer video is especially necessary for the onboarding video as they are aimed at newer users, thus they need to provide detailed explanations of task-specific details, but also of the sequence or progress of the content, whereas more experienced users benefit more from shorter and more in-depth videos, aiming at minimizing the extraneous cognitive load (Rapchak, 2017; Oud, 2009). Besides the longer onboarding videos, the general video content within the design should aim to be of a shorter length in order to both accommodate the need for reduction in extraneous load, but also to provide a more transparent overview of the website's content, thus being able to provide specific in-depth scaffolding as expressed by both participant samples, CSMs and users.

Although we argue for users to learn one biosensor at the time, the investigation of applied biosensor research, presented in chapter 2, strongly recommended the simultaneous use of multiple biosensors (Tan et al., 2012; Tobin & Ritchie, 2012; Cohn, 2005; Walker et al., 2019; Goldberg et al., 2002). As such, the video content would reflect this recommendation in the form of explanations of biosensor methodology, thus the user would become aware of these recommendations, but also be provided with suggestions of how to approach the learning sequence of multiple biosensors.

The combination of watching a video about setting up the study design, with both the visual and audio channel used, while also having the software and hardware available, can be a valuable experiential learning approach for the user (Kolb, 1984). Because the user has access to test out the actions performed in the video, while also having explanations to each step as to why these steps are performed, this allows the user to gain concrete experiences of the software and hardware, while also being able to reflect on the action taken, with the explanations from the videos (Kolb, 1984). This form of learner interactivity could also provide the user with an opportunity to experience software feedback on which actions are right and wrong in a task-specific context (Oud, 2009). As such, the new video-assisted learning site should provide a couple of links that allow the user to download test-studies which matches the studies shown in a tutorial video, thus allowing the user to interact and follow the instruction within the software. This form of interactivity aims to teach users how different features and functionalities work by allowing them to get immediate feedback. In this context feedback should be understood as all the responses the user receives from the software, indicating right and wrong actions. As such, the user would be able to reflect upon those actions and the process, thus creating new knowledge through experiential learning (Kolb, 1984; Oud, 2009).

Providing an online onboarding session as the users are learning the iMotions software, we argue that giving new users a positive first experience with the design solution would cause the user to be more comfortable using the new video-assisted learning website for solving potential problems, thus becoming more self-directed in their learning experience.

7.3 A new approach to iMotions' Interface

This section will present the second part of this research's solution, which will focus on providing a more accessible biosensor software, based on the main findings presented in chapter 6. Providing examples of the current state of iMotions, initial researcher sketches, and low-fidelity mockups, each new design element will be presented and discussed.

One of the commonly expressed challenges, both by CSMs and users, was the complexity and the confusion regarding getting new users started with iMotions' software and becoming self-directed learners. This was due to multiple reasons, but specifically, in relation to the software, two main issues were discovered in chapter 6, Results & Analysis. Firstly, users were being overwhelmed by the number of options being presented by the software, and secondly, the users could be unaware of the possibilities and methodological considerations of biosensors in general. As such this section aims to provide design solutions for these challenges.

The interview participants expressed that complexity was limiting them in utilizing the software to its fullest potential or even being a source of errors, as it would confuse the user, as exemplified by CSM 2 stating "... what I think that makes it complex is the options you can choose between, there are a lot and you can not filter anything away." (Appendix 2: CSM 2 - 00:19:04). Norman (2013c) argues for a separation of these two concepts: complexity and confusion, as he states "... I argued that complexity is essential: it is confusion that is undesirable." (p. 247). To describe the difference between the two concepts Norman (2013c) draws on the analogy of a kitchen, which can be a very complex concept, with many different objects and affordances, and thus, confusing for users who are unfamiliar with the environment, whereas, most people are not confused by their own kitchen. As such, the design should assist the users in becoming familiar with the software and for them to utilize the software's many affordances provided by this complexity.

Confusion as an obstacle should also be considered in the context of what was presented in chapter 3, regarding users' extraneous cognitive load, as unnecessary software elements increase confusion by requiring the user to process unnecessary information (Mutlu-Bayraktar et al., 2019). Student 3 expressed this very clearly as "I think it would definitely help if they could clear up the UI in a way so it's more logical, and not just everything together in one place…" (Appendix 8: Student 3 - 00:40:43). This indicates that some form of re-design of iMotions' interface is warranted, and for comparison and visualization, the current interface can be seen below in figure 7.7.

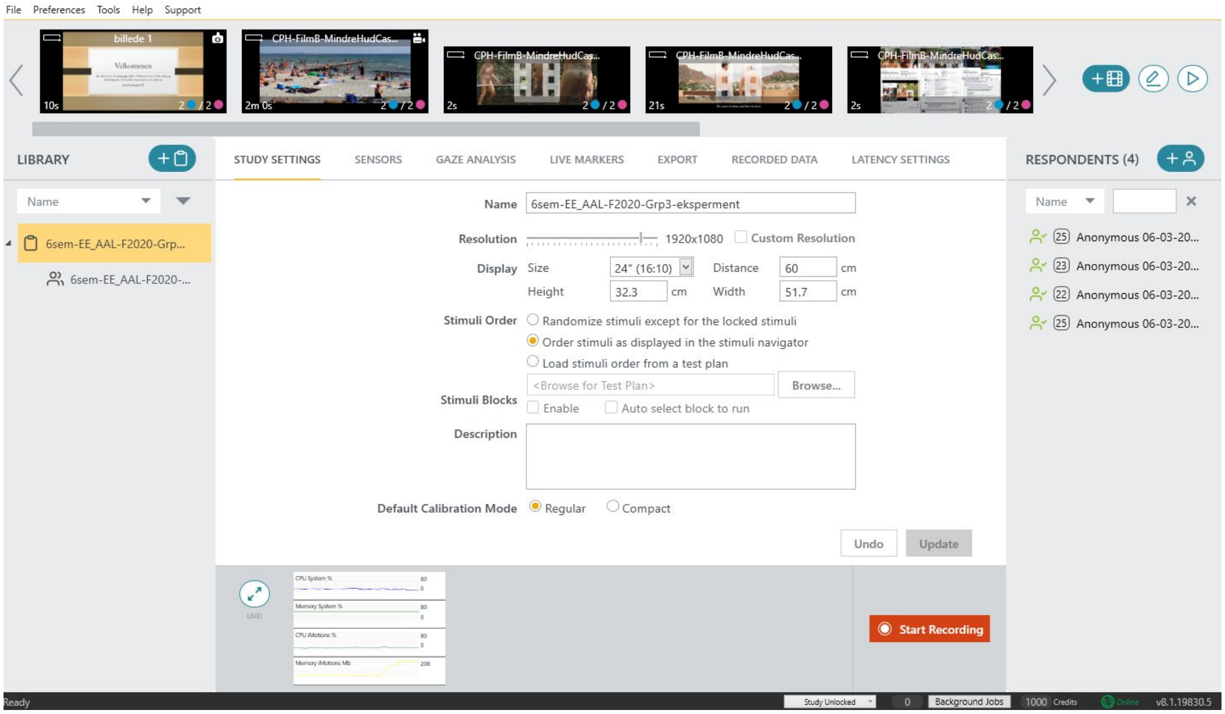

Figure 7.7: Example of iMotions' current interface.

Figure 7.7 shows how multiple UI elements are presented all at once, such as the project library on the left side, stimuli menu at the top, respondents menu to the right, and biosensor live-feed at the bottom. We argue that these specific elements should only be presented when the user is interacting with the task-specific element. As such, numerous sketches were drawn, during the ideation process, in order to produce new solutions to how this confusion within the software could be minimized, as shown in figure 7.7.

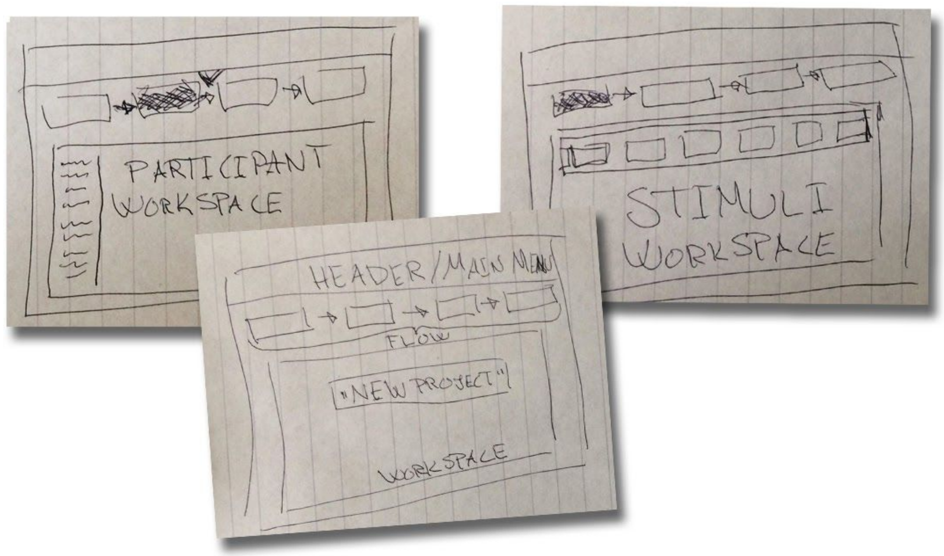

Figure 7.8: Sketches of a new interface.

These sketches combined with an internal researcher sensemaking process provided the basis for a low-fidelity design, shown below in figure 7.9.

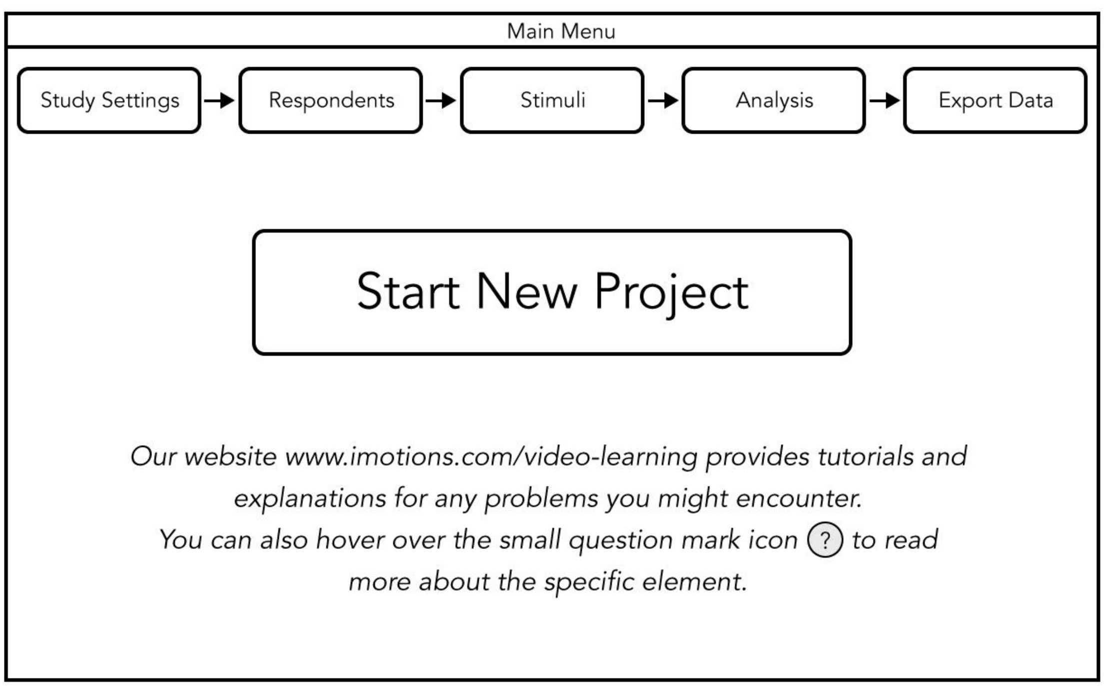

Figure 7.9: Proposed low-fidelity design of the software's starting view.

As seen in the proposed design solution, in figure 7.9, each of the previously mentioned UI elements; project library, stimuli menu, respondents menu, and live-feed, have been removed and combined into a single menu. This new menu can be seen at the top of the design, displaying each of the big tasks the user has to go through in order to produce biosensor insights. Comparing the new proposed software interface with the current iMotions example shown in figure 7.7, each button of the new menu functions as signifiers in order to clearly communicate where each individual task takes place, again as to reduce confusion (Norman 2013c). This new menu aims to provide an intuitive workflow approach to the software, as suggested by both participant samples, but also remove non-relevant information to minimize the user's extraneous cognitive load (Mutlu-Bayraktar et al., 2019; Pickens, 2017; Oud, 2009). This is also in accordance with design principle 5, as the aim is to clearly communicate the software process and assist the user through each step. Furthermore, this design is supported by Norman's (2013c) idea of designing for activities rather than smaller individual tasks, as this new design aims to accommodate a seamless workflow through the different tasks which constitute the overall activity of producing biosensor data, without focusing on minor individual tasks all at once. Lastly, as seen above in figure 7.9, the new interface will show information concerning the new video-assisted learning website, for both new and experienced users. To clearly communicate where to access additional guidance and instructions a textbox is presented upon opening the software, aiming at always reminding the user of the additional video scaffolding which the video-assisted learning website could provide.

Below in figure 7.10, this new workflow menu allows for an expanded workspace, marked in red, which allows for more space for displaying complex content and additionally, able to show more task-specific information.

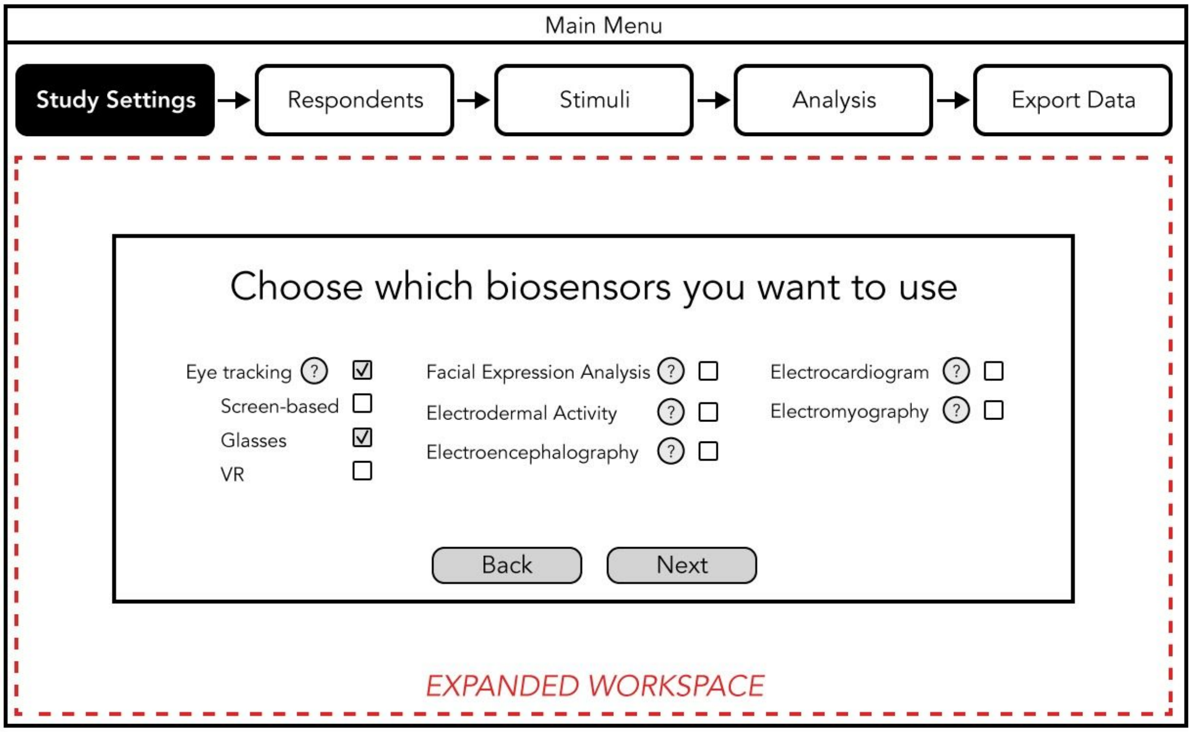

Figure 7.10: Proposed low-fidelity prototype of the guided process.

Upon selecting to start a new project, a start-up window will be shown, for each of the workflow menu's steps as seen in figure 7.10. This aims to guide the user in setting up constraints, limiting the perceived affordances, based on the user's study and desired outcome, which is also represented by design principle 6. This guided start to each task facilitates the user to personalize their workspace by setting up constraints in order to provide a less confusing interface which only shows relevant options but also assists the users to only focus their attention on the needed functionalities (Norman, 2013b; Faraj & Azad, 2012). Figure 7.10, displays the example of how a user would start their study by selecting which biosensors they are going to use throughout the specific project. In this example, the user has selected to use ET with glasses and ready to click the next button at the bottom in order to proceed to the next step of setting up a new study.

This form of in-software assistance also aims to scaffold the user, especially during the data analysis, visualization, and export steps of the process, as this process was challenging or even unapproachable for some participants. This challenge was directly reflected by a statement made by Student 4, when asked about how they had to learn the software by themselves "I didn't find it easy, everything I understood, I understood from the conversation with [an iMotions CSM]." (Appendix 9: Student 4 - 00:14:04).

An in-software solution which adds additional explanatory information to the interface should visually be kept to a minimum as to not create an unnecessary extraneous cognitive load, by displaying helpful information for a user who might not need the guidance. As such, new users will be able to select their experience level with iMotions' software but also their general knowledge level concerning biosensors, upon starting a new project, to accommodate design principle 4. These settings will determine how much task-specific guidance and support information the software will provide during each step, throughout the process. As seen in example displayed in figure 7.10, the user has previously selected that they do not possess a high level of knowledge pertaining to biosensors, and as such, the software displays question marks which can provide information for each biosensor, or even redirect the user to the video-assisted learning website for additional information. The user should always be able to change these settings when and if they become familiar with the software or accumulate new biosensor knowledge.

Although the users are assessing themselves, Merriam et al. (2006) argue that adult self-directed learners are able to participate in this assessment. This feature aims to provide task-specific scaffolding based on the users' pre-existing knowledge, which is required for an efficient learning environment (Pol et al., 2010; Knowles et al. 2005c). This form of scaffolding should be provided in the form of explanatory in-software text, either in case-specific textboxes or hidden behind icons signified by a question mark. Furthermore, for tasks that require a more in-depth explanation, walkthrough, or instruction, links to the video-assisted learning website would be provided, in order to minimize the risk of the user being unable to complete the specific task or proceed on their own. Where this scaffolding should take place throughout the software would need to be further researched with users participating in further prototype testing.

7.4 The rigorous and independent learner

In the following section, the methods personas and user scenarios will be applied to the designs. This is done to put the designs in a context and to highlight the different types of users that would make use of the iMotions software and how their different backgrounds and user type can lead to different actions. The personas and scenarios can, therefore, be seen as a product of the research gathered, which may also be used for further research on the subject.

Personas

Based on the insights that were gathered throughout this thesis, two archetypal learners are established, the rigorous and the independents. These personas are not based on demographic data, but on interpretations of the participants' answers and their approach to learning the iMotions' software. Both of these types will each be exemplified by a persona given a name, age, and occupation to provide an idea of who these learner types actually are. Due to the lack of gathered data on commercial users, these personas are characterized as academic users.

The learner type "the rigorous" refers to a type of user who prefers to have a solid foundation of knowledge of biosensors in preparation before engaging with and learning the software. Furthermore, they may not be used to the more technical aspects of the software, and prefer to seek human expert guidance when they face problems. As exemplified by the data featured in this paper, they are professors who therefore are in contact with iMotions and have received guidance on how to use the software. The following is a persona of who such a user might be:

Name: David Smith
Age: 44
Profession: University professor
Learner type: The rigorous

David Smith is an English 44-year-old professor of cognitive psychology at the University of Cambridge, and he has recently taken an interest in using ET as a research method due to hearing positive things about it from his peers. He is inexperienced when it comes to using software outside of Microsoft Office programs, but hopes that he can learn the software. In order to gain some prior knowledge, he has studied online materials and research papers that describe what biosensors can be used for, and what kind of results they can provide. However, he has no actual experience using the biosensors himself. As such, he has requested and received a license for the software for research use, as well as ET hardware. Furthermore, he does not feel entirely confident in his ability to use the software as there is a large amount of information on-screen, and as he lacks general IT skills. He is interested in using the software to carry out experiments relating to cognitive psychology but feels hesitant as he feels overwhelmed by the options and technical aspects.

The second learner type is called "The independent" and refers to a type of user who wants to jump into and learn the software by trying out the different features available on their own. In this vein, they prefer to help themselves through videos or online help in order to learn, and generally have experience with this approach of learning software in a self-directed manner. Furthermore, along with this desire to learn in an unassisted and exploratory manner, they like to be able to customize the system to their needs as part of feeling in control of how they learn and use the software. What follows is a persona which serves to exemplify the learner type described:

Name: Sarah Jensen
Age: 24
Profession: Master's student
Learner type: The independent

Sarah Jensen is a Danish 24-year-old didactics of mathematics student at Copenhagen University, who has recently learned through one of her professors that biosensors can be used to research how students learn mathematics. Taking an interest in this as a potential master's thesis research subject, she has inquired further about using this technology and as a result, is borrowing ET and GSR equipment from her university. She has no experience regarding how to use this technology but has been taught the basics of what the software can output in terms of data collection through using ET and GSR. She is moderately experienced with having to learn new software unassisted, but would still prefer to have some type of informative resources available when she encounters problems specific to her experiment. As a student, she does not have direct contact with iMotions and would, therefore, need to ask her professor in order to contact iMotions for help and advice. Therefore, she is relying on her professor if she needs help, and relying on her own exploration for learning the software.

Scenarios

In order to describe how users interact with the proposed design, scenarios of how a user might use and interact with the design are described using the established personas from above.

In the first scenario, the actor is our persona David Smith, situated in the setting of trying to get a better understanding of iMotions' software due to not fully grasping it and its many options after having read about it in studies and related theory. In order to learn about the software before using it, he carries out the action of going to the video-assistance learning website, as he remembered an iMotions employee telling him that is where they prefer users to go for help first. Entering the newly designed video-assisted learning site, he finds an overview of several different videos that offer the option of simple overviews of software options, but also detailed examples of how to use individual features within the software, as shown in figure 7.5.

As the design provides the option to learn through the material, he navigates the site and its menu and notices that there is a series of videos on exporting data from iMotions' software, and begins watching them. Through these videos he is able to rewind to specific sections when he wants to make sure he understood certain sections correctly, allowing him to understand the lessons at his own pace, and seeing a user perform the actions in practice. He notices that there are timestamps to the right of the videos pointing to which topics are discussed when, allowing him to skip past information about functions he feels he does not need to use at this moment, and focusing only on learning what he believes he needs. Trying out the software himself, he launches it on his computer, after which the software asks him which biosensors he would like to use. As he is currently only interested in ET, it is the only option he selects, providing him with an interface that only displays what he needs to carry out his task. In this streamlined interface, he is able to navigate to the needed sections of the software with ease and begins exporting data the way he learned from the videos. In evaluating what he has learned, he is now able to export meaningful data he needs in order to carry out research using ET.

In this next section, a scenario displaying the second persona's first-time use and learning scenario is displayed, providing insight into the use case and journey of "the independent" learner type.

The second scenario, for the independent user, Sarah Jensen, is different as she chooses to dive straight into the software in order to learn how to use it without prior knowledge. In this case, her context is the first time use of iMotions' software, and learning both what the software can do, as well as how to utilize it. She wants to use ET to study how people react to mathematical equations and the process of understanding and solving them. The main action then is navigating the software and trying to understand the different features by interacting with them. As she is interested in combining ET and GSR, she selects both options when the software is launched, making her exploration of the software focused on the hardware she intends to use. Her central action is navigating and exploring the software, and in doing so, she is exposed to the tips within the software that provide details about the feature she is trying to learn about, through a small question mark placed next to the feature that can be hovered over to learn more. In this scenario, it is ET using ET glasses that the participant has to wear, as opposed to a stationary eye tracker. Aside from detailing exactly what the possibilities of ET are and providing some context for its use, the tip also provides a link to the ET section on the video-assisted learning site. Despite having less prior knowledge of how ET is useful in general than David, she is primarily interested in videos that focus on how ET functions when using ET glasses, so that she may try it for herself. This is due to her "learning by doing" approach, as she is primarily interested in seeing if she can use the software herself. By watching a video tutorial on setting up ET glasses, by having an expert guiding her on how to install the hardware. She had problems calibrating the glasses to the software, but she saw a timestamp in the video, specifically explaining how to calibrate the glasses, which helped her overcome the obstacle. She is now capable of utilizing this biosensor for exploring didactics of mathematics, and should she forget any details, she is able to go back to the videos she watched and rewind to the areas relevant to her newly established knowledge on the area.

These two personas and their scenarios describe ideal cases in which first-time users have to learn to use iMotions and are assisted in doing so without requiring the help of a human teacher. Though there is a similarity between the two scenarios in that they both end up using video-assisted learning to understand the software, it is worth noting that their path to get there is different. While David, the "rigorous" learner, desired to read exemplary information before anything else, Sarah, the "independent" learner, was more interested in learning by doing approach in which she focused on how exactly the hardware worked so she could test it out for herself. They both learn from video-assisted learning, but both of their learning preferences are accommodated in order to achieve an ideal learning scenario.

7.5 Design Reflections

In the literature review, chapter 3, Oud (2009) argues that instructional videos should accommodate users' prerequisite knowledge levels, in order to provide an adequate learning experience. This was a sentiment that was also expressed by both CSMs and users for this research. Although we argue that the video-assisted learning solutions aim to provide sufficient scaffolding and guidance through the website design solution, for both beginners and more experienced users, arguments can be made that the design does not attempt to accommodate users who lack specific software-prerequisite knowledge. A new user who already possesses knowledge pertaining to biosensor technology would still need to view the onboarding videos in order to learn and become familiar with the software, but through this process, this user might be frustrated by being presented with biosensor-specific information which they already know. Even though we have incorporated timestamps into the proposed design, allowing for better content control as users can skip undesired content, it might prove impossible to produce a design and video content which does not present and explain some of the users' prerequisite knowledge.

This challenge of providing a perfect video-assisted learning experience for biosensor software, which accommodates each user's individual skill levels is something that might require human teacher interaction. This was indicated by the learning theories explained in chapter 4, where we explained how to approach a self-directed learning experience through scaffolding within the ZPD, but multiple authors still expressed the need for a teacher to utilize an in-depth assessment of the learner in order to provide a dynamic and beneficial learning experience (Knowles et al., 2005c; Pol et al., 2010; Grow, 1991).

8. Conclusion, Reflections, and Future Research

This chapter contains our conclusion of both the research questions and the problem statement. We will additionally present our reflections concerning methods, research approach, and finally, a discussion of how future research should be conducted and what insights it could provide.

8.1 Conclusion

In the following section, we will conclude the thesis. First, we will answer our research questions, which serve as a foundation for answering the problem statement.

RQ1: *What are the best practices of using biosensors and the best practices for facilitating non-human teaching?*

Through our literature reviews in chapters 2 and 3, this paper found best practices using biosensors and best practices for non-human facilitated multimedia teaching and how different types of user types can be accommodated in a learning design solution.

By researching the background and best practices for biosensors and their applied uses, a key takeaway was the high level of complexity of biosensors. There is a variety of biosensors based on vastly different technologies, that require specific knowledge about each one. Another finding was the applied use of biosensors, where all literature found argued for the use of biosensors in combination with each other, in order to yield strong, quality results.

In relation to the best practices of facilitating non-human teaching, the key takeaway from our literature review in chapter 3, is how the total cognitive load experienced by a learner should not exceed their learning capacity, making it important for designers to be aware of what content is being taught, and what the limitations of the learner's cognitive load are (Mutlu-Bayraktar et al., 2019). Furthermore, task complexity and presentation of only critical information are particularly important in order to design software or learning designs that are easy for the user to learn (Mutlu-Bayraktar et al., 2019).

Specifically for multimedia learning, a combination of video and audio was recommended by Rapchack (2017), such as combining audio instructions with video footage of the action the learner is instructed to perform. Most importantly, the knowledge level and preferences of the learner are crucial to understand and accommodate (Oud, 2009).

These conclusions provide a useful foundational understanding of how to support effective learning for learners of software, as well as critical knowledge of how to present and facilitate multimedia knowledge. Through these foundations, a robust multimedia learning approach can be designed.

RQ2: *How do iMotions currently aim to provide their clients with a meaningful and productive learning experience using iMotions' complex software?*

Researching iMotions' current efforts for introducing users to the software and assisting their learning provided insight into iMotions' motivations for those efforts, and details regarding what they are currently doing to ensure users learn how to use the software. A key detail for iMotions' motivation was that their aim is for new clients to be able to utilize the software on their own, which means a new digital solution should also be designed with this goal in mind. Their current method of an iMotions CSM spending three hours with a client as part of an onboarding session for first-time use may provide the information they needed, but it did not always guarantee that they were able to use the software independently as they would reach out for help after the sessions had finished.

Additionally, the iMotions' CSMs indicated that using videos of recorded onboarding sessions for learning had a positive effect on this desired independent learning process since users would be able to rewind the recorded footage unassisted if they wanted to refresh details they had forgotten or were unsure of. This provided a deeper understanding of how one might ensure new users of iMotions' software are able to learn how to use the software and provided early inspiration for how that could be achieved with a digital solution without human involvement.

Finally, due to the onboarding sessions being three hours long and containing a large variety of different information regarding complicated subjects, users often felt overwhelmed and confused by the amount of information. This showed a need for rethinking how users learn the software and what kind of support they need for a successful learning experience.

RQ3: *How do users experience iMotions' software?*

Through the interviews, it became apparent that different users have different approaches to learning, and that applying these considerations to a learning design is critical. Simply put, in order to ensure that users are able to learn how to use iMotions, their personal preferences for learning must be accommodated by a digital solution.

Adapting to the differences in the prerequisite knowledge of the users proved to be important. This means that depending on the existing level of knowledge a user has about biosensors or learning new software, they may need different levels and types of scaffolding or interface presentation to make it easier for them to learn and accomplish their tasks.

Finally, data processing in the software posed a particularly big challenge for the users, making it an important aspect for the design solution to address. This challenge regarded both understanding exactly what type of data could produce what type of insights, but also the act of navigating the many different possible options in the interface of the software.

RQ4: *Based on learning and design theories, how can the participant's insights be synthesized into meaningful solutions for improving the learning experience?*

Through theoretical perspectives regarding learning and design, participant insights were used to generate solution ideas that intend to improve the learning experience for iMotions' users. This means that the visual design of a design solution is not specified here, instead, the needs of the users and how the design solutions could be developed to fulfill those needs are in focus.

One crucial design element was rethinking the existing iMotions help-center, as both the iMotions CSMs and the users expressed that contacting iMotions staff currently worked much better for helping users when they experienced problems.

Furthermore, through analyzing user data and synthesizing them into main findings, six design principles were developed: Providing user-guidance in the software, facilitating self-directed learning, making tutorial videos available, accommodating prerequisite knowledge levels of users, communicating feature details clearly and using constraints to only display necessary information.

Through these steps, the key needs to be addressed were discovered, and beginning suggestions and conditions for design solutions were established.

RQ5: *Through design thinking theory, how can the users' ideas be conceptualized based on learning theories, in order to propose a design for this case study?*

In order to discuss general thoughts about design ideas, and in order to create an overview and a shared understanding of those ideas, several tools inspired by a design thinking approach were used. A process of sensemaking using Google Docs for writing down ideas during a brainstorm was carried out, and online post-it notes through Google Jamboard were utilized for discussing general thoughts about design ideas in order to achieve a common understanding of the ideas. As a final step, a sketching session was carried out in order to illustrate possible prototype designs for the shared design ideas, which was used as an opportunity to discuss and reach a consensus on which ideas to proceed with and what the prototype designs should consist of.

A design solution was conceptualized, based on the two main ideas generated collaboratively through design thinking and a sensemaking process. These design solutions consist of two primary designs: A video-assisted learning platform, and a new software interface for the iMotions' software.

The video-assisted learning platform provides the opportunity for users to learn about biosensors and how to use iMotions' software with concrete video examples, along with the ability to download test-study tutorials to learn in an interactive manner. The new software interface focuses on setting up constraints for the information presented through start-up options that ask the user questions about their context of use. It also presents a newly designed workflow design, in an attempt to make the necessary steps for gathering and analyzing data easier for the user to understand. Finally, the software now contains tips to act as a method of scaffolding for understanding and learning its features, which also link to the video-assisted learning platform where relevant.

Problem Statement

To conclude this thesis, we address the problem statement, shown below:

How can a digital learning experience for the use of biosensor software be designed, based on domain insights into biosensor software and the end-users' experience of biosensor software?

Through the above research questions, the individual problem areas of the problem statement were addressed and answered. Best practices for facilitating non-human teaching were established, details of how iMotions teach their clients to learn their software were investigated, and how users experience iMotions' software were researched and described. Finally, the specific needs and initial ideas for design solutions were established, leading to generation and finalization of design solutions. By answering the research questions, the most central aspects were the design principles meant to address the problems of learning and using biosensor software, and the proposed design solutions meant to address the specific case description for this thesis.

The proposed design solution is an attempt to address the problems experienced by iMotions' users, aiming to solve issues of cognitive load and lack of workflow overview, while attempting to make the users self-directed. This is attempted through a design that utilizes online video-assisted learning and a redesign of the iMotions software interface. Nonetheless, we are aware that this design solution addresses iMotions' software challenge specifically, and that the software is not necessarily representative of all biosensor software.

Through our findings, six design principles were produced, by combining knowledge from literature, theory, domain insights, and end-user insights.

1. Software guidance and assistance should be integrated within every step of the design.
2. Support options should facilitate self-directed learning.
3. Videos should be utilized for providing non-human teaching and scaffolding.
4. The design should accommodate users' prerequisite knowledge levels.
5. The design should communicate and assist the user through each of the software's processes.
6. The design should be able to set up constraints, limiting the amount of information that the user is exposed to.

These design principles represent our recommendations for a broader context of learning biosensor software. As such, they are applicable to a more generalizable context, within the domain of biosensor software. However, these design principles still need to consider the context of which they are applied, as biosensor software design and use can vary. Furthermore, this research's participants consisted of academic users, although the research population consists of both academic and commercial users, some reflections on the generalization will be presented in the following section.

8.2 Methodological Reflections

In chapter 5. Methodology, we present our research framework, methods used, and the procedure of these. A central topic to discuss is the user-centered approach we have taken. In chapter 5, we present the four steps of user-centered design, where the fourth step is the evaluation of the design. Some reflections about the weaknesses of the design are made in chapter 7, but these reflections are based on our own perception of the design and not the users' perception. As such, we want to evaluate to what extent the design can be considered fully user-centered. Despite evaluating and reflecting on the proposed design, our thoughts might not be completely in congruence with users' reflections and evaluations of the design. With the current design, we are aware that there is a lack of user input, and this might influence how the design would work in real life if it is not supported by the users. Since we can only speculate on what users' reflections and insight could hold, instead we want to focus on how their reflections could have been gathered.

An approach that would have gathered more user input to the design would be to conduct sessions with the users in a focus group format as a replacement for the interview. With the interview format, the data collection process was static, in the sense that users knew that they would be asked questions, and only needed to answer them. By having a focus group format, a more dynamic process could be created, letting users interact with each other, discussing their experiences, and sharing their thoughts. This could give new perspectives on the design, perspectives we as researchers would not think of, as the insights are created in the interaction between users (Bryman, 2016g). However, conducting a focus group would have restrictions, as the same circumstances of COVID-19 were still present. Hence, the workshop would need to be conducted online, which has its own characteristics. The strength of having an online focus group would be that it would overcome the challenge of social distancing, allowing multiple participants across countries to participate and share their experience, without physically meeting. In addition to this, the participants can use online tools that can facilitate a discussion, such as brainstorming, Google Jamboard, and similar.

Despite the strengths of an online workshop, we argue that conducting an online workshop is a difficult task. Talking in an online setting can have technical problems, and users may have a hard time having their sentiments heard in an ongoing conversation as their microphones may not function as well as another participant's microphone. In terms of the findings from the focus group, online focus groups tend to yield data of less quality, compared to face-to-face focus groups (Bryman, 2016g). As mentioned in chapter 5 the qualitative interview, maintaining motivation, and engaging the participants in an online setting is a difficult feat. Particularly if a workshop needs to cover several topics and steps, it can cause fatigue for the users due to the extensive nature of the workshop, and this may affect the findings (Bryman, 2016g). In addition to this, conducting an online workshop instead of using the qualitative interview with individual users might not have afforded the option of going in-depth with the opinion of an individual, as several different participants would need time to talk, possibly creating more but shallower insights. As such, we are aware that the design currently lacks user feedback and iterations, which could validate the effectiveness of the design. Hence, if we refer back to the double diamond model presented in chapter 5, the design and the design process is still at the development stage, with a proposed solution that we do not know the effectiveness of. This relates to a reflection of the findings.

Reliability and validity

As presented earlier in chapter 5, we introduced the terms reliability and validity, with the purpose of reflecting on them, and how we address these criteria.

In order to accommodate the criterion of internal reliability, all the interviews were recorded. This was done, as all interviews were conducted by two researchers, allowing the non-present researcher to listen to and watch the interviews and form their own interpretations. In addition to this, the interviews were listened to and coded individually by each thesis member. After the coding was finished, the codes were discussed internally, ensuring that all three research members had the same understanding of the data and the findings. This provided a common understanding of the findings and allowed for a consistent analysis and interpretation of data.

As previously mentioned in chapter 5, internal validity is often a strong point of qualitative research. In this thesis, we have been in close contact with the users and their context, trying to understand their needs, by having several lengthy interviews with both users and iMotions' CSMs. As such, the data derived from these interviews should be very much in line with what the participants meant with their answers, however, analyzing the data also requires us to interpret what the users meant.

In terms of external validity and the issue of generalization, the sampling size is relevant to address, as our user sample consists of six individual users of the iMotions' software. Of the six, two had prior experience with other biosensor software, meaning that users had generally little insights about other biosensor software, and can primarily express their insights about the iMotions' software. With a sampling of six users and three CSMs, the participants' insights are able to be gathered, but the sample size is relatively small for their insights to be generalized across all the different kinds of users of biosensor software. Furthermore, the sampling size of six users only reflects one type of user, academics, and not commercial users which is roughly 50% of iMotions' clients (Appendix 10). This affected the findings presented in chapter 6, which can only be related to the academic segment of biosensors and biosensor software. There is also an issue of generalization when it comes to a case study approach for investigating the learning experience of biosensor software for iMotions users. iMotions have one way of introducing new users to the software, causing the learning experience for the users to be unique to this company's approach. Some users have experience with other biosensor software such as Tobii and Ogama, but these software were not investigated as the scope of this paper did not look to investigate competitors. As such, the findings presented in the proposed design solution are mainly aimed towards improving the iMotions software. However, the design principles which were developed and presented in chapter 7, are based on participant insights but also learning theories and best practice of multimedia learning, and as such, could be taken into consideration for the context and the users, therefore being applicable to larger contexts.

8.3 Future Research

As previously mentioned in the conclusion, we are aware that both the proposed design and design principles would benefit from further research, and we see it necessary to address how future research benefits these.

To further investigate the design principles, we advocate that the current proposed design solution should be further developed through iterations. The original approach for this thesis would be a natural approach to usability testing of the iMotions' software and help-center. Utilizing biosensors to conduct these tests would provide content-specific insights regarding the users' experience, and as such, aim to reshape or expand on the design principles, in order to facilitate a more beneficial learning experience.

Furthermore, the established design principles are yet to be tested in a practical setting, meaning there has been no feedback collected on whether or not they have the intended effect. Similarly, as discussed in the previous section, adding iterations in the form of focus groups with users from both the commercial and academic segments to reflect and discuss the proposed design, can provide new insights into the design and overall design principles. This would allow the design solution, presented in this paper, to be tested in relevant settings, and for potential changes to be made depending on the results.

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10. Appendices

10.1 CSM 1

Uploaded audiofile - Appendix 1: CSM 1

10.2 CSM 2

Uploaded audiofile - Appendix 2: CSM 2

10.3 CSM 3

O = CSM 3, A = iMotions employee, S = Simon, L = Louis, M = Mathias

S: How are the clients generally for these sessions?

O: it varies significantly

S: what about the technical skill?

O: it varies

S: I'm also guessing, it depends a lot if you're doing the physical ones, it's easier to point directly where it is

O: it depends because you have a lot of people that are were technically skilled or that have a lot of skills with computers in general, but maybe don't know the like theoretical side of sensors or why they are using them. Or it can be the flip opposite, where it's a professor whos been doing this for ages, but haven't touched a computer at all in their life. So it's a mix.

S: what about like, physical, how often is physical?

O: more often digital. 80% of the time.

A: it's usually if the client has a physical project. Like LEGO, where they do stuff on the screen. They would want to report kids playing with lego or packaging studies seeing people opening their stuff. Or IKEA would want "can people assemble the furniture". So that … to see how those work, and I would be physical. But most stuff is digital.

L: So it sorta sounds like sometimes you function more as a like, not just onboarding, but you consult and that you actually help them work with the software instead of like learning it, teaching it.

O: Yea, that's the aim. So we should be. It less about "press this button to this" or "press that button to that". It's more like consulting about what the project is and then when we have that sort of information we make the training aim towards that. So I wouldn't go through like every single functionality. It be more what's important for you, lets set up this in a way because that makes sense for this reason. And then it like an ongoing conversation that we have with them. It's not like they are trained, it's more longer than that.

S: and it's for 3 hours or?

O: that's sorta like, the standardized structure as we have. an hour and a half for the first onboarding. going through interface, designing the study within it, getting all the sensors hatched, upon until they would collect data. Then usually a few days later or the next week. you have, they'd have some time to go and collect the data or a least pilot studies for the data. And then we do the second half, which is the analysis and we're going to process the data and that sorta stuff. So that usually is another hour and a half. and then there's usually a q&a session after they, scheduled it a couple of weeks later, just to check-in. And then it's just, every person has different needs. It can vary from I don't hear from people for 3 months to I hear from them like 3 times a day.

L: now this is my first looking at the software and I just know a lot of theoretical stuff behind the hardware and this stuff, how you work with it, but seeing the software now, makes me think it does so much, there's so much in this, I can imaging working with it just having that 1.5 hours with you and then having the pilot studies myself with this software, but still take time to play with is.

O: But this is why we try to get them to the point where they basically have to set up the respondents and press record. We always encourage people to have a fiddle with things, but yeah, a lot of people have various projects they wanna do all at once. "Let's pick this one, that's kinda straightforward", and then we just go through.

S: is sorta sounds like you don't really have normal schedules for the test, it's very personalized for each client because there are so many different aspects.

O: so many different variables, everyone has different hardware, moduled combinations, someones to do UX with is, some want to just have people sit watching videos, and someone wants to run around in the supermarket. It's not really a hard and fast solution to this.

A: but some is the same. the way you have to add a study and add stimuli and respondents.

O: there's always the core parts, so we shift the focus after that.

A: so what percentages do you think, you saying exactly the same thing vs. different for different people?

O: I don't know, usually only they have like glasses usually people start with something screen-based, which makes it easier to run with. 65/70% of the time. Again it depends, you get like psychology students and stuff or professors, so they already know what the want to do when they come to the table and it's like trying to figure out how and if the software can actually do it, in the smartest way.

M: so it seems like there is like a core thing that everyone has to go through, but like the steps needed to be taking to like teach them how it works, is that very different depending on the person or their background?

O: to an extent, I mean there are some similarities like their need to collect everything. they need to add in the study, the stimuli. And I mean when I do the training as well even if they don't know exactly what they are doing, like for instance when we went through the stimuli one by one and said what they are.

Like I would do that throughout like with however when the sensors are added into the study. explaining this is that and the point of this is that we can synchronize everything bla bla bla, but you can click this one for this reason. So a lot of that mainly from a business point of view to highlight this is the main function, this is what we are here for and look how flexible we and you can do tons of different things.

--- break in transcription (discussing the booking of the meeting room) ---

O: So there are something I would go through every single time, and that's just a personal preference.

S: do you experience that people would write back about basic stuff, like how do i add the stimuli, how do analyze this?

O: no, not that often. a lot of stuff with analysis and that's mainly if I don't know. The main thing I sorta hear back is if people have forgotten things or if there something technical like the screen resolution. a lot of the questions I get mainly are just like, "this doesn't look right" or "this has gone slightly wrong", and 9 times out of 10 its generally fine, 1 time out of 10 it gets sent through to support.

S: so a very specific thing for them.

O: yeah, there's no like. if you have something that the majority of people are being like "shit how do I do this" or "this has gone wrong", then either that's a major bug or me being shit at my job. I like to say that that doesn't happen too often.

A: what are the things that people forget the most?

O: I don't really know. its a lot of different. sometimes people have trouble with…I don't know. It's a different thing every time. and you get it from different people doing different things. That's not really a very helpful answer. So sometimes, for instance, people don't understand why they cant aggregate on like a website recording and you just remind them to split it up. or they forgot where the gaze mapping is or you show them something specific that doesn't have a very obvious, like with annotations there's an options to copy it to all your respondents but you have to right-click on the specific annotation to find that hidden menu, but just stuff that like slightly more hidden. you show people and they're like "yeah, cool" and then you continue on and they don't remember. Its quite often I record the training sessions and sent I to them. So I get less feedback now, so they already know that if they forget something the can just go to this recording and its there.

L: it makes sense. This session was also compressed right. but there was still a lot of information to go through, I mean it would be helpful for me to go back and say "ahh".

O: the meeting platform we use has the record function to 9 times out of 10 I use that. it actually has a very nice, which I found out recently, a 'control the mouse function' as well. Which I've started to use for this exact reason where I'm like, "its there, its there, its there, no its there".

S: I was just wondering why it called GSR? It's just when I read literature about it its mostly EDA, but older articles say GSR.

O: I think its a US European thing.

A: GSR is an older term, so it used to be called that. and I think with many things US, the rest of the world learn something better and adapts and the US is like "NO, who needs the metric system, we're good with our inches and feet, forever". About half of our clients are in the US. But we started using the term EDA as well. But its also you don't wanna change terms on people cause they are like "what happened, GSR just disappeared".

10.4 Professor 1

Uploaded audiofile - Appendix 4: Professor 1

10.5 Professor 2

Uploaded audiofile - Appendix 5: Professor 3

10.6 Professor 3

Uploaded audiofile - Appendix 6: Professor 4

10.7 Student 1 and 2

Uploaded audiofile - Appendix 7: Student 1 and 2

10.8 Student 3

Uploaded audiofile - Appendix 8: Student 3

10.9 Student 4

Uploaded audiofile - Appendix 9: Student 4

10.10 iMotions' Mail Correspondence

Mail correspondence with iMotions employee, UX Designer at iMotions

1. How do you teach users how to use iMotions?
- At the moment, each potential new customer is given a demo, which is around an hour where a salesperson and PS (product support) person walk the customer through what iMotions can do, tailored to what research the salesperson has already learned that the customer wants to do. If they end up buying our solution, once they have received their hardware and installed iMotions, then the onboarding sessions are arranged. Onboarding is where their assigned CSM (customer success manager) assists the customer setting up his first study (or just an example study) and after the customer collects data, a second onboarding to help them do the analysis. We also have the option of customers attending the

iMotions Academy, where they spend a week getting more in-depth training to how all the sensors work and also how to do a study in iMotions. Other than those more 'formalized' things, everything else is handled by customers asking their CSM questions as they come up, or support when they have a problem. Also, we do have a Help Center with many articles explaining how to do different things, such as how to connect a specific sensor, like the Tobii Nano, or how to create an aggregate heat map from a group of respondents.

2. Is that approach scalable?
- Nope! From my own past experience (and probably business 101?), anything that has to be done by a human being is not scalable, or at least not cost sustainable in the long run. It's something that as we grow, unless we want to spend more money on more CSMs or overwork the ones we have, we won't be able to help customers at the same quick and high level of individual attention as we do now. The more you can automate, the more scalable your solution can be.

3. As a UX designer who has worked with iMotions for some time, where do you think the iMotions software challenges for learning lie? How do you come to that conclusion?
- So, I've been at iMotions since June 2019. I am the first UX designer they have ever had. And, if you look at the software, it reflects that. iMotions is incredibly powerful, the shear amount of data that is able to be collected, synced, and analyzed is actually quite amazing. You can set up such a vast array of different types of studies, and can support massively different and unique research needs. But, everything was 'designed' by developers. And most of the best and important features are basically hidden. I feel like you could almost make a game of which-elements-have-hidden-right-click-menus? And if things are hidden, or in flows that are not at all intuitive, it means that they are not easy to discover, learn, or recall. And there are no clues or nudges in the software to help guide users along with their desired tasks. So most of my focus has been on trying to use visual cues (such as changing all the buttons to be *one* style to make it clear when it's clickable or disabled, or simplifying all the 100 shades of grey, or just trying to declutter all the elements showing at the same time) and focus on making the core flows simpler with more explanations of what is happening or what the user needs to do.

4. On what basis you do make changes to the UX of iMotions? Is it your experience, the clients? How have you gathered that data?
- It's a mix. There are some things that I knew from the moment I saw iMotions, needed to be fixed as they were quite basic UX no-no's. Or flows that as my colleagues explained how they worked, left *me* confused (because if it confuses me, I *know* it will confuse real users). But, we have the luxury of being quite close to our customers. That's the benefit of being small: our sales, CSM, PS, and support people spend time daily talking to users about their individual problems and needs. So, we definitely hear when things don't work. And things that we get the most complaints about, or things that our CSMs have to explain (over and over and over) are usually what becomes higher priority. Our PM (product manager) team is constantly gathering feedback and trying to prioritize between user problems & needs, development resources, and business goals. And with feedback from the dev team, is how the PMs choose which projects are done.

5. What are the most used biosensors used by clients? Do you have any data on which combinations of biosensors your clients use?
- In order of highest use: Eye tracking, Facial Expression Analysis, GSR, EEG. We also support other sensors (PPG, ECG, EMG, and more I can't remember right now) but I think their use is quite small. I don't personally have the data (it's so annoying working from home...), and I would probably ask Kiara or

Oscar....so perhaps to save time it would be easier if you ask them directly, instead of waiting for me to ask them and then pass it along? (But I can ask, if you would prefer)

10.11 Literature review: Applied Biosensor Research

Literature search: Eye tracking

Block 1	Block 2	Block 3
Eye-tracking OR "eye tracking" OR eyetracking	"Product evaluation" "User experience" "Usability testing" Re-designing Usability Onboarding	"User-centered design" "Behavioral theory"

Search string:

(Eye-tracking OR "eye tracking" OR eyetracking) AND ("Product evaluation" OR "User experience" OR "Usability testing" OR Re-designing OR Usability OR Onboarding) AND ("User-centered design" OR "Behavioral theory")

Results:

Ebscohost: 30 results. 2 results are worth further investigation. 3 were not accessible.

Scholar: 3140 results. 17 results are worth further investigation.

In total, 19 relevant articles were accessible. These articles were read through and of these, 8 were deemed relevant for this literature review.

Literature search: Electrodermal Activity

Block 1	Block 2
"Electrodermal activity" OR EDA" OR GSR OR "Galvanic skin response" OR "Skin conductance" OR SC	Usability Test* "User experience" OR UX Uses Pros & cons "Product evaluation"

Search string:

“Electrodermal activity” OR EDA” OR GSR OR “Galvanic skin response” OR “Skin conductance” OR SC AND Usability test* OR “User experience” OR UX OR advantages OR disadvantages OR Pros & cons OR “Product evaluation”

Search results:

Scopus: 1330 results, Mostly electrodermal activity surface, maybe try without it. 8 results worth further investigation. 3 were not accessible.

Ebscohost: 70 results. 9 results are worth further investigation. 2 was not accessible.

Scholar: 18100 results. Mostly about usability and not biosensor. None found relevant.

In total, 11 relevant articles were accessible. These articles were read through and of these 6 were deemed relevant for this literature review.

Literature search: Facial Expression Analysis

Block 1	Block 2	Block 3
“Facial Expression Analysis” OR “FEA”	“Development*” OR “Usability” OR “Evaluation*” OR “UX” OR “User experience*”	“Learning theory” OR “Behavioral theory” OR “User-centered design” OR “Learning*”

Search String

(“Facial Expression Analysis” OR “FEA”) AND (“Development*” OR “Usability” OR “Evaluation*” OR “UX” OR “User experience*”) AND (“Learning theory” OR “Behavioral theory” OR “User-centered design” OR “Learning*”)

Results

Ebscohost: 97

All abstracts were read and 3 articles were determined to be relevant.

Scopus: 104

All abstracts were read and 4 articles were determined to be relevant.

From reading the 7 articles, 6 of them were found to be relevant for this research.

3 additional relevant sources were discovered through the references from the initial 6 articles.

10.12 Literature review: Facilitating Learning

For this literature search, a search string was created through block search. When searching for literature, the first 50 results were reviewed through title and abstract. Articles that were found relevant were subdued to be read in order to be deemed relevant or not. The search engines used were Ebschohost, Scopus, and Google Scholar.

Search 1

Block 1	Block 2	Block 3
Learning* teaching* evaluate* Education*	Biosensors Biometric sensor Software Advanced software	

Search String:

Learning* OR teaching* OR evaluate* OR educate OR educating AND biosensor* OR software OR "advanced software" OR technology

Ebscohost: 342,948 results

5 articles found through reading the first 50 titles. Only 1 accessible...

Scopus: 24001 English results,

4 articles found through reading the first 50 titles, 2 accessible

Scholar: 26600 results

3 relevant results, based on reading the first 50 titles, only 1 available

Search 2:

Block 1	Block 2	Block 3
Learning* teaching* evaluate* Educating*	Biosensors Biometric sensor Software Advanced software Technology Multimedia	Cognitive Cognitive research Cognitive load

Search string:

Learning* OR teaching* OR evaluate* OR educate OR educating AND biosensor* OR software OR "advanced software" OR technology OR multimedia AND Cognitive OR "Cognitive research" OR cognitive load

Scopus: 1269 results
5 relevant results, 4 accessible

Ebscohost: 36239 results
5 relevant results, 3 accessible

Scholar: 6210 results
0 relevant

Total, 7 results available. These articles were read through and of these 3 of these were deemed relevant for this literature review. In addition to these articles, two articles were found, through using sources in the literature found.

10.13 Field Notes

Onboarding session with CSM 3 at iMotions.
He will be onboarding a participant, who has no experience with iMotions.
Biases: The participant is a student of information studies, and also quite young (or something), but it can be that he is more adept using technology than other clients would be. Additionally, three people are observing the session, an iMotions employee, an iMotions UX designer, and Interviewer and Observer who will be taking notes during the session.

Notes

They drop directly into an already done experiment in order to show the different symbols and how it works. After a few minutes, they go into "how to create a study". First, they show the different tabs of the "Create a new study". Going through the options from how the stimuli are exposed to the subject. It's all going pretty fast. They are moving on to "Sensors", explaining which sensors they are going to use and what happens if they are not connected. Moving on to adding stimuli, going through all 7 ways of stimuli, and how they can be used. The participant is asking questions throughout the session. CSM 3 allows The participant to create his own study, for something that might be relevant for him. The participant discovered a bit late, that when adding stimuli, it's in a new tab. When The participant is asked to add a new questions in the stimuli, it's not apparent for The participant immediately. Moving onto adding participants, going through potential demographics and which sensors should be used for the participants. Quite a lot of data options for the sensors. Moving on to the conducting the study, how the different sensors are presented, when connected, going through how FEA works. Going through GSR, giving several examples of how to test if it is working. Encountered a problem when starting recording the session. Moving on to Adding analysis. Going through how to add analysing the different results from the different sensors, GSR, FEA and ET. Goes through what is most commonly used and not all of the different ways to analyse the data. Explaining how to analyse the data, compared to static pages and dynamic pages, in order to be able to analyse the results across participants. Going through AOI's (areas of interest) giving more accurate data about the eye tracking. Now moving to how to create annotations. The participant is a little confused about what exactly he did due to how fast it went. Now moving on to exporting the data, what you would normally import, and what they would include. Also includes how to interpret the data in excel/notepad for both ET, and GSR.

The session

CSM 3 shows The participant how to use iMotions.
Starts by saying what it is and how to use the very basics.
Provides detailed descriptions of the different features (left side, center, right side).
Has The participant carry out actions to demonstrate how it works (meaning it's interactive).
He has The participant create an experiment and walks him through it.
The participant has a question, asks it and gets an answer. There's some room for back and forth, but it required The participant to ask a question.
CSM 3 talks about some different scenarios and how it would work in those different scenarios – it's a lot of information, unsurprisingly, as there are many scenarios under which it can be used.
More rundowns of different features and different cases in which they could be used.
The participant goes through a test for UX testing of the iMotions site. He creates an experiment / session for it.
The participant interacts quite a bit with the software, and talks to CSM 3 while doing so. Questions and reconfirming what CSM 3 said.
They continue as The participant learns more and seems receptive: "I think I got this".
Again, there is room for The participant to inquire a bit and for CSM 3 to answer.
Walks The participant through some stimulus options.
They begin to involve some equipment, GSR. They walk through how to find it in the software when it is connected to the PC. Eye tracking and the shimmer as well.
CSM 3 then walks The participant through how it looks when iMotions is receiving data, and what it is, how to use it etc.
He introduces The participant to some different ways data can be affected by things occurring.
An error occurs – not sure what it is, but they need to do calibration first.
The participant goes through the iMotions website, looks around on it and explores some stuff.
They walk through some things – CSM 3 points out that something should be ignored, something a digital strategy probably couldn't recognize in the moment.
They move on to analysis, looking at the recorded eye movements for the eye tracking website. They talk about gaze mapping and different applications of it.
The participant is walked through how to retrieve gaze map data and such.
More interaction with the data and CSM 3 explaining to The participant what options he has and The participant trying some of them.
As The participant interacts with it, CSM 3 walks him through it and gives tips as well for possible options.
They try to use excel but they have no license. iMotions can export data in excel format for stimuli and everything.
Walks through AOI exporting, general data exporting. So generally the data exporting.

Side note: There is some level of prepared knowledge usually thanks to the participants having had meetings before the session (they've seen someone click through it, they know which things to purchase in terms of sensors etc.).
Side note: The participant has some knowledge about eye tracking, GSR etc. It would be interesting to see how a less technically aware person might receive some of the information about how it can used in iMotions.
Side note: Whatever we make digitally still will not have the power of being able to just ask someone for help.
Side note: iMotions employee being in the room had some effect. On 4 – 5 occasions, as CSM 3 was explaining things, he turned around and looked at her when talking about features that were soon going to change.

10.14 Interview Guide

Interview guide - iMotions CSM 1 and 2

Length: Approximately 40-60 minutes.

Briefly explain the aim of the interview and to consider this as a dialog rather than a rigorous interview (encourage dialog rather than short answers).

"With this interview, we are hoping to gather insights into the process of iMotions' onboarding sessions, in order to understand how users experience advanced biosensor software."

Consent form

Before the interview provide a consent form for audio and video recording and for permission to keep the data until this research is completed, approximately August 2020, and in correspondence with GDPR.

Background information.

Invite the participant to briefly tell about their position at iMotions and their work responsibilities.

Questions	Corresponding research aim
1. How would you describe the general demographic of the onboarding clients?	The aim is to get as much information about the CSM employees' insights into the demographic of their clients, age, employment, technical skills (both computer knowledge and in regards to biosensors).
2. What is the general aim of the onboarding sessions?	In order to provide new concepts for a digital onboarding experience, a broader context and aim of the current consultant-supported onboarding needs to be specified.

3. Can you describe a typical onboarding session with the different phases and particular challenging processes? What do you expect of the clients' preparation before the session? We understand that the typical onboarding structure requires two sessions, each of an hour and a half, with varied time in between the sessions, and usually followed by some form of a Q&A session. How does this correspond with your process? (Flexibility and/or additional sessions). What are particularly challenging processes?	Understanding the practical process of onboarding new clients is important in order to assess the full scale of the users' onboarding experience if this is to be translated into a purely digital solution.
4. What is the normal ratio of digital versus physical sessions? And how do those sessions differ and are you making use of any particular tools for the digital sessions? (Oscar's use of "mouse guidance" and recorded sessions).	The question aims to investigate an estimate of digital vs. physical onboarding, and furthermore, which tools have the consultants noticed is essential or beneficial when providing a digital onboarding. Gaining insights into already used tools/concepts for providing a better learning experience.
5. We know that there are some core concepts that you need to go through (add study, add stimuli, add respondents, and general analysis), but how customized do you make these sessions?	What does iMotions do in order to accommodate their clients, in terms of customized sessions, maybe towards a specific project? This could indicate how detailed a purely digital and non-human onboarding experience needs to be designed.
6. Which parts of the iMotions software seem to be the most difficult for the clients to get a grasp of? What parts will clients call/write back to you with questions concerning? Why do you think this is?	Aims to investigate the CSM's context-specific knowledge regarding already know problem areas relating to knowledge retention or parts of the software that require more in-depth explanation/assistance.
7. Are there any user types in particular that tend to face particular problems, what are their demographics and background? Why do you think it's particularly difficult for this group?	Getting an understanding of how the iMotions employees perceive the users and their problems, which gives insights into aspects of the problem that we as researchers cannot get without long term experience.
8. What are your thoughts on the learnability of iMotions? Which aspects do you see as intuitive and easier to learn, and which ones are less intuitive? Why?	This question aims to investigate the CSM's knowledge, but this time in regards to how they perceive where clients direct their feedback in terms of features and functions which work and which do not, in the process of learning the software.
9. What do you think could help make this onboarding process better for the end-users? Any ideas that have occurred throughout your experience?	This question is less about getting ideas for our own solution and more about understanding the iMotions perspective, and how they perceive potential problems with the onboarding process.

Interview guide - iMotions' Clients

Length: Approximately 40-60 minutes.

Briefly explain the aim of the interview and to consider this as a dialog rather than a rigorous interview (encourage dialog rather than short answers).

“With this interview, we are hoping to learn about the user experience and the user context of using iMotions.”

Consent form

Before the interview provide a consent form for audio and video recording and for permission to keep the data until this research is completed, approximately August 2020, and in correspondence with GDPR.

Background information.

Ask participants who they are, demographic info, what they do (academic + work).

Set the context for iMotions’ interface: https://www.youtube.com/watch?v=tUcSerW5sC0

Questions	Corresponding research aim
1. How did you learn to use the software? Did you get any help, tutorial, onboarding? (iMotions onboarding steps)	Aims to provide insight into understanding what kind of a user they are. It's essential to asses the participant in relation to their preexisting knowledge.'
2. When you used iMotions for the first time on your own, what was it for?	To get an understanding of what their first-time use context was to understand the potential situations of use and what the background of the interviewee is.
3. What was the first time use process like, was it difficult, any major problems or struggles?	Understand what problems (if any) they faced when trying to use iMotions for the first time. Aims to find out what the first experience was, and furthermore, in correlation to the previous question to investigate the effect of Q2.
4. How many times have you used iMotions? Did it get easier as you used it, or did you need to contact iMotions?	Aims to understand if there was a learning curve for the user, as they tried the software, or if they met steep challenges that could only be solved by expert knowledge.
5. What are the biggest challenges or problems you’ve had with using iMotions?	Looking at their all-time history with iMotions and seeing if there are any major problems that have persisted or seem unintuitive, to gain insights into their experiences and learn about them as users.
6. Is there anything in particular you like or dislike about the software, in a general sense?	Trying to see both positives and negatives based on their experience, to learn more about them as users. Highlight specific aspects and why these were positive or negative.
7. Reflecting on this, is there anything you would want from iMotions in terms of either teaching you the software or helping you when you face problems?	Exploring if they have any current ideas on how to improve the user experience of iMotions, to see how they think about their problems and how they believe

What could have made it easier for you to master the system?	they can be alleviated.
8. Have you used any other software similar to iMotions, and is there anything you liked better in comparison? What about advanced software in general?	Seeing if they have past experiences that could inform potential solutions to problems, and learning about their experience with similar software to understand how they may want to be assisted.
9. Have you previously tried to learn new software, purely based on digital guidance (articles, video, etc)?	Investigate the participant's former learning experiences through non-human teachings, to provide indicators as to what worked. Aiming at providing new insights into the target audience's preference for learning.
10. Any concluding comments, anything on your mind?	Wrapping up the interview and making sure nothing is left on the participant's mind before concluding.