2/9/2018

Graduation Project

What is the effect of dominance on the human smiling behaviour in a human-agent dyad?

Jasmijn Kol
SUPERVISOR: KHIET TRUONG

Table of Contents

Acknowledgements

I would like to express my appreciation for all of those who provided me with the possibility to complete this report, and everyone who gave support and advice along the way.

I especially would like to acknowledge my direct supervisor, assistant professor Khiet Truong, who really helped me in the process of finding the right research material, who gave me important suggestions to research, and at times gave much needed feedback, so that I could finalize this thesis to the best of my abilities.

Furthermore, I would like to thank Dave Letink, and the company Letink Design, where I worked on my research for half a year. Dave provided me with all the equipment, software, and design support that I needed.

I would also like to thank Mariët Theune and Dirk Heylen, for being in my examination committee, so that I can graduate. Mariët Theune also gave me valuable feedback that improved my thesis considerably.

Lastly, I would like to thank my parents, sister and friends, who have continuously supported me through the entirety of my student career. Thank you for proofreading my thesis, giving me feedback on my presentation, and keeping me motivated to work hard.

List of Figures

Abstract

This document contains a thorough description of the research about the effects of dominance and submissiveness on the human smiling behaviour within a human-agent dyad. Studying previous research revealed that it was important to incorporate the dominance trait into virtual agents, since it could benefit specific training and simulation programs in which dominant agents need to be used, e.g. job interview simulations. Research questions were established to find correlations between smiles and a dominant and submissive personality. Based on previous studies conducted by other researchers, it was hypothesized that interactions with a dominant agent should increase the frequency of the smiles of the participant. Moreover, it was hypothesized that interactions with a submissive agent should increase the amount of Duchenne smiles displayed by the participant. Through the analysis video recordings of the experiment sessions, facial electromyography data from the participants and post-hoc questionnaire data, it was found that these hypotheses could not be accepted. Though the participants experienced the two different agents as dominant and submissive respectively, the participant didn't express themselves as hypothesized. There was no significant difference between the two participant groups and their smiling frequency. There was also no significant difference found between the number of Duchenne smiles displayed by the two groups. We can therefore conclude, that there is no significant effect of dominance on the number of smiles or the type of smile that is displayed.

1. Introduction

Virtual agents are becoming increasingly important in the development of training- and simulation tools, e.g. for job interviews. For these types of simulations to be developed, it is important to examine how people interact and behave with a virtual person.

Virtual agents and virtual reality have been used in many different fields of research. The focus of these studies has generally been on the development of virtual agents and how they can be implemented to research societal issues. Studies have found, for example, that virtual agents should display appropriate behaviours corresponding to their virtual appearance. That is, a highly anthropomorphic appearance should be paired with highly anthropomorphic behaviour (Bailenson et al., 2005; Cassell & Tartaro, 2007). Depending on the function of the virtual character, it is important that it has realistic human qualities in both appearance and behaviour, e.g. in interrogations and job interviews.

According to the research of Cassell and Tartaro (2007), the development of virtual agents is too focused on the “physical” appearance of the agent. They suggest that focusing on the dyad instead - the human-agent interactive partners - is more beneficial to this development. They argue that the importance of virtual agents lies in their ability to communicate with humans. The focus of the research should therefore not solely revolve around creating believable agents, but rather around how people behave when they interact with these agents (Cassell & Tartaro, 2007).

Believability in virtual interactions is mainly established by giving virtual agents great computational functionality. It is however, also important to make the appearance and the behaviour of the agent human-like, because the highly anthropomorphic appearance motivates people to socially interact with virtual entities (Baylor, 2009, 2011). This means that the agents should be able to display some type of emotional behaviour, personality and social capabilities, so that the participant will feel like they are able to interact with this non-human entity. The studies described above concern themselves with trying to create a believable agent. However, as Cassell and Tartaro state, it is more relevant to research the behaviour of people when paired with a believable virtual agent, since this will benefit the development of virtual agents (VA) technology and the research about this topic has been lacking. Therefore, it is relevant to explore human behaviour by studying the human-agent interaction dyad.

One particular aspect of behaviour is dominance and its display, which is the focal point of this research. Studies suggest that “social factors including affiliation, authority and conformity (all qualities of dominance, or lack thereof), should be incorporated in the design of virtual agents, as they can have effective and persuasive power in human-agent interaction” (Katagiri, Takahashi, & Takeuchi, 2001). In other words, depending on the function of the agent it is important to implement the trait of dominance in human-agent interactions. To see how the implementation of this character trait into a virtual agent influences the human in the dyad in the same way as another human would, this research will focus on studying the human behaviour in reaction to the dominance display of a virtual agent.

When studying dominance, there are many attributes one can focus on: gaze, posture, head movements etc. to gain information about the level of dominance attributed to a person or agent (Ellyson & Dovidio, 1985). However, studies have stated that smiles, as one of the only facial expressions, have the ability to provide information about the social status power of the sender of the smile (Goldenthal, Johnston, & Kraut, 1981; Ketelaar et al., 2012), and thus, how people behave when interacting with dominant people or agents.

Researchers have concluded that less dominant individuals smile more often than their more dominant counterparts (Ketelaar et al., 2012). Moreover, people who have a (visibly) higher status are more likely to show dominant traits than their dyad partner (Mazur & Cataldo, 1989). In other words, when a visibly dominant individual enters an interaction dyad with another person, this person will act less dominantly compared to the visibly dominant person in the dyad. These studies combined, suggest that when an individual is paired with a visibly dominant person, the less-dominant individual will smile more frequently because their behaviour will become more affiliative.

Furthermore, it was found that for high- and equal-power participants, smiling correlated with positive affect, whereas for low-power participants, it did not (Hecht & LaFrance, 1998). The researchers interpret this finding as a sign that high-power people have a license to smile when they are so inclined, while low-power people have an obligation to smile regardless of positive feelings (Hecht & LaFrance, 1998). This suggests that high-power individuals are more likely to perform Duchenne (genuine) smiles, and that low-power individuals are more likely to display non-Duchenne smiles.

These studies indicate that dominance is a relevant behavioural pattern to implement in virtual characters, because it can have a significant effect on how the user decides to interact with the agent. Furthermore, these studies provide evidence that smiles are a good indication of the dominance level of a person or of the dominance level of the person they interact with. Therefore, this research focusses on the effects of dominance on the smiling pattern of people.

1.1. Research questions

For this research, it was decided to create a scenario in which a virtual agent with a certain dominance level interacts with a human participant. Through the interaction that occurs in the human-agent dyad, we will be able to answer the following main question: What is the effect of dominance on the human's smiling behaviour in a human-agent dyad?

This main question will be answered through the investigation and answering of the following subquestions:

- Do people smile more when interacting with a dominant virtual character?
- Do people smile more in a non-Duchenne way when interacting with a dominant virtual character?

By answering these questions, we will gain insight into the correlation between smiles and dominance, and we will be able to see if human-agent interactions are similar to human-human interactions.

1.2. Thesis overview

In Chapter 1, the Introduction, the main reasons and goals for this research have been discussed. Furthermore, the research questions that were answered through the experiment summarized in this thesis are established.

In Chapter 2, the theoretical framework, by which we mean the previously conducted studies most relevant to this experiment, is discussed. This chapter also includes the established hypotheses that are tested through the experiment described in this thesis.

In chapter 3, the methods needed to answer the research questions and test the hypotheses are discuss. This includes the creating of virtual characters, the research design, the used measurement and analyzation tools, the experiment set-up, and an overview of the subject demographic.

In chapter 4, an overview of the found results are given, and the hypotheses are either accepted or rejected, based on thorough analyzation of the data.

In chapter 5, we will discuss the limitations of the research, and potential future research.

In chapter 6, a summary of the thesis, as well as the most important results are provided.

2. Literature

To answer the proposed research questions, it is important to discuss the literature that has been written previously. This section of the document gives a thorough description of the research about virtual agents, dominance and smiles and virtual reality in general. By analyzing these papers, it is possible to create hypotheses for the proposed research questions.

2.1. Virtual Agents

Virtual agents are software interfaces that allow for natural, often human-like, communication with machines. Research suggests that, from the perspective of the user, interaction with a virtual character is similar to an interaction between humans. This is explained through the idea that, due to a human's social nature, they will use their usual interaction routines when faced with a virtual person that exhibits some human characteristics (Kramer, Von der Putten, & Eimler, 2012). This is beneficial for simulations and training practices that involve social situations and interactions e.g. product recommendation agents (Qiu & BenBasat, 2009), collaborative virtual environments (Swinth & Blascovich, 2001) and virtual health agents (Gratch et al., 2013).

According to Moon and Nass (2000), there is clear evidence that individuals mindlessly apply social rules and expectations to computers. People tend to over-use human social categories such as gender and ethnicity, by applying them to computers. For example, scientists evaluated the effect of a female and male voice-over on a computer, that was both aggressive and dominant. Results show that the female-voiced computer was perceived as less friendly compared to a male-voiced machine. This corresponds to the idea that dominant males are received positively while dominant females are perceived as pushy or bossy. Furthermore, participants found that the voice-over functioning as a tutor for the user, was significantly more competent (and friendlier) when the voice was male, compared to a female-voiced computer. This shows that gender stereotypes are easily applied to non-human objects or entities. People also engage in over-learned social behaviours, that is, deeply ingrained habits, such as politeness and reciprocity towards machines.

Moreover, people exhibit premature cognitive commitments. This means that people are likely to jump to certain conclusions about other people or situations, without having enough knowledge to make an informed decision. When people make a premature cognitive commitment, they are likely to close their minds to any changes in the perspectives they committed to. For example, when a person is confronted with what is labeled as a "specialist", they are inclined to believe what the specialist says based on the common definition of a specialist (Moon and Nass, 2000).

Furthermore, several studies show that a human-like appearance of a virtual agent, will lead to a distinct increase in the amount of utterances from the user. Moreover, a virtual person is perceived as a social entity, and, because of this, people are more likely to communicate with a virtual agent in a human-like manner. It is even the case that when confronted with a virtual entity, people give nonverbal reactions that are related to specific behavioural cues of the agent (Kaiser, Wehrle, & Schmidt, 1998) e.g. mimicry. This means that the availability of social cues does not only lead to an increase in communication attempts from the user, but also amplifies behaviour that is comparable to human-human interaction.

Some studies have focused on proximity between human-human and human-agent interactive partners. In a study conducted by Bailenson et al. they focused on the phenomenon that people unconsciously keep a specific distance from each other in a human-human dyad. In their research, participants were asked to walk around a virtual agent so that they could memorize the name that was displayed on the front of its T-shirt. People stood closer to a non-human figure compared to a human-like agent, especially when this agent showed realistic human behaviour (Bailenson, Blascovich, Beall & Loomis, 2001). This study underlines the idea that humans show communicative behaviour that resembles behaviour from human-human interaction the more human a virtual agent appears to be. Bailenson et al. concluded that, "participants in our study clearly did not treat our human-like agents as a mere animation" (2001).

The studies mentioned above have focused on establishing short interactions between humans and agents. Other studies have focused on the establishment of relationships between humans and agents. Bickmore and Picard (2005) studied participants' reactions to a fit-track system that features an agent as a health advisor and fitness instructor. Participants used this system for 4 weeks, and it was found that the establishment of a bond was dependent on the behaviour of the system: if the agent showed social capabilities, the agent was liked better and the participants were more inclined to act in a sentimental and emotional manner towards the agent (Bickmore, Gruber & Picard, 2005).

All of these studies confirm that people react similarly to agents as they would to humans, if the virtual agent exhibits social behaviour and some sort of human characteristics. Users are then inclined to interact with the agent as if they were human. This is important because it increases the user's engagement, motivation, self-efficacy and more (Baylor, 2011). This also implies that programs that involve human-agent interaction are realistic and can be used for training and simulation purposes as stated before.

A virtual character should thus display some human-like social skills and human-like characteristics for a person to interact with them as if they were human. This means that an agent needs to be believable. Believability places a variety of demands on an interactive agent, since their behaviour should resemble that of a human. This includes the ability to react, set goals, display emotions, recall memories, have personality etc. (Bates, 1994; Thalmann, 2001). A very important factor that enhances the believability of the agent is the display of emotions. Emotions must affect everything about the entity: the way it moves, the way it talks and the expression on its face (Thomas & Johnston, 1995). Furthermore, an agent is more believable if it can behave in a way that is typical for the culture it is supposed to represent and when it has a personal style in terms of communication (De Carolis, Pelachaud, Poggi, & Steedman, 2004). Another way to increase the believability of a virtual agent is the inclusion of nonverbal communication elements, since 65 percent of the substance of a face-to-face interaction is presented through nonverbal elements (Argyle, 2013). This can be done by the manipulation of the posture of the virtual agent and its facial expressions, because these give nonverbal indications of what a person is feeling.

However, virtual agents do not need to have high anthropomorphism in appearance to come across as believable. On the contrary, people establishing a connection with a less-anthropomorphic avatar reported more co-presence and social presence than the people interacting with a highly anthropomorphic character. This is due to the expectations of the user; the more anthropomorphic in appearance, the higher the expectation of the user in regard to the social and behavioural abilities of the agent (Nowak & Biocca, 2003). Therefore, virtual agents should display appropriate behaviours corresponding to their virtual appearance. That is, a highly anthropomorphic appearance should be paired with a highly anthropomorphic behaviour (Bailenson et al., 2005; Cassell & Tartaro, 2007).

In short, it has become apparent that humans react to VA's as they would to other humans, if the agent exhibits social behaviour and humanistic characteristics. An agent should also be believable, which means that the appearance of the agent should be in line with its behaviour, e.g. a highly anthropomorphic appearance should be paired with highly anthropomorphic behaviour.

2.2. Virtual Reality as a Research Tool

Virtual Reality is often associated with simulation systems that train people for certain functions or tasks, e.g. for the military and flight attendants. However, there is much more that can be done with VR. Virtual reality is a great medium to obtain certain data that cannot be obtained through other media. There are a number of methodological problems that arise when researching psychology and behaviour through "normal" methods.

The first problem is the trade-off between mundane realism and experimental control. In other words, it is necessary to minimize the effects of variables other than the independent variables (experimental control), while also keeping a degree to which the experimental scenario is similar to the real-world scenario (mundane realism). Mundane realism increases a participant's engagement within experimental situations and through this, increases the degree to which experimental manipulations impact participants with the experiment's intended effect. Generally speaking, the more elaborate and complicated scenarios become, the more immersive an experiment will be for the participant. However, these large scenarios also cost more and decrease the control over the experiment. It increases the number of variables, which makes it more difficult to replicate the experiment and can cause biases. For example, it is difficult to have actors create the exact same scenario over and over again, necessary for a valuable experiment. Slight differences in non-verbal and verbal communications, and other types of actions can skew the results that one obtains from an experiment. With virtual reality technology, it is possible to develop a complicated scenario and can keep all the variables presented to the participant the same during every experiment (Blascovich et al., 2002).

Furthermore, immersive virtual environments increase the possible amount of manipulations on participants. In social and cognitive studies, manipulations are often introduced in the form of written passages, verbal instructions, video, imagery and sound. However, the effectiveness of these elements is limited by the attention span, motivations and imaginative capacities of the participant. Immersive virtual environments amplify these capabilities, because VR manipulates multiple senses simultaneously. This increases experimental realism and reduces the potential bias in the results (Loomis, Blascovich, & Beall, 1999).

There are also some disadvantages to VR that should be mentioned. The largest problem is that not all senses can be manipulated at once and that can cause a distortion in the perception of the user. Imperfections in rendering models (e.g. in shadows and lightning), limitations of the visual display and lags can all disrupt the perception of reality of the user (Loomis et al., 1999). This needs to be taken into account, and appropriate measures need to be taken to decrease these factors.

2.3. Dominance, virtual agents and smiling behaviour

It is important to bring focus to the behaviour of a virtual agent and even more so, the response of humans in a human-agent dyad, because it is likely that virtual agents will be integrated into our society in the future. Especially concerning simulation tools that are being developed with virtual agents, it is important to know how people react to different types of agents and if they react similarly to those agents as they would to humans, otherwise virtual agents will not be useful in society. This research concentrates on studying the effects of dominance on the smiling patterns in a human-agent interaction set. Studies suggest that it is relevant that "social factors including affiliation, authority and conformity are incorporated in the design of virtual agents, as they can have effective and persuasive power in human-agent interaction" (Katagiri et al., 2001). In other words, depending on the function of the agent, it is important to implement the trait of dominance, or lack thereof, in human-agent interactions.

2.3.1. Characteristics of Dominance and Submissiveness

First it is important to see what constitutes as dominance, how it is displayed and how this characteristic is perceived. Every individual has certain observable "signs" or behavioural cues, which suggest whether their status can be perceived as high or low. A human's social position, e.g. having official authority, occupation, education, wealth or race, are all signs of one's status within a certain group. A person who has all these factors in large quantities and has the ethnicity of the social majority, is often perceived as having a high status. Gender, age, health and physical strength are also indicators of one's perceived status. These specific factors are often referred to as "constant" status signs, because they are aspects that one has whether he wants them or not, e.g. someone is born with a larger physique and with a certain gender. The opposite of these factors are "controllable" status signs, which are different, because they are behavioural cues that a person can control, e.g. facial expressions and posture (Mazur, 1985). There are many different gestures and actions that an individual can use to express their dominant or submissive character. In 1872, Charles Darwin already introduced some of them. He described the expression of human pride (head and body erect) and of shame or shyness (averted gaze, head tilted down) in ways that suggest dominance and submission respectively (Bee, Franke, & Andree, 2009). More dominant cues can be found in expressions of physical threats, erect posture, direct gazes, the invading of one's personal space and a relaxed demeanor. In contrast, submissive people are more likely to cower, have a stooped posture, avert their eyes, retreat from social conversation and express nervousness (Burgoon & Dunbar, 2006; Burgoon & Saine, 1978; Lee & Ofshe, 1981). Furthermore, studies have indicated that smiles, as one of the few measurable facial expressions, have the ability to provide information about the social status and dominance level of the sender of the smile (Goldenthal et al., 1981; Ketelaar et al., 2012).

Dominance can also be found in verbal expressions, e.g. through a commanding rather than a requesting tone and using different semantics. These cues are often mixed together when having a conversation. One does not necessarily express their dominance throughout an entire conversation. They might implement some opposite traits, to establish balance in their interactions. The effect of status display is therefore rather variable (Mazur, 1985).

These are the main expressions associated with dominant and submissive behaviour. An overview can be found in table 1.

Table 1. Dominant and submissive characteristics and behaviours in humans.

Dominant trait	Submissive trait	References
Male	Female	Mazur (1985), Eagly & Johannessen-Schmidt (2001)
Older	Younger	Mazur (1985)
Good Physical Shape	Lesser Physical Shape	Mazur (1985)
Wealthy	Poor	Mazur (1985), Cheng & Tracy (2013)
Erect Posture	Stooped Posture	Mazur (1985)
Physical Threats	Cowering	Mazur (1985)
Direct Gaze	Averted Gaze	Mazur (1985), Fukayama et al. (2002)

Head Tilted Up	Head Tilted Down	Mazur (1985), Darwin (1872), Mignault & Chaudhuri (2003)
Invading Personal Space	Retreat from Conversation	Mazur (1985)
Relaxed Demeanor	Express Anxiety	Mazur (1985), Nass et al. (1995)

2.3.2. Dominance and Virtual Agents

Some studies have been conducted around dominance and virtual agents. One study by Bee et al. (2009) focused on facial displays, eye gaze and head tilts. In other words, the researchers were interested in the interaction of different non-verbal cues. They present a study, in which a variation of different eye gazes and head tilts were combined with five basic emotions. These combinations were implemented in a number of graphics and animations and then presented to a large number of participants. The participants needed to attribute a dominance value to each image they received. The researchers found that the avatars expressing joy, disgust and anger, were generally rated as more dominant than the ones with a neutral, fearful or sad expression. Furthermore, only joy was perceived as less dominant when the gaze was averted. An increase in dominance was found when anger and fear were combined with averted eyes (Bee et al., 2009).

Other studies have focused on dominant animal behaviour rather than human behaviour (e.g. Tomlinson & Blumberg, 2002).

It becomes clear that not a lot of research has focused on the interaction between a dominant agent and a human participant. However, based on the research by Katagiri, Takahashi and Takeuchi, it is important that dominant behaviour is implemented into virtual agents and therefore it should be researched thoroughly (2001).

2.3.3. Dominance and Smiles

As stated before, smiling frequency and types can give an indication of the dominance level of the sender of the smile. Researchers have concluded that less dominant individuals smile more often than their more dominant counterparts (Ketelaar et al., 2012). According to them, the association between smiles and lower status generalizes across two forms of status: prestige and dominance. They conducted a number of experiments in which they examined the relationship between prestige and smiles, and dominance and smiles. Their first experiment focused on the relationship between the smiling pattern and prestige of the displayer. They examined whether the faces of fashion models representing less prestigious brands were similar to accurate (happy or embarrassed) smile displays than the faces of models representing highly prestigious brands. They found that the less prestigious models presented more canonical smiles than the models representing prestigious brands. Models for the more prestigious brands also displayed more negative and neutral emotions than their less prestigious counterparts. According to these findings, Ketelaar et al. conclude that people of higher status smile less often than people of lower status (2012).

Ketelaar et al. conducted another experiment which focused on the relationship between smiles and dominance rather than prestige. They focused on physically small football players, who are presumably less likely to dominate a football game, to see if they would display more happiness and embarrassment smiles compared to their larger counterparts. They found that smaller (less dominant) football players displayed more smiles than larger football players. Furthermore, large football players (more dominant) displayed more negative emotions than their smaller counterparts. The same conclusion as for prestige could be drawn: people with a higher dominance level smile less often than people who are more affiliative (Ketelaar et al., 2012).

Moreover, people who have a (visibly) higher status are more likely to show dominant traits than their dyad partner (Mazur & Cataldo, 1989). Mazur and Cataldo conducted an experiment in which dyads, consisting of a professor and a student, were asked to interact so that styles of conversation could be compared. The professor was the person who had a visibly and established higher status than the student. They used more dominant conversational signs than the student. Their results indicated that the students started to behave in a more affiliative way and displayed more affiliative signs. This suggests that when a visibly or established high-power individual enters an interaction dyad with another person, this person will act less dominant compared to the visibly dominant person in the dyad. These studies by Ketelaar and Mazur combined, suggest that when an individual is paired with a visibly dominant individual, they, the not-visibly dominant individual, will smile more frequently because their behaviour will become more affiliative.

Another study, conducted by Hecht and LaFrance (1998), tested whether social power and sex affected amount and type of smiling. Participants of their experiment were assigned to certain power positions (low, high or equal) and put together in interaction dyads. For high- and equal-power participants, smiling correlated with positive affect, whereas for low- power participants, it did not. Women smiled more than men and showed more genuine (Duchenne) smiling when in an equal power situation. Hecht and LaFrance interpreted their results as that high-power people have a license to smile when they are so inclined (Duchenne) and that low-power people have an obligation to smile regardless of how positive they feel. This suggests that low-power individuals are inclined to display more non-Duchenne smiles and high-power individuals are more likely to show genuine smiles.

Form the findings of Duchenne de Boulogne (1862), came the definitions of the Duchenne- and non-Duchenne smiles. Duchenne smiles are presented as genuine smiles, in the sense that they express a positive feeling of the displayer and is activated by the muscles around the eyes and mouth. Non-Duchenne smiles on the other hand, are represented by the activation of the mouth muscles only (figure 1). The smile doesn't reach the eyes. This type of smile is commonly associated with submissiveness (Ketelaar et al., 2012). The two broad categories can be segregated into around 18 subcategories in total, according to Ekman (1985). Enjoyment smiles, Duchenne smiles, are associated with pleasure, relief, amusement etc. Non-Duchenne smiles include masking smiles, false smiles, miserable smiles, embarrassed smiles, and polite smiles.

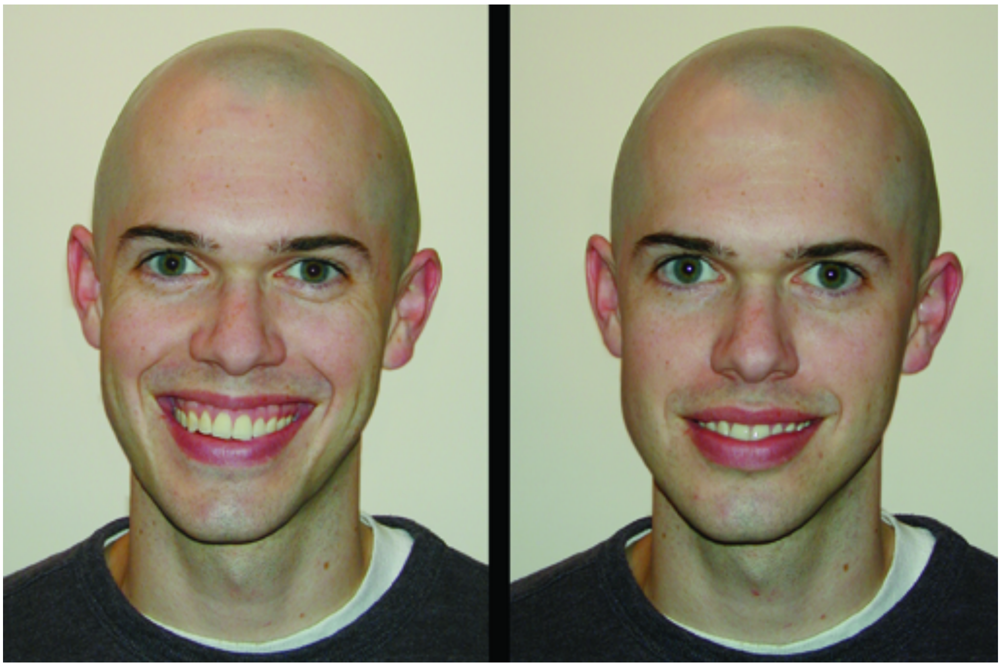


Figure 1: A Duchenne smile (left, activation in eye corner and lip corner) and a non-Duchenne smile (right, only the lip corners are activated and less intense).
Source: LaFrance, M. (2013), Why Smile? The Science Behind Facial Expressions, W.W. Norton

2.4. Hypotheses

The research above suggests that human-human interaction is considered similar to human-agent or human-robot interaction, as humans consider artificial entities as social beings. Therefore, humans are likely to interact with an agent in a similar fashion as they would with other humans. Furthermore, within human-human interactions, people are likely to smile more frequently when paired with a dominant person compared to when they are paired with a submissive person. Moreover, within human-human interactions, people are more likely to smile in a non-Duchenne way when paired with a dominant person. Since, humans are likely to interact similarly to agents as they would to humans, we can establish the following hypotheses based on the research questions proposed in chapter 1.

H_1: People smile more when interacting with a dominant agent.

H_2: People smile more in a non-Duchenne way when interacting with a dominant agent, than when they interact with a submissive agent.

H_3: People smile less in a Duchenne way when interacting with a dominant agent, compared to when they interact with a submissive agent.

These hypotheses will be tested through an experiment which will be discussed further in the next chapter.

3. Method

To answer the proposed research questions an experiment is proposed which is described in this section of the document. First, a general description of the experiment will be given. Next, the decisions concerning the design of the agents are described. Then, the experimental design with its experimental procedure is reported. Next, the data that will be measured - a questionnaire, video data and facial electromyography - is defined. Moreover, the demography distribution of the experiment's participants and the description of the study site are described.

3.1. General Description of the Experiment

The goal of the experiment is to find a relationship between dominance and smiles in a human-agent interaction and to compare these interactions with the results of a similar human-human interaction. As stated before, the main research question of this paper is: What are the effects of dominance on the human smiling pattern within a human-agent dyad? The subquestions are:

- Do people smile more when interacting with a dominant virtual agent?
- Do people smile more in a non-Duchenne way when interacting with a dominant virtual character?

The wizard-of-Oz type of experiment that is conducted, will answer these questions. The participants of the research will enter a job interview through virtual reality goggles. Research suggests that people change their behaviour during job interviews, depending on the perceived dominance level of the interviewer. When the interviewer is more dominant, the interviewee will act in a more submissive manner and vice-versa (Von Baeyer, Sherk & Zanna, 1981; Tullar, 1989; Tiedens & Fragale, 2003). These studies suggest that in human-human job interviews, the interviewee is likely to adapt their behaviour oppositely to the dominance level of the interviewer. Based on the research described in section 2.1., it is likely that the same type of behavioural differences will occur in human-agent interactions. Furthermore, research is already done concerning virtual agents as job recruiters (Callejas, Z., Ravenet, B., Ochs, M., & Pelachaud, C. (2014), so dominance could be an important feature to include in virtual agent development.

The agent will ask questions to the participant, which the participant has to answer verbally, as one would during a human-human job interview. The agent will not respond verbally to the answers that the participant gives, but he is able to communicate through head and facial movements controlled by the researcher, e.g. nodding and smiling. Through facial electromyography, we will measure the facial contractions occurring around the mouth and eyes of the participant, so that Duchenne and non-Duchenne smiles can be detected. Video data will be recorded to review the behaviour of the participant during the research, so that smiles can be annotated and the duration of each smile can be processed. After the measurements have been taken and the job interview is finished, the participant will answer some questions about their experience with the virtual agent and how they perceived his behaviour. This questionnaire functions as a post-hoc standardization tool, with which we can check whether the agents were created sufficiently dominant or submissive.

3.2. Creating Virtual Agents

As explained before, it is important to create believable virtual agents. Which means that the behaviour of the agent should correlate with its physical appearance. Since our research focuses on a relatively realistic job interview, it is important that the created virtual agents are realistic (or human-like) as well. Therefore, the agent needs to look human, and behave like a human. It was decided to create two virtual agents: one submissive agent, and one dominant agent. The research above gives a number of parameters associated with dominance and submissiveness, that can be used as a guideline for the creation of the virtual agents (table 1, Chapter 2).

3.2.1. Experiment: Choosing the character

Through the research by Mazur (1985) described in chapter 2.3, it became apparent that there are certain “constant” status signs, that are mostly physical attributes that present themselves as dominant or submissive. For example, physical height, wealth, muscles etc. are controlled status signs. To see what kind of agent is perceived as more dominant than the other, a small experiment was created in which participants were asked about the physical appearance of four different agents through an online survey. The goal of this experiment was to find the right dominant and submissive character to use during the actual research.

Figure 2a-d presents the four agents that were created with a program called MakeHuman, which allows for the creation of realistic looking 3D characters. They were placed in an office-like setting. The first two figures represent the characters who were assumed to be perceived as the most submissive. The agents differ in size, character 2 being smaller than character 1. The second agent also has a different mouth-shape which gives him a friendlier look. Character 3 and 4 were assumed to be a perceived as more dominant.

Figure 2a-d: The four created agents that were rated in terms of their status, power, dominance, prestige and intimidation, based on their appearance.

This is due to the fact that they seem older than the first two characters. The clothing is different. The suit of character 4 seems more expensive than the suit worn by character 3. This was done because perceived wealth is a "constant" status sign, and can therefore have an impact on the perceived dominance level. Furthermore, character 4 is larger than any of the other characters, which should also increase the perceived dominance level. An overview of the differences between the created agents can be found in table 2.

Table 2. Overview: decisions made per agent.

Physical Traits	Agent 1	Agent 2	Agent 3	Agent 4
Age	Young	Young	Old	Old
Size	Small	Small	Large	Large
Clothing (wealth)	Simply Styled	Simply Styled	Suit	Expensive Suit
Facial Expression	Sullen	Smile	Smile	Sullen

: Dominant Trait : Submissive Trait

For each agent, participants of the survey (N = 26) answered the following questions:

1. Based on what you see in picture (1-4), how high would you rate this agent's prestige and status on a scale of 1-10?
2. Based on what you see in picture (1-4), how high would you rate this agent's level of dominance and power on a scale of 1-10?
3. On a scale from 1-10, how intimidating is the agent presented in picture (1-4)?
4. Why did you rate the agent in picture (1-4) with the answers of question 1-3?

The questions within this experiment all focused on figuring out which character is considered the most dominant in appearance. By creating different questions revolved around the same construct, "dominance", it was possible to see if the wording of the question matters in finding answers, and to see if there is internal consistency between the questions. To figure out if this consistency was there, a Cronbach's alpha test was done on all the gathered data. The data consisted of N = 104 cases (4 characters with 26 answers each). The Cronbach's alpha over the three questions was found at 0.974. This means that the internal consistency between these three questions is very high, which shows that the questions measure the same construct, which, in turn, gives a higher validity to the answers given by the participants of the experiment. Because the Cronbach's Alpha value was very high, all the answers to the questions were combined, so that the number of answers per rating for each agent became clear, without taking the question number into consideration (figure 3).

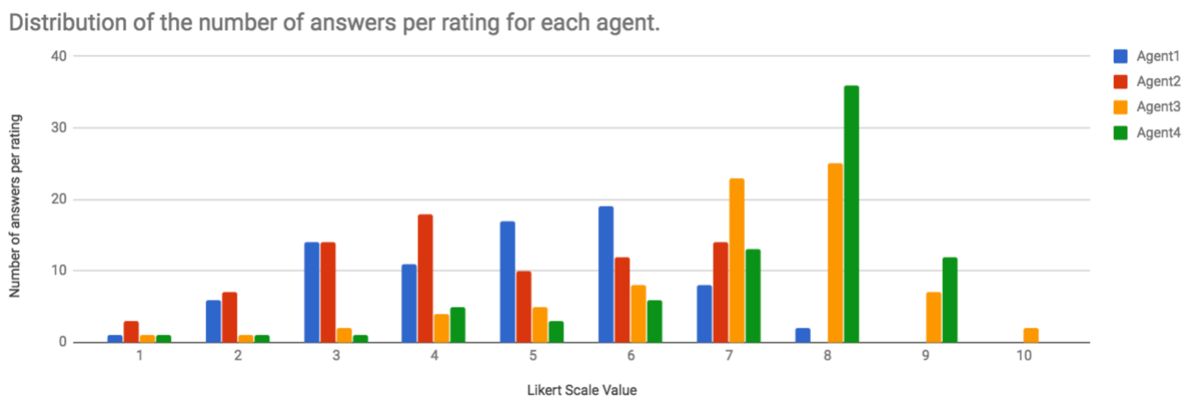


Figure 3: counting the number of participants that chose which rating (1-10) applied for each agent.

A within-subject ANOVA test was conducted over the combined data with an added post-hoc Bonferroni correction, which allows for pairwise comparisons between the agents.

The result of this ANOVA test can be found in table 3. There is a significant difference between all agents. Over all the questions, it was found that there is a significant difference between agent 1 and agent 2 ($p = 0.019 < \alpha = 0.05$). Moreover, there is a significant difference between 3 and 4 ($p = 0.000293 < \alpha = 0.05$). As expected, there are large significant differences between the pairs agent 1 vs. agent 3, agent 2 vs. agent 3, agent 1 vs. agent 4, and agent 2 vs. agent 4 ($p = 0.0000 < \alpha = 0.05$).

Table 3. Within-Subject ANOVA test with post-hoc Bonferroni correction

Agent Nr. (I)	Compared Agent Nr. (J)	Mean-Difference (I-J)	St. Error	P-value
1	2	0.244	0.08	0.019
	3	-2.205	0.086	0
	4	-2.487	0.098	0
2	1	-0.244	0.08	0.019
	3	-2.449	0.103	0
	4	-2.731	0.115	0
3	1	2.205	0.86	0
	2	2.449	0.103	0
	4	-0.282	0.066	0.000293
4	1	2.487	0.098	0
	2	2.731	0.115	0
	3	0.282	0.066	0.000293

As a final question on the survey, participants were asked to say which character had the most dominant appearance and which character held the highest status. Here, 14 people (53,8% of participants) stated that character 4 is the most dominant agent, contrary to 10 people (38,5% of participants) who chose character 3. A chi-square goodness-of-fit test was conducted to see if the difference between the expected equal frequency distribution was found. The expected frequency was 8.7 participants choosing each agent. At the $\alpha = 0.05$ level of significance, there is enough evidence to conclude ($p = 0.013 < \alpha = 0.05$) that the people have chosen agent 4 as the most dominant agent.

Moreover, 15 people (57,7% of participants) found that character 4 held the highest status, contrary to 10 people (38,5%) who chose character 3. A chi-square goodness-of-fit test was conducted to see if the difference between the expected equal frequency distribution was found. The expected frequency was 8.7 participants choosing each agent. At the $\alpha = 0.05$ level of significance, there is enough evidence to conclude ($p = 0.003 < \alpha = 0.05$) that the people have chosen agent 4 as having the highest status. Character 2 was the only character which nobody considered to be the most dominant or the agent with the highest status (figure 4a-b).

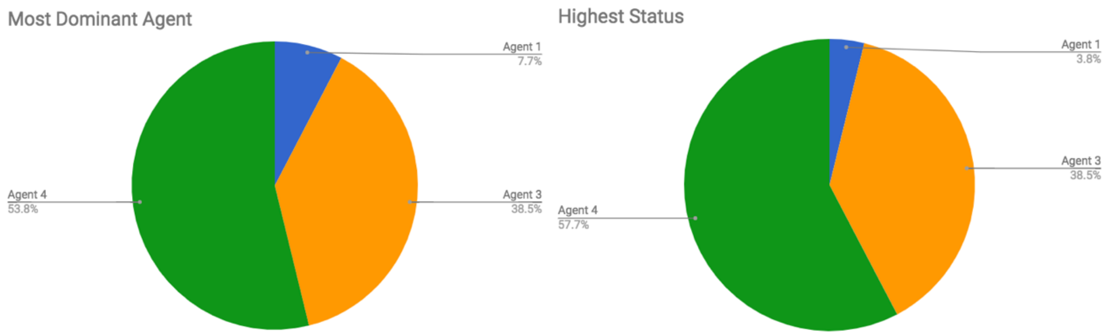


Figure 4a-b: Percentile distribution of participants concerning the most dominant agent and the agent with the highest status.

The participants could give feedback on why they rated a character as they did. This gave insight into what participants focused on when rating the dominance level of a character.

Agent 2 was rated lower due to its “young and non-threatening” appearance. The appearance also suggested a “lesser rank” in society. Additionally, the agent was perceived as “less muscular” and he seemed more “approachable” and therefore not intimidating or dominant. Agent 4 was rated the highest due to its “serious expression, muscular form and unafraid expression”. He also seemed “well-groomed” and he is wearing a “nice suit”. Some people also suggested that “he looks like a company boss”. Furthermore, people stated that “his regal posture and suit give him a high level of intimidation”.

Based on the participants’ commentary concerning agent 2 and agent 4, and the significant differences found as a result from the experiment described above, it was decided to use character 2 as the submissive VA and character 4 as the dominant VA for the next steps of the research. The agents had a submissive and dominant appearance, respectively. It was then decided to create the behaviours of the agents guided by the parameters given in table 1.

3.2.2. Created Characters

Submissive agent

The submissive agent is seen below, in its virtual environment. You can see that his eyes are averted, he seems small in his chair. Looking at the animation, you will be able to see that he fidgets with both his hands and in the way, he sits on his chair. His posture is slightly slumped. Table 4 describes the guidelines from table 1 and the decisions made in the creation of the submissive virtual agent.

Figure 5: Final created submissive agent in virtual environment

Table 4. Submissive characteristics and the adaptations applied to the submissive virtual agent.

Submissive trait	Choices Created Agent
Female	It was decided to focus on two men, one dominant and one submissive. Female agents are not included in the scope of this research.
Younger	The submissive agent seems young and inexperienced
Lesser Physical Shape	The submissive agent seems relatively small and not very muscular
Less Wealthy	The submissive agent is wearing a relatively simple button-down shirt. This still shows some kind of wealth, but that is necessary for him to come across as a believable CEO.
Stooped Posture	The posture of the submissive agent is hunched further than that of the dominant agent
Cower	The submissive person cowers during the animation
Averted Gaze	The gaze of the submissive agent is averted at times. The agent will also look at the participant but significantly less often than the dominant agent.
Retreat from Social Conversation	For this research, it is not possible to include this trait, because the agent needs to actively participate in the conversation.
Express Nervousness	The agent fidgets a lot with his hands. The agent will also shift in his chair from side to side during the conversation.

Dominant Agent

The Dominant Agent is seen below. In contrast to the submissive agent, the dominant agent looks bigger, both in height and in muscles. The dominant man is older and wears a more expensive suit. His posture is erect and his demeanor seems relaxed. All decisions concerning the creation of the dominant agent can be found in table 5.

Figure 6: Final created dominant agent in his virtual environment

Table 5. Dominant characteristics and the adaptation applied to the dominant virtual agent.

Dominant trait	Choices Created Agent
Male	The agent is male, as is the submissive agent.
Older	The dominant agent is older than the submissive agent. It is commonly thought that expertise and experience comes with age, which is why older people often have a higher status and a higher level of power and dominance.
Good Physical Shape	The dominant agent seems large and more muscular in comparison to the submissive agent.
Wealthy	The dominant agent wears a suit. This makes him seen wealthier and more official in his function as CEO of a company.
Erect Posture	The dominant agent sits up straight, and he remains like that throughout the entire interaction, though a slight offset is animated, to make the agent livelier.
Physically Threatening	This is not present in the created dominant agent, since it does not seem realistic that a CEO would make physical threats towards his potential employee.
Direct Gaze	The gaze of the dominant agent is completely focused on the participant. The dominant agent will blink to make him look more realistic.
Invading of Personal Space	It is not possible to implement this trait into the created agent. The agent is sat down stationary behind a desk. Invading the personal space of the participant is then not a realistic option.
Relaxed Demeanor	The dominant agent has a relaxed demeanor. He does not fidget, though small animations are added to the body to make the agent seem more alive, and less like a robotic entity.

Both characters were created with a program called MakeHuman, which allowed us to create realistic looking characters and transform them into manipulable agents. The characters were imported into the Unity Game Engine, after which the agents were animated according to their level of dominance. The environment was built around them and decoration was added to make the environment seem more realistic and immersive. Blendshapes were created of each character, which allowed us to morph their movement and mouths as necessary. The blendshapes were manipulated using the LipSync Pro Unity plug-in. Through this plug-in, it was possible to add speech to the character with phoneme movements added to the mouth. The same plugin made it possible to add movements of the eye, which made the agents seem more alive and realistic.

It was important to only establish differences between the agents, not their environments or script. This would create too many variables that could skew the proceedings of the research. Measurements could be influenced by variables in the environment rather than the agent itself.

3.3. Experimental Design

In this section of the document, the decisions revolving around the experimental design of the experiment are described.

3.3.1. Research Design

In behavioural research there are two main designs that can be used to sample measurements: between subject design and within subject design (Charness, Gneezy, Kuhn, 2012). In the case of this research between-research design would separate two groups. One group would be interviewed by the dominant agent, while the other group would be interviewed by the submissive agent. During the within-subject design, all participants would get interviewed by both agents. There are advantages and disadvantages to both designs, but for this research it was deemed that a between-subject approach would be more beneficial.

If a within-subject approach was chosen, it would be necessary to add a randomness to the order in which the participants would view the two agents. Furthermore, the experiment session would last longer per person, which can cause restlessness and annoyance in the participant. It would also be necessary to create different job descriptions for each character, since the participant might get bored or confused by answering the same questions twice. Creating two different job descriptions could also cause a disruption in the gathered data, because it would add another variable to the research. Therefore, it was decided to take the between-subjects approach.

3.2.2. Procedure and Scenario

With the between-subject approach, the steps of the research per participant can be found in table 6.

Table 6. The research procedure with estimated amount of time necessary for each procedural task.

Nr.	Procedural task	Approximate time (m)
1	The participant is given a booklet with a consent form and job description	-
2	The participant reads and signs the information sheet when all questions are answered	5
3	The participant reads the job description	2
4	The researcher applies EMG sensors on the skin of the participant and does a short test run.	3
5	The researcher places the Oculus Rift on the head of the participant and starts the app	1
6	The participant is transported to the virtual environment and answers the questions proposed by the virtual agent.	10
7	The researcher takes off the Oculus rift and the EMG sensors from the participant	1
8	The participant fills out a questionnaire about their virtual experience	3
	TOTAL	25

This procedure will take up to 25 minutes to complete by the participant. This is a rough estimation, but it is important to leave some space for unexpected circumstances in system complications, and slow readers or talkers.

During the participant's time in the virtual environment, he or she answered the questions that were asked by the virtual person. These are questions that are often asked during regular job interviews and can be found in table 7. The questions revolve around a function description, that is provided to the participant at the beginning of the session, which describes a job as a VR designer. This job description was chosen, because many types of students will work with this technology, and because the experiment was held at the University of Twente, where many technological studies can be found. The students that participated in the research would therefore be able to apply for this job in real life, which makes the experiment more realistic to the participant. The job description can be found in appendix I.

Table 7. The questions asked during the job interview by the virtual agent in the virtual environment.

Q. Nr.	Question
1	Introduction of the company and some contextual information for the participant
2	"Now that you know a bit about the function and your possible tasks, can you tell me what you like about this description?
3	"Tell us something about yourself, what do you like to do in your free time?"
4	"How would you describe yourself as a person?"
5	"What would you say is your greatest strength in professional situations?"
6	"What is it that you are looking for in a job?"
7	"So, why should we hire you?"
8	Ending

3.4. Measurements

There are multiple sets of data and variables that have been measured during the experiment. To be able to find answers to the research questions, it is important to combine all the analyzed data. Through the video data it is possible to annotate the number of smiles, their duration, and their annotation type. With this as a guide, we can find the points where the smiles have occurred and compare them to the EMG data, which allows us to find which smiles are Duchenne and which smiles are not. A post-hoc questionnaire functions as a check to examine whether or not the agents were perceived as dominant or submissive. So, there are a few dependent variables that will be measured through specific measuring methods:

1. Number of smiles is measured through video recordings of the participant;
2. Number of Duchenne smiles is measured through detection by an EMG sensor;
3. Perceived dominance is measured through a post-hoc questionnaire.

In this section of the document, each dependent variable and their analyzation method is described.

3.4.1. Number of smiles - Video Recordings

It is important to gain insight into how many times a person smiles per minute during an interaction with a virtual agent. Through video recordings, it is possible to tally and annotate the smiles from each participant post-hoc. The dependent variable “number of smiles” is related to the H_1, and when the tallied and annotated data has been analyzed, we can either accept or discard this hypothesis.

Only the faces of the participants are visible on the video’s. It is necessary to record the participants, because the researcher is not able to observe the participants during the experiment. Furthermore, a video allows us to annotate the smiles that occur, their duration and the time in which it occurred. This would not be possible without the video material.

The video captures are analyzed with the aid of a program called ELAN by The Language Archive (https://tla.mpi.nl/tools/tla-tools/elan/), which is a comprehensible and professional tool to annotate complex video imagery. Each video is put through this program, and smiles of different types are annotated for each participant. By using this program, we gain insight into the number of presumed smiles, and the duration of each smile. In annotating, three different annotations are distinguished from each other. These have nothing to do with Duchenne or non-Duchenne smiles, but rather give information about how long a smile lasts, if it is a smile with sounds, and whether the participants mouth is open or closed during the smile.

- Twitch smile: some people are more likely to move their lips in a certain way, which might seem like a small, quick smile, but can also be a type of behavioural tic. Analyzing the EMG data should give more insight into this.
- Small smile: with a small smile, we mean the smiles that can last relatively long, but there is not a lot of mouth movement supporting the smile. Small smiles are usually created by closed lips, no sound, and no other body movements.
- Large smile: a large smile is a smile that is open mouthed, lasts relatively long, produces sound and possibly increases shaking in other body parts, like a full-belly laugh.

It is important to distinguish these different smiles, especially because of the twitch-smile, because it can impact the smiling frequency that is found per participant. As stated in the literature, chapter 2.3., smiles can differentiate a lot from each other. A non-Duchenne smile can be a smile out of e.g. uneasiness or politeness. Therefore, we cannot say with certainty that a twitch smile, is not a smile, but we cannot say it is a smile either. It is important that we differentiate those from the other smiles (small and large) that occur during the experiment.

From the video data, it is possible for us to find the number of smiles per participant and average per group, and helps us calculate the frequency of smiles per participant.
The information manually annotated through the ELAN program give information about the duration of each smile and when each smile occurred, this is very useful since it allows us to compare the presumed smiles, collected from the video's, to the collected EMG data. The timeline of the video is laid next to the timeline of the EMG sensor, which shows if the presumed smile is actually measured as a smile and if so, what type of smile it is: Duchenne, or Non-Duchenne. The presumed smiles that are not found within the EMG data are classified as 'unidentifiable'. The timestamp from the video data in seconds, is multiplied by the sample rate of the EMG sensor, which is 51 samples per second. This calculation allows for the comparison between the EMG data and the timestamp of each smile.

3.4.2. Number of Duchenne Smiles - Facial Electromyography

To measure the second dependent variable, the number of Duchenne smiles, Facial Electromyography (EMG) will be used. After gathering the data from this sensor and analyzing it, we will be able to either accept or discard the second hypothesis H_2: People smile more in a non-Duchenne way when interacting with a dominant virtual agent.

Facial Electromyography (EMG) is a data gathering method that is used in this research, to collect information about muscle spasms in the face. The electrodes of the sensor are attached to the participants face at the zygomatic major and the obicularis oculi major, the two muscles that are activated when creating a Duchenne smile (figure 8). The sensor gathers data concerning the activity that occurs at these two muscles during the interaction with the virtual agent. The gathered information will give insight in the types of smiles that occur during the interview.

Baseline EMG amplitudes and affective EMG response magnitudes strongly vary between individuals, not only because of differences in certain processes but also due to differences in anatomy and biology (van Boxtel, 2010). This gives that determining group means can be difficult since the individual measurements can vary strongly. This is important to keep in mind while analyzing the data.

One problem associated with systems that rely on observable facial actions, is that weak or moderate responses might be visually undetectable. Using EMG, even the weakest responses can be detected through the electronic signals. This is a big advantage of the EMG. For this research, specifically, EMG also has an advantage that normally wouldn't be associated with this type of signal processing. This research will use virtual reality goggles to transport a participant to a different environmental setting. This means that part of the participant's face will be covered by these goggles, and therefore make differences in eye movements visually undetectable. With EMG technology, it is possible to apply the sensors underneath the goggles, which allows for a detection of eye movements and muscle spasms around the eyes. This is necessary to be able to distinguish a genuine smile (Duchenne) from a non-genuine smile (Non-Duchenne).

The EMG technology that will be used during this research, is the Shimmer 3 by Consensys. This is a small, portable and accurate physical detection kit that, among other sensors, includes EMG support. The shimmer EMG component has two channels, which means that activity of two muscles can be measured at once. Each channel has a negative and a positive terminal. The positive and negative terminal from each channel need to be placed on the muscle that needs to be measured, with a distance of 2 centimeters between the centers. The measuring rate for this experiment is set at 51 Hz, which means that 51 samples will be taken per second. This number of samples, will give us accurate enough data and will simultaneously minimize the amount of lines of data that needs to be processed afterwards. The EMG sensors are placed on two specific muscle groups on the participant's face (figure 8).

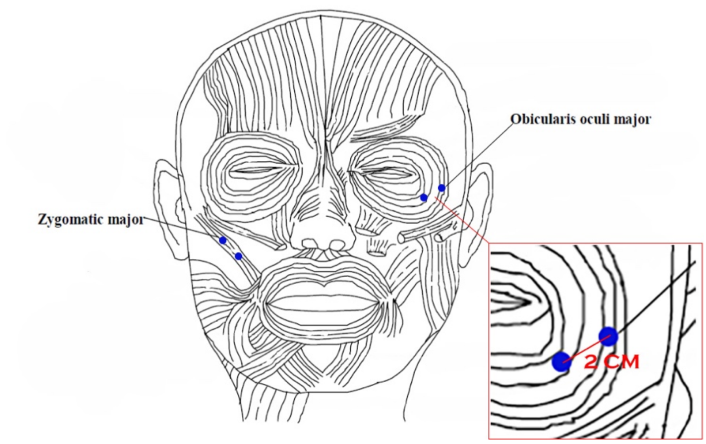


Figure 7: Facial EMG sensor setup on the facial muscles of the participant (origin: https://imotions.com/blog/electromyography-101/)

For a Duchenne smile to occur, the muscles of the zygomatic major and the orbicularis oculi major both need to be active at the time the smile occurs. If only the zygomatic major muscle contracts during a smile, a non-Duchenne smile has appeared. A graph of both channels can be created from the generated datapoints through a program called Matlab (https://www.mathworks.com/products/matlab.html). The time-ranges of each smile are extracted from the video data and displayed alongside the EMG data from both channels, so that it becomes clear when a smile occurred (according to the video), and which muscles were activated in that specific timeslot. The plots are then manually compared to each other and each smile is annotated as either Duchenne, non-Duchenne or Unidentifiable.

3.4.3. Questionnaire Data

A post-hoc questionnaire is conducted as a manipulation check, to see if the created agents behave submissively or dominantly as necessary to draw valid conclusions. The questionnaire also functions as a way to see how the participant perceived the behaviour and aesthetic of the VA.

The questionnaire consists of 13 statements about how the participant experiences the virtual agent (Appendix II). The participants answered these questions by rating each statement on a 5-degree Likert scale (strongly disagree, disagree, undecided, agree, strongly agree). It was decided to use a 5-degree rather than a 7 or 9-degree Likert scale, because previous states that a five-point scale is readily comprehensible for participants, because they can express their feelings in a clear way (Marton-Williams, 1986). Seven-point and nine-point scales would nuance the options of the participants. Furthermore, it has been found that a 5-point Likert scale has a higher reliability (Jenkins & Taber, 1977; Lissitz & Green, 1975)

To analyze the answers given in each participant group, the scales were transcribed to a numerical scale after the participants had filled in their answers (strongly disagree = 1, disagree = 2, undecided = 3, agree = 4, strongly agree = 5). From these numbers, a mean can be found which allows for a comparison between the means of each group.

3.5. Subjects

The total number of researched participants was N = 34. Each researched group consisted of 17 participants. The participants were selected through a convenience sample. This means that the selection is based on the opportunities of the researcher. Convenience sampling is a form of nonprobability sampling that a researcher can use to choose a sample of subjects from a certain population. In convenience sampling, members of the target population can meet certain practical criteria, such as availability, accessibility, proximity and willingness to participate. “Captive participants such as students in the researcher’s own institution are main examples of convenience sampling”. (Etikan, Musa, Alkassim, 2016) In this research, participants were selected based on their accessibility and proximity to the researcher. This was due to time and limited resources. A few criteria were established to take into account when people were selected.

Table 8. Distribution of Gender, Age and Nationality within each group. Group 1 is the group that interacted with the submissive agent, while Group 2 is the group that interacted with a dominant agent.

Group 1 (Submissive Agent)			Group 2 (Dominant Agent)		
	N = 17			N = 17	
	Gender			Gender	
Male	9	53%	Male	9	53%
Female	8	47%	Female	8	47%
	Age (μ = 23.24)			Age (μ = 22.88)	
17 - 20 Years	8	47%	17 - 20 Years	3	18%
21 - 25 Years	7	41%	21 - 25 Years	11	64%
26 - 30 Years	1	6%	26 - 30 Years	3	18%
41+ Years	1	6%	41+ Years	0	0%
	Nationalities			Nationalities	
Dutch	15	88%	Dutch	14	82%
Italian	1	6%	German	2	12%
Chinese	1	6%	Iranian	1	6%

Since a between-group research design is used, it is of importance that the gender distribution is equal in each group, since gender can have a big influence on how dominant or submissive a person behaves. Furthermore, people with extensive facial hair, beards in particular, were not able to participate in the research since the EMG electrodes do not stick to very uneven surfaces. Furthermore, the participants could not suffer from epileptic seizures, since the effects of VR on those people has not been sufficiently researched yet and could pose a danger to those individuals. The distribution of age, gender and nationality in each group can be found in table 8.

3.6. Description of study site

The experiment took place at the University of Twente, because it is where a large number of potential subjects can be found. Within the University, a room was chosen in which many experiments take place and where all the equipment, needed to successfully complete the research, was present. There are some pieces of equipment that were necessary to successfully complete this research. A simplified model of the setup can be found in figures 7a-b.

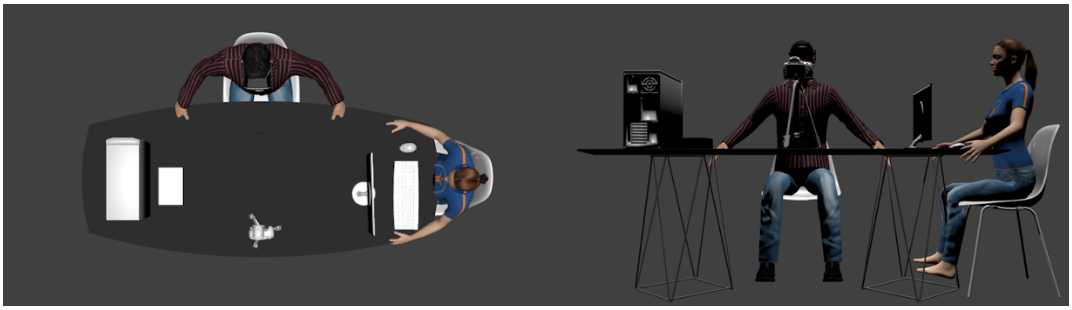


Figure 8a-b: Physical setup top(a) and front view (b).

The figure shows, two people: the observer (female) and the participant (male in this case). The observer is placed in front of the computer screen that displays what is happening during the simulated job interview. The monitor is connected to a computer that drives the virtual reality goggles placed on the face of the participant.

The observer partially controls what the participant gets to see. That is why it is important that the observer is able to see what is displayed to the participant. The observer can then timely control the movements and animations of the agent. For example, if the agent should smile because the participant said something funny, the observer is able to control this response. Furthermore, the observer is able to switch between questions. When the participant is finished answering one of the questions, the observer can press a button to go to the next question. This process continues until the participant is at the end of the interview.

The participant is wearing VR goggles to be transported into the VR setting. The VR goggles, an Oculus Rift, is connected to the computer. One oculus infrared motion capture sensors are placed on the sides of the participant to capture his or her movements in the scenario.

The EMG sensor that is used in this study, the Shimmer 3 Consensys, consists of two electrodes attached to a small device in which the gathered data can be stored. The electrodes are connected to this device by an unfortunately very short wire. This wire cannot be extended. This is unfortunate, because there might be issues with the wires and how people naturally move during a conversation. From a pilot test, it was found that it was possible to put the EMG device on the table in front of the participant and that the wires did not constrict the movements of the participant in any way.

The video camera is placed directly in front of the participant to capture all the facial, physical and verbal responses the participant might give. This is necessary, because the observer is not able to do this herself while she is performing the task of controlling the virtual agent. However, the information that is gathered from observing the participant can be valuable, which is why this is a necessary part of the physical set-up.

4. Results

In this section of the document, the results of the experiment and the analysis of each dependent variable with its measuring method is discussed.

4.1. Descriptive Statistics

There are a number of aspects of this research that do not necessarily answer the research question, but are still valuable to analyze, because they give a broader context to the research. These variables are described in this section of the document.

4.1.1. Differences between interaction-duration and smile-duration

First of all, it is interesting to get an idea of the duration of the session. Though the duration of the session will not directly give any information about the number of smiles of the type of smiles that are displayed, it will be relevant in calculating the smiling frequency. The average duration of the interaction with the dominant agent is 247.5 seconds, which translates to about 4:08 minutes. The average duration of the interaction with the submissive agent is 242.7 seconds or 4:03 minutes. After doing an independent t-test with a confidence interval of 95%, it was found that there is no significant difference between the lengths of the sessions for the dominant and the submissive agent ($p = 0.757 > \alpha = 0.05$).

An independent t-test was conducted to find if there are any significant differences between the duration of smiles of people paired with a dominant agent and those paired with a submissive agent. In total, the participants paired with the submissive agent smiled 112 times, while the participants paired with the dominant agent smiled 104 times. The average duration of a smile for participants paired with a dominant agent was $\mu = 2.3635$, while those paired with a submissive agent had an average smile duration of $\mu = 2.4156$. There is no significant difference between the average duration of smiles ($p = 0.806 > \alpha = 0.05$).

4.1.2. Differences between male and female respondents

Furthermore, it is necessary to research the difference between male and female responses to the agent. Though this comparison is not part of a research question, it is possible that the difference between the responses is significant, and can form a foundation for further research.

An independent t-test was conducted to compare the duration of smiles between male and female participants. It was found that men smiled averagely longer ($\mu = 2.395$) than women ($\mu = 2.379$) by a marginal amount. However, there was no significant difference found ($p = 0.967 > \alpha = 0.05$). Furthermore, the number of smiles per minute displayed by women ($\mu = 1.820$), was larger compared to the number of smiles displayed by men ($\mu = 1.363$). Yet the difference was not significant ($p = 0.148 > \alpha = 0.05$) enough to be able to conclude that these findings can be seen as a pattern of behavior.

Moreover, an independent t-test was conducted that compared whether men displayed more Duchenne smiles, non-Duchenne smiles and Unidentifiable smiles, than women. It was found that women are significantly more likely to smile in a Duchenne way, no matter the dominance level of the agent ($p = 0.038 < \alpha = 0.05$). Men are more likely to smile in a non-Duchenne way ($\mu = 0.481$) compared to women ($\mu = 0.5946$) but not on a significant level ($p= 0.578 > \alpha = 0.05$).

4.1.3. Subject Variability

It is also useful to take a look at the spreading of the responses by studying the standard deviation. This will not directly answer any of the research questions, but it gives more context to interpret the response results. The most important variances to establish for this study, are the variance in the number of smiles, and the variance in the number of Duchenne and non-Duchenne smiles.

The standard deviation of the number of smiles for the dominant agent ($\sigma = 3.445$) is lower than the standard deviation of the number of smiles for the submissive agent ($\sigma = 4.95$). This means that there is more variance between the respondents paired with the submissive agent compared to those paired with the dominant agent. This is largely due to a specific participant, participant 12, who was paired with the submissive agent and who smiled 12 times more than the general average of 6.54 smiles. This participant displayed the largest number of smiles during their interaction, but it cannot be considered an outlier, because the p-level of this value is larger than the used two-sided significance interval of 95% (stat test, spss). In figure 9 the scatterplot of the number of smiles from each participant can be found. In this figure, the variety of the number of smiles between respondents becomes clear.

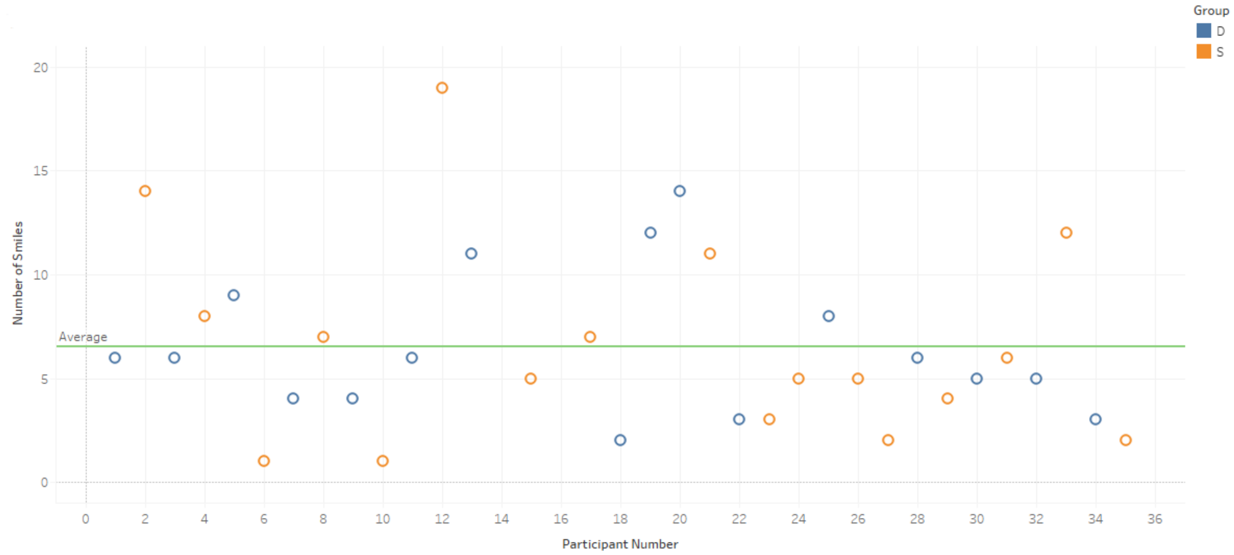
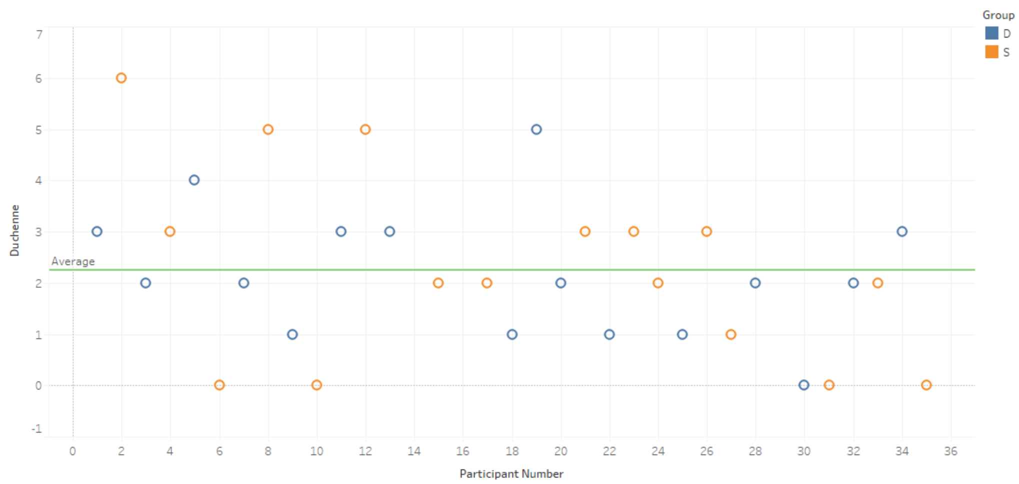


Figure 9: subject variability between number of smiles, sorted by group, with a reference line that shows the average.

The standard deviation of the number of Duchenne smiles (σ = 1.586) is smaller than the standard deviation of the number of non-Duchenne smiles (σ = 2.509). This means that there is more variance present in the number of non-Duchenne smiles compared to the Duchenne smiles. The larger variance is caused by the number of non-Duchenne smiles displayed by participant 20. It was found that this datapoint is a significant outlier ($p < \alpha = 0.05$). However, it is unnecessary to eliminate this outlier, since it does not change the results that will be discussed in chapter 4.3. Furthermore, there is no apparent reason why this participant presented more non-Duchenne smiles than other participants. The scatterplot of the number of Duchenne (figure 10a) and the number of non-Duchenne smiles (figure 10b) are depicted. These figures show the variety of displayed smiles.



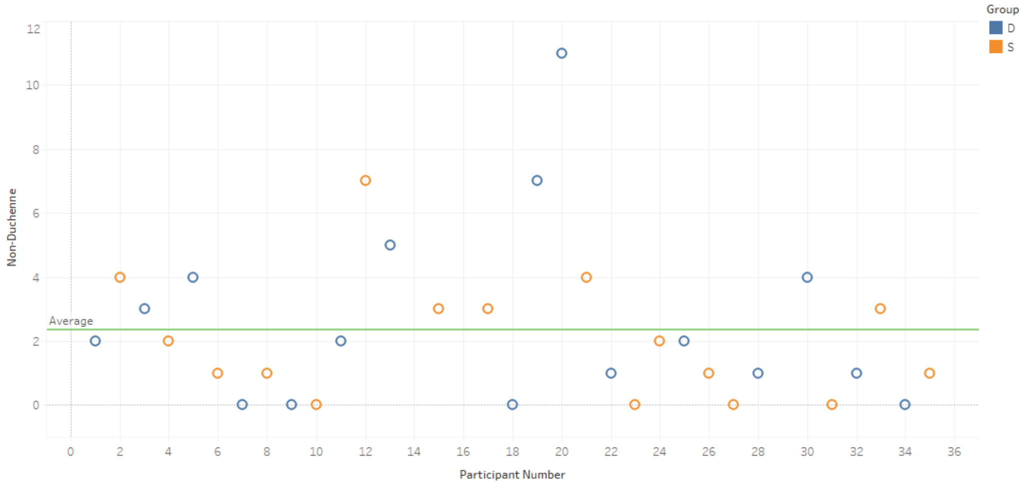


Figure 10a-b: Subject of variablity of number of Duchenne and non-Duchenne smiles.

4.2. Number of smiles - Video Capture Data

As stated in section 3.3.1. of this document, the number of smiles were measured through video recordings of the participants during their interaction with the agent. The video recordings function as a reference point so that the EMG data could be analyzed in a more effective manner. From the video recordings data was gathered about the number of smiles that seemingly occurred during the session. The raw findings can be found in Appendix III-A.

The lip twitches, that some participants exhibited, are left out for the rest of this analysis, due to the fact that they are too subjective to be classified as smiles.

There are a number of interesting findings that can be drawn from all the data that is gathered through the recordings and the annotated smiles from these video files. The first independent t-test is conducted to analyze the significant difference between the mean number of smiles presented to the dominant agent and those presented to the submissive agent. Furthermore, in order to normalize the number of smiles for the duration of each session, the frequency of smiles is calculated and a comparison between the dominant and submissive agent is conducted.

After conducting an independent t-test with a confidence interval of 95%, it was found that the average number of smiles shown during a session with a dominant agent, was 6.50 smiles. The average number of smiles displayed during the period with the submissive agent, was 6.59 smiles. To be able to draw valuable conclusions, it was necessary to create a measurement that could compare the means in a more equal manner. This means that the frequency of the smiles, to normalize the duration, need to be calculated through the following function (1).

(1) $$\frac{Amount\ of\ smiles}{Duration\ of\ session\ (s)} = f(s)$$

The results of this calculation can be found in the table in appendix III C. Since smiles are not displayed within a second but rather during a larger timeframe, it was decided to recalculate these findings into the number of smiles per minute. This was done by using function (2).

(2) $$\left(\frac{Amount\ of\ smiles}{Duration\ of\ session\ (s)}\right) \times 60 = f(m)$$

To calculate whether the difference of the frequency in minutes between the dominant and the submissive group is significant, another independent t-test with a confidence interval of 95% was established. The mean of the frequency in minutes for the dominant group was at 1.559, compared to 1.583 for the submissive group. The difference between these two means was also insignificant, with a p-value at 0.941 ($p = 0.941 > \alpha = 0.05$).

The same tests were conducted to compare female to male responses. It was found that men smiled averagely longer ($\mu = 2.395$) than women ($\mu = 2.379$) by a marginal amount. However, there was no significant difference found between the mean duration of a smile presented by women, compared to that displayed by men ($p = 0.967 > \alpha = 0.05$).

Furthermore, the number of smiles per minutes displayed by women ($\mu = 1.820$), was larger compared to the number displayed by men (μ. = 1.363). However, the difference was not significant ($p = 0.148 > \alpha = 0.05$) to be able to conclude that these findings can be seen as a pattern of behaviour. All of these results can be found in table 9.

Table 9. Results of 5 independent T-tests concerning session duration, number of smiles and frequency of smiles per minute.

Variable	Group	Mean	Std. Dev.	P-Value
Session Duration	D (N=17)	247.5	41.223	0.757
	S (N=17)	242.71	46.466	
	F (N = 16)	2.3793	1.179	0.967
	M (N = 18)	2.395	0.951	
Number of smiles	D (N=17)	6.5	3.445	0.953
	S (N=17)	6.59	4.95	
Frequency (m)	D (N=17)	1.5589	0.73349	0.941
	S (N=17)	1.5827	1.05243	
	F (N = 16)	1.8204	0.78222	0.148
	M (N = 18)	1.3635	0.98875	

Based on this research, H_1: People smile more when in contact with a dominant virtual agent, can be discarded. There is no significant evidence which proves that people smile more when interacting with a dominant virtual agent.

4.3. Number of Duchenne and non-Duchenne smiles - EMG Data

To analyze the EMG Data and compare them to the video data, it was important to know when which smile, as seen in the recordings, occurred. To allow for this type of comparison, the smiles were annotated and the timestamp of the start and ending of each smile was documented. This timestamp was then translated into seconds. The EMG sensor recorded data through a sampling rate of 51Hz, meaning that 51 samples were taken per second. So, in order to compare the data points of the EMG with the video recordings, it was necessary to use formula (3), to really equate these data sets and draw valuable conclusions.

$$\text{(3)} \qquad Duration\ of\ smile\ (s) \times Sampling\ rate\ (Hz)$$

The results of these calculations can be found in Appendix III-A in the last two columns. The values between a beginning and ending of a smile can be considered the smiling range. This smiling range was added to the sensor data. If a smile occurred during a specific timestamp in the sensor data, that datapoint was given the value “1”. If a smile did not occur, that datapoint was given the value “0”. This was done, so that the information could be plotted into a structured graph together with the sensor data recorder from each EMG channel. The plot for each of the participants can be found in Appendix IV-A, with the two EMG channels and the smiling range combined.

In figure 9 and 10, examples from the data (participant 19) are provided. Figure 9 shows a Duchenne smile. The video recording shows a person with a large open-mouthed smile. The yellow line in the graph represents the smiling range as annotated through the video. The orange line shows the EMG sensor data that was gathered from the zygomatic major and the blue line shows the EMG sensor data from the obicularis oculi major. Both of the EMG graphs show a dip in the value at the time the smile occurred. This means that both muscles contracted during the smile and therefore a Duchenne smile occurred.

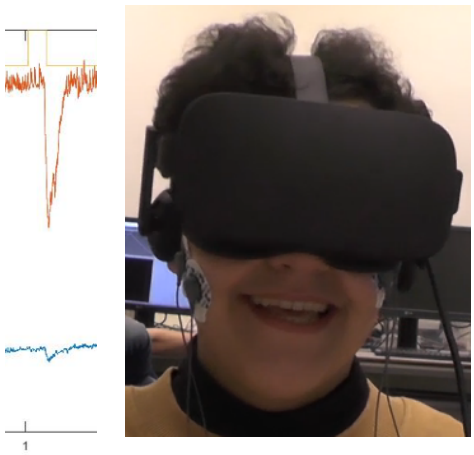


Figure 11: Duchenne smile as visible in the data, with its corresponding video image (participant 19). Yellow line: smile range, orange line: cheek muscle EMG, blue line: eye muscle EMG.

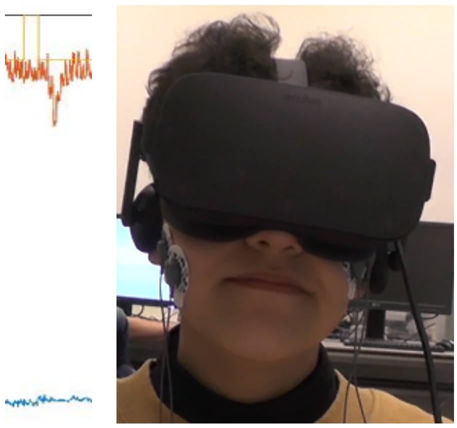


Figure 12: Non-Duchenne smile as visible in the data, with its corresponding video image (participant 19). Yellow line: smile range, orange line: cheek muscle EMG, blue line: eye muscle EMG.

Figure 10 shows a non-Duchenne smile. It is small, but that doesn’t necessarily mean it is less genuine than the smile displayed in figure 9. The smile in figure 10 however, is not genuine as can be seen when comparing the range of the smile to the collected EMG data. It shows that there is a dip in the measurements from the zygomatic major, but not in the measurements from the obicularis oculi major. This means that only the zygomatic major was active during this smile, which gives that a non-Duchenne smile occurred.

After analyzing these graphs, a distribution of types of smiles per participant could be established (Appendix IV-B). Based on the information provided in this appendix, an independent t-test was established that compared whether the group paired with the dominant agent displayed more Duchenne smiles, non-Duchenne smiles and Unidentifiable smiles, than the group paired with the submissive agent. Moreover, an independent t-test was conducted that compared whether men displayed more Duchenne smiles, non-Duchenne smiles and Unidentifiable smiles, than women. This was done for the submissive group as well. The results of these t-tests can be found in table 10.

Table 10. T-test conducted over the distribution of the frequency of types of smiles, based on the comparison between video and EMG data.

Variable	Group	Mean	Std. Dev.	P-value
Duchenne	D	0.5306	0.2833	0.785
	S	0.5672	0.4489	
	F	0.6913	0.3506	0.038
	M	0.4233	0.3485	
Non-Duchenne	D	0.6104	0.6498	0.451
	S	0.4625	0.4219	
	F	0.5946	0.4431	0.578
	M	0.4851	0.6292	
Unidentifiable	D	0.4022	0.3690	0.389
	S	0.5459	0.5448	
	F	0.5019	0.5225	0.756
	M	0.4495	0.4195	

Based on the results from this test, we can state that participants paired with a submissive agent do not smile significantly more in a Duchenne way ($p = 0.785 > \alpha = 0.05$) than those participants paired with a dominant agent. Women are significantly more likely to smile in a Duchenne way, no matter the dominance level of the agent ($p = 0.038 < \alpha = 0.05$). Furthermore, participants paired with a dominant agent, did not smile more in a Non-Duchenne way ($p = 0.451 > \alpha = 0.05$), than those paired with a submissive agent. Unfortunately, there were many unidentifiable smiles, such as visible in the data collected from participant 31 (figure 11). This can mean that there are more Duchenne or Non-

Duchenne smiles than currently analyzed, or that some type of system failure occurred during the session, which caused a sensory problem in the data collection.

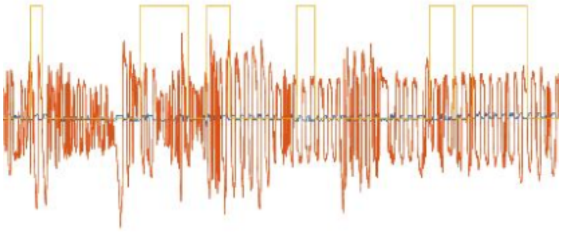


Figure 13: Data collected from participant 31 with clusters of unidentifiable smiles. Yellow line: smile range, orange line: cheek muscle EMG, blue line: eye muscle EMG.

In conclusion, the second hypothesis H_2: People smile more in a non-Duchenne way when interacting with a dominant agent, than when they interact with a submissive agent, can be rejected. This study shows no significant evidence on the truthfulness of this theory. Furthermore, the third hypothesis H_3: People smile less in a Duchenne way when interacting with a dominant agent, than when they interact with a submissive agent, is rejected as well. The results of this study show no significant evidence that this theory is true.

4.4. Questionnaire Data

As a manipulation check, participants were asked to fill out a questionnaire at the end of their session, which asked some standard demographic questions (gender, age, nationality), some questions about their experiences during the session and how they experienced and perceived the virtual agent. The questions can be found in table 11 and the raw data can be found in appendix V.

Table 11. Post-hoc questions asked about the experience with the virtual agent.

Q. Nr.	Question
1	I perceive that there is another person in the virtual room with me
2	I feel that the person in the virtual room is watching me and is aware of my presence
3	The thought that the person is not a real person crosses my mind often
4	The person appears to be alert, conscious and alive to me.
5	I perceive the person as being only a computerized image, not a real person
6	I like the virtual person
7	I think the virtual person is attractive
8	The virtual person is of higher social status than I am

9	My relationship with the virtual person is a casual and informal one
10	I am interested in the virtual person
11	I feel that the virtual person is interesting to look at
12	The virtual person seems physically strong
13	The virtual person seems dominant

This questionnaire was largely taken from a questionnaire by Bailenson et al. (2004). Two questions (question 12 and 13) were added by the researcher, based on the information about dominance that was found during the literature studies. According to the researchers that created the largest part of this questionnaire, this questions in this survey could be divided into four categories: Presence, Likeability, Interest and Dominance. To see if there was a significant correlation within these categories a Cronbach's Alpha test was conducted (table 12).

From this table, it becomes clear that there is not a lot of consistency within the groups of questions. Even for the dominance questions, which were partially based on a previously used questionnaire and partially based on the questions described in section 3.1, the Cronbach's Alpha value was low.

Table 12. Cronbach's Alpha results between question groups

Group	Cronbach's Alpha	Question	Mean	Std. Dev.	Cronbach's alpha if deleted
1 - Presence	0.226	Q1	3.68	0.976	0.212
		Q2	3.53	0.961	0.113
		Q3	3.24	1.017	0.264
		Q4	3.15	0.821	0.044
		Q5	3.47	0.825	0.337
2 - Likability	0.179	Q6	3.5	0.663	-
		Q7	2.56	1.05	-
3 - Interest	0.359	Q10	2.79	1.008	-
		Q11	3.24	0.741	-
4 - Dominance	0.494	Q8	3.24	0.955	0.147
		Q9	2.38	1.047	0.852
		Q12	2.94	1.278	0.167
		Q13	2.85	1.158	0.021

However, in the last column of the table the "Cronbach's Alpha if deleted" is given, which provides information about the importance of a certain question. Looking in this column, it becomes apparent that Q9 is the question that does not have a connection within the dominance group. If this question was left out of this consideration, the Cronbach's alpha would be at 0.852, which means that the consistency and correlation between Q8, Q12 and Q13 is high. However, due to the low cronbach's alpha value, all questions were considered individually. Table 13 provides the question number, the mean and standard deviation in each group, the p value after comparing the means, and whether the Null-hypothesis is accepted. To calculate the significance of the differences between means between group 1 and group 2, an independent t-test was conducted, which is a good choice for a between-group research design.

Table 13. Results of the questionnaire between two groups of participants, after Bonferroni correction.

			Results			
	Group 1 (N = 17)		Group 2 (N = 17)			
Q. Nr.	*μ*	*σ*	*μ*	*σ*	*p-value*	*Significant difference*
1	3.88	0.857	3.47	1.068	0.066	No
2	3.65	1.057	3.41	0.87	0.532	No
3	3.06	0.899	3.41	1.121	0.209	No
4	3.24	0.752	3.06	0.899	0.294	No
5	3.29	0.772	3.65	0.862	0.85	No
6	3.76	0.437	3.24	0.752	0.018	No
7	2.59	1.064	2.53	1.068	0.968	No
8	2.71	0.686	3.76	0.903	0.001	Yes
9	2.82	1.131	1.94	0.827	0.026	No
10	2.94	0.899	2.65	1.115	0.274	No
11	3.18	0.728	3.29	0.772	0.534	No
12	2.24	0.831	3.65	1.272	0.001	Yes
13	2.29	0.92	3.41	1.121	0.003	Yes

To calculate the significance of the differences between the means of each question between group 1 and group 2, the confidence level was set at 95% ($\alpha = 0{,}05$). As can be seen in table 6, there are significant differences found for question 6, 8, 9, 12 and 13. To reduce the chances of having false positive results, a Bonferroni correction was added over the results, which reduced the significance level α to $0.05/13 = 0.004$. Only question 8, 12 and 13 then remained significant, which seems logical, since these are the only questions that are related to each other according to the Cronbach's Alpha correlation calculation.

Based on the significant difference between means for question 8, we can conclude that the dominant agent is perceived to have a higher social status compared to the submissive agent ($p = 0.001 < \alpha = 0.004$). Furthermore, it also becomes clear that the dominant agent is perceived as significantly stronger than the submissive agent ($p = 0.001 < \alpha = 0.004$). Lastly, the dominant agent is perceived as significantly more dominant than the submissive agent ($p = 0.003 < \alpha = 0.004$). All other questions didn't show any significant results.

These findings suggest that the created agents were believable, in the sense that the participants perceived the agents as they should have been perceived. Group 1 perceived their agent as dominant, as was the intention. Group 2 perceived their agent as submissive, as was the intention. This means that the agents were set up correctly so the research questions can be answered.

5. Discussion

5.1 Hypotheses

Through research by Ketelaar et al. (2012) it was found that people paired with a dominant individual smiled more frequently in an interaction than people paired with a submissive partner. Based on this research, the hypothesis, H_1: people smile more when interacting with a dominant agent, was established. Our research cannot confirm this theory because no significant difference was found between the two participant groups. For example, participant 12 smiled a total of 19 times and was paired with the submissive agent. During the session, she felt that she became more powerful, dominant and confident due to the exhibited submissiveness of the agent. Yet, she smiled more often than any of the other people participating in this research. This means that she felt dominant over the submissive agent, but expressed this dominance in an opposite manner than was expected. H_1 was therefore rejected.

Furthermore, based on the research conducted by Hecht and LaFrance (1998), H_2: people smile more in a non-Duchenne way when in contact with a dominant virtual agent, in comparison to a submissive virtual agent, was established. Through our research, no significant evidence was found that confirms this theory, and the hypothesis was therefore rejected.

Based on the same research, H_3: people smile more in a Duchenne way when in contact with a submissive virtual agent, in comparison to someone paired with a dominant agent, was established. Through the research described in this document, no significant evidence has been found that supports this claim.

5.2. Limitations of the Research

There are a few potential reasons why our results do not agree with the conclusions by Ketelaar et. al. (2012) and Hecht and LaFrance (1998).

Three different data types were gathered through the course of this research. Based on the information collected through the questionnaire, it was found that the created submissive and dominant agent fulfilled their function, in the sense that participants perceived them with the correct level of dominance. However, through reviews of the session together with the participants, some small issues with the virtual agent became apparent.

Some participants found that the agent was too close to where the participant was seated, which generated an extra uncomfortable feeling within a couple of the participants. Furthermore, the dominant agent was very large, while some of the participants were quite small. Due to a programming mistake, the eyes of the dominant agent were not targeted towards the eyes of the participant. Some participants noticed this problem because they were very short and the agent seemed to look over them, rather than at them. This caused that some participants felt less presence than the other participants and in turn, made the agent less believable.

Moreover, it is possible that there are not enough people that participated in this research, to be able to draw a conclusion based on a significant difference between the submissive and dominant agent. It was not possible to have more participants due to the time, money and accessibility limitations that accompanied this research. It is possible, that more participants will generate results that show significant differences between participants paired with a dominant agent and those paired with a submissive agent. This, however, is not certain.

Furthermore, due to the limitations of this research, thorough personality studies were not conducted. However, personality can easily contribute to how participants behave with a virtual agent, which can be seen on the video recordings. Some people get more nervous when confronted with displays of nervousness by the virtual agent, while others get a feeling of power. Some people freeze up in their facial expressiveness when confronted with a dominant agent, while other get more expressive. In other words, this research shows that it is possible that personality should be added to the data collection process, to be able to potentially draw better conclusions.

Another limitation of this research, was that the agent did not respond verbally to what the participant was saying. In a job interview, the interviewer usually asks follow-up questions that refer to the answers given by the interviewee. The lack of verbal responses from the agents caused a certain uneasiness for some people. It also meant that the agents were not as human in their behaviour as they could be which made them less believable since the agents had a very human-like appearance. This limited the possibility of having a natural conversation. However, this limitation was necessary, because the addition of intelligence to the virtual agent would increase the number of variables significantly. The resources to both create and process this intelligent entity, were simply unavailable.

Moreover, the graphs in appendix IV show that there are large differences between the sensory data of different participants. This can be due to how the sensors were placed, or what type of surface they were placed on. For example, some participants had more fat on their cheeks, which could have influenced the data gathered from the sensor.

5.3. Future Research

This research focused on finding the effects of dominance on the human smiling behaviour in a human-agent interaction dyad. The scope of this research was limited to finding correlations between dominance and the number of smiles, and finding correlations between dominance and the number of Duchenne and non-Duchenne smiles. Furthermore, this study used two, Caucasian male agents in a job interview setting to answer test the hypotheses.

In further research, we recommend a shift in focus, so that more facets of the effects of dominance on smiling behaviour can be tested.

Firstly, it would be beneficial to include a personality test in the research, since one's personality can have a big influence on how they respond to perceived dominance. A person who is a generally happy person might be more likely to smile than people dealing with depression, for example. Comparing the results of this test to the data that is gathered through the interaction, can give a better insight into human smiling behaviour when interacting with a dominant or submissive virtual character.

It could also be relevant to do a pretest concerning the mood of the participant. Smilling frequency, at least for Duchenne smiles, could be dependent on the person's mood of that day. If, for example, someone's cat has died that morning, they might feel sad and are therefore less likely to smile than otherwise. Similarly, if someone received a 10 for their research proposal 10 minutes before the start of the interaction, they might feel euphoric and smile more than usual. It could be beneficial to incorporate this kind of test before starting the interaction with the agent.

Furthermore, the current agents are male and Caucasian. It would be interesting to see if there are cross-cultural differences or differences between genders. As can be found in many studies (e.g. Hess, U., Blairy, S., Kleck, R.E., 2000), people react differently to women in power and different races in power, depending on their own race and gender.

Moreover, it would be beneficial to see if a change of scenario would affect the smiling behaviour of the participant. For this project, we focused on a potential job interview.

However, there are many other potential scenarios in which a dominant or submissive person would interact with the participant, e.g. in a professor-student relationship.

Lastly, it can be useful, to create a larger scenario in which a longer interaction between human and agent can take place. This way, the researcher is able to gather more data and can potentially draw more valuable conclusions.

6. Conclusion

At the beginning of this document, research questions were established. Through the course of this study, we tried to find answers to these questions by placing participants in a virtual environment and letting them interact with a dominant or submissive virtual agent. Data was gathered through video recordings, an EMG sensor and a questionnaire. By analyzing this data, the research questions could be answered.

The first subquestion researched was: Do people smile more when interacting with a dominant virtual agent? Based on our research, we have found the opposite to be slightly true, but not significantly so. It is fair to state that this question can be answered negatively. People do not smile more when interacting with a dominant virtual agent.

The second subquestion researched was: Do people smile more in a non-Duchenne way when interacting with a dominant virtual character? By analyzing the data and combining video and EMG information, it was found that this appeared to be marginally true, but the difference was not significant. The question can therefore be answered negatively. People do not smile more in a non-Duchenne way when interacting with a dominant virtual character.

Therefore, the main question - What is the effect of dominance on the smiling behaviour in a human-agent dyad - can be answered as follows. Two of the main effects of dominance on the smiling behaviour in a human-agent dyad, should be the frequency and the type of smile. Based on the research conducted here, these factors do not have a measurable effect. There might be other effects of dominance on smiling patterns not within the scope of this research.

References

Adams, E. (2016). Most Virtual Reality Is Not Virtual Reality. Here's Why. Retrieved from https://gearpatrol.com/2016/07/18/virtual-reality-vs-360-video/

Argyle, M. (2013). *Bodily Communication*. Routledge.

Bailenson, J. N., Blascovich, J., Beall, A. C., & Loomis, J. M. (2001). Equilibrium Theory Revisited: Mutual Gaze and Personal Space in Virtual Environments. *Presence: Teleoperators and Virtual Environments*, *10*(6), 583–598.

Bailenson, J.N., Guadagno, R.E., Aharoni, E., Dimov, A., Beall, A.C., Blascovich, J. (2004). Comparing Behavioral and Self-Report Measures of Embodied Agents' Social Presence in Immersive Virtual Environments. In *Proceedings of the 7th Annual International Workshop on PRESENCE*

Bailenson, J. N., Swinth, K., Hoyt, C., Persky, S., Dimov, A., & Blascovich, J. (2005). The Independent and Interactive Effects of Embodied-Agent appearance and behavior on self-report, cognitive, and behavioral markers of copresence in immersive virtual environments. *Presence: Teleoperators and Virtual Environments*, *14*(4), 379–393.

Bates, J. (1994). The Role of Emotion in Believable Agents. *Communications of the ACM*, *37*(7), 122–125.

Baylor, A. L. (2009). Promoting motivation with virtual agents and avatars: role of visual presence and appearance. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *364*(1535), 3559–3565. https://doi.org/10.1098/rstb.2009.0148

Baylor, A. L. (2011). The Design of Motivational Agents and Avatars. *Educational Technology Research and Development*, *59*(2), 291–300.

Bee, N., Franke, S., & Andree, E. (2009). Relations between facial display, eye gaze and head tilt: Dominance perception variations of virtual agents. In *2009 3rd International Conference of Affective Computing and Intelligent Interaction and Workshops* (pp. 1–7).

Bickmore, T., Gruber, A., & Picard, R. (2005). Establishing the computer-patient working alliance in automated health behavior change interventions. *Patient Education and Counseling*, *59*(1), 21–30.

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive Virtual Environment Technology as a Methodological Tool for Social Psychology. *Psychological Inquiry*, *13*(2), 103–124.

Boxtel, A. van (2010). Facial EMG as a Tool for Inferring Affective States. *Proceedings of Measuring Behaviour* (pp. 104-108)

Burgoon, J. K., & Dunbar, N. E. (2006). Nonverbal Expressions of Dominance and Power in Human Relationships. *The Sage Handbook of Nonverbal Communication*, *2*.

Burgoon, J. K., & Saine, T. (1978). *The Unspoken Dialogue: An Introduction to Nonverbal Communication*. Houghton Mifflin Boston.

Callejas, Z., Ravenet, B., Ochs, M., & Pelachaud, C. (2014). A model to generate adaptive multimodal job interviews with a virtual recruiter. In *LREC* (pp. 3615-3619).

Cassell, J., & Tartaro, A. (2007). Intersubjectivity in human-agent interaction. *Interaction Studies*, *8*(3), 391–410.

Charness, G., Gneezy, U., & Kuhn, M.A. (2012). Experimental methods: Between-subject and within-subject design. *Journal of Economic Behavior & organization, 81(1)*, 1-8

Congdon, E., Novack, M., & Goldin-Meadow, S. (2016). Gesture in Experimental Studies: How Videotape Technology can Advance Psychological Theory. *Organizational Research Methods*.

De Carolis, B., Pelachaud, C., Poggi, I., & Steedman, M. (2004). APML, a markup language for believable behavior generation. In *Life-Like Characters* (pp. 65–85).

Ekman, P., Davidson, R. J., & Friesen, W. V. (1990). The Duchenne Smile: Emotional Expression and Brain Physiology: II. *Journal of Personality and Social Psychology*, *58*(2), 342.

Ekman, P., Roper, G., Hager, J.C. (1980). Deliberate Facial Movement. *Child Development, 51(3)*, 886-891

Ekman, P., Friesen, W.V., Simons, R.C. (1985). Is the startle reaction an emotion? *Journal of Personality and Social Psychology, 49(5)*, 1416-1426

Ellyson, S. L., & Dovidio, J. F. (1985). Power, Dominance and nonverbal behavior: Basic concepts and issues. In *Power, Dominance, and Nonverbal Behavior* (pp. 1–27).

Etikan, I., Musa, S.A., & Alkassim, R.S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics, 5(1)*, 1-4

Goldenthal, P., Johnston, R. E., & Kraut, R. E. (1981). Smiling, appeasement, and the silent bared-teeth display. *Ethology and Sociobiology*, *2*(3), 127–133.

Gratch, J., Morency, L.-P., Scherer, S., Stratou, G., Boberg, J., Koenig, S., … Rizzo, A. A. (2013). User-State Sensing for Virtual Health Agents and Telehealth Applications. In *MMVR* (pp. 151–157).

Hareli, S., Shomrat, N., & Hess, U. (2009). Emotional versus neutral expressions and perceptions of social dominance and submissiveness. *Emotion*, *9*(3), 378.

Hecht, M. A., & LaFrance, M. (1998). License or obligation to smile: The effect of power and sex on amount and type of smiling. *Personality and Social Psychology Bulletin*, *24*(12), 1332–1342.

Hess, U., Blairy, S., & Kleck, R. E. (2000). The Influence of Facial Emotion Displays, Gender, and Ethnicity on Judgments of Dominance and Affiliation. *Journal of Nonverbal Behavior*, *24*(4), 265–283. https://doi.org/10.1023/A:1006623213355

Hess, U., Kappas, A., McHugo, G. J., Kleck, R. E., & Lanzetta, J. T. (1989). An Analysis of the Encoding and Decoding of Spontaneous and Posed Smiles: The Use of Facial Electromyography. *Journal of Nonverbal Behavior*, *13*(2), 121–137.

Jenkins, G. D., & Taber, T.D. (1977). A Monte Carlo study of factors affecting three indices of composite scale reliability. *Journal of Applied Psychology, 62*(4), 392

Kaiser, S., Wehrle, T., & Schmidt, S. (1998). Emotional Episodes, Facial Expression, and Re-ported Feelings in Human-Computer Interactions. In *Proceedings of the 10th Conference of the International Society for Research on Emotions* (pp. 82–86).

Katagiri, Y., Takahashi, T., & Takeuchi, Y. (2001). Social Persuasion in Human Agent Interaction. In *Second IJCAI Workshop on Knowledge and Reasoning in Practical Dialogue Systems* (pp. 64–69).

Ketelaar, T., Koenig, B. L., Gambacorta, D., Dolgov, I., Hor, D., Zarzosa, J., … Wells, L. (2012). Smiles as signals of lower status in football players and fashion models: evidence that smiles are associated with lower dominance and lower prestige. *Evolutionary Psychology*, *10*(3).

Konstantinidis, E. I., Hitoglou-Antoniadou, M., Luneski, A., Bamidis, P. D., & Nikolaidou, M. M. (2009). Using Affective Avatars and Rich Multimedia Content for Education of Children with Autism. In *Proceedings of the 2nd International Conference on Pervasive Technologies Related to Assistive Environments* (p. 58).

Kramer, N. C., Von der Putten, A., & Eimler, S. (2012). Human-agent and Human-robot interaction theory: similarities to and differences from human-human interaction. In *Human-Computer Interaction: The Agency Perspective* (pp. 215–240).

Lee, M. T., & Ofshe, R. (1981). The Impact of Behavioral Style and Status Characteristics on Social Influence: A Test of Two Competing Theories. *Social Psychology Quarterly*, *44*(2), 73–82.

Lissitz, R.W., & Green, S.B. (1975). Effect of the number of scale points on reliability: A Monte Carlo approach. *Journal of Applied Psychology, 60*(1), 10.

Loomis, J. M., Blascovich, J. J., & Beall, A. C. (1999). Immersive Virtual Environment Technology as a Basic Research Tool in Psychology. *Behavior Research Methods, Instruments, & Computers*, *31*(4), 557–564.

Marton-Williams, J. (1986). Questionnaire design. *Consumer market research handbook*, 3.

Mazur, A. (1985). A Biosocial Model of Status in Face-To-Face Primate Groups. *Social Forces*, *64*(2), 377–402.

Mazur, A., & Cataldo, M. (1989). Dominance and Deference in Conversation. *Journal of Social and Biological Structures*, *12*(1), 87–99.

Nass, C., & Moon, Y. (2000). Machines and mindlessness: Social responses to computers. *Journal of social issues, 56(1)*, 81-103

Nowak, K. L., & Biocca, F. (2003). The Effect of the Agency and Anthropomorphism on Users' Sense of Telepresence, Copresence, and Social Presence in Virtual Environments. *Presence: Teleoperators and Virtual Environments*, *12*(5), 481–494. https://doi.org/10.1162/105474603322761289

Qiu, L., & Benbasat, I. (2009). Evaluating Anthropomorphic Product Recommendation Agents: A Social Relationship Perspective to Designing Information Systems. *Journal of Management Information Systems*, *25*(4), 145–182.

Sayette, M. A., Cohn, J. F., Wertz, J. M., Perrott, M. A., & Parrott, D. J. (2001). A Psychometric Evaluation of the Facial Action Coding System for Assessing Spontaneous Expression. *Journal of Nonverbal Behavior*, *25*(3), 167–185.

Slater, M., Usoh, M., & Steed, A. (1994). Depth of Presence in Virtual Environments. *Presence: Teleoperators and Virtual Environments*, *3*(2), 130–144.

Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of Communication*, *42*(4), 73–93.

Swinth, K., & Blascovich, J. (392AD). Perceiving and Responding to Others: Human-Human and Human-Computer Social Interaction in Collaborative Virtual Environments. In *Proceedings of the 5th Annual International Workshop on Presence* (p. 2002).

Thalmann, D. (2001). The Foundations to Build a Virtual Human Society. In *Intelligent Virtual Agents* (pp. 1–14).

Thomas, F., & Johnston, O. (1995). *The Illusion of Life: Disney Animation*. Hyperion New York.

Tiedens, L. Z., & Fragale, A. R. (2003). Power moves: complementarity in dominant and submissive nonverbal behavior. *Journal of Personality and Social Psychology*, *84*(3), 558.

Tomlinson, B., & Blumberg, B. (2002). Alphawolf: Social learning, emotion and development in autonomous virtual agents. In *Workshop on Radical Agent Concepts* (pp. 35–45).

Tullar, W. L. (1989). Relational control in the employment interview. *Journal of Applied Psychology*, *74*(6), 971.

Von Baeyer, C. L., Sherk, D. L., & Zanna, M. P. (1981). Impression management in the job interview: When the female applicant meets the male (chauvinist) interviewer. *Personality and Social Psychology Bulletin*, *7*(1), 45–51.

Appendix I – Job Description used during Experiment

DorseyDesign

Job description: Junior Virtual reality designer

Virtual reality is currently one of the fastest developing tech fields and the home of some of tech's hottest jobs.
"The number of projects in the VR market is growing very fast", said Vassili Philippov, founder of MEL Science, an education startup that uses virtual reality technology. "In 2016 the number of VR headsets sold will increase more than 10 times. There is a good chance it will grow even more in 2017."

As a junior virtual reality designer for Dorsey Design, you are a tech designer who likes to work in 3D and has extensive knowledge about different programming languages such as Java, C#, HTML and CSS. You will use these skills and various computer programs to create animations that can mimic a world or make a completely new one. As a virtual reality designer, you will have superior skills with development suites such as Unreal Engine and Unity 3D.

Dorsey Design is a large company that creates VR solutions for many esteemed companies. As a virtual reality designer you will be put in a team that collaborates together to create the best VR solutions possible. You have many opportunities to grow inside our company to for example a leader of a creative team. Many of our clients are based internationally, so you will have many opportunities to explore countries and cultures.

We offer you

- a stable job in a large pioneering company.
- a good starting salary of 2800 euro bruto per month
- a company car, phone and laptop

We expect you to have

- perfect knowledge of 3D
- perfect knowledge of design methodology
- the ability to coordinate in a team
- sufficient programming skills in Java and C#
- some experience with HTML and CSS
- sufficient English skills
- a lot of motivation
- sufficient social skills to be able to converse with our stakeholders and clients

Appendix II – Questionnaire used in Experiment

Thank you for participating in this research. This survey will ask you some questions about your experiences in the virtual environment. Please answer them as honestly as you are able to.

Gender:

Male / Female / Undefined

Age:

…………………………………………....

Have you worked or played with virtual reality before?

Yes / No

Have you ever been interviewed for a job?

Yes / No

What is your nationality?

……………………………………………..

Rate the following statements as best as you are able to.

I perceive that there is another person in the virtual room with me.

Strongly Disagree / Disagree / Undecided / Agree / Strongly Agree

I feel that the person in the virtual room is watching me and is aware of my presence.

Strongly Disagree / Disagree / Undecided / Agree / Strongly Agree

The thought that the person is not a real person crosses my mind often.

Strongly Disagree / Disagree / Undecided / Agree / Strongly Agree

The person appears to be alert, conscious and alive to me.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

I perceive the person as being only a computerized image, not a real person.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

I like the virtual person.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

I think the virtual person is attractive.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

The virtual person is of higher social status than I am.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

My relationship with the virtual person is a casual and informal one.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

I am interested in the virtual person.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

I feel that the virtual person is interesting to look at.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

The virtual person seems physically strong.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

The virtual person seems dominant.

Strongly disagree / Disagree / Undecided / Agree / Strongly Agree

Appendix III – Video Data

A. Raw Video Data – twitch data not included

P. Nr.	Gender	Group	Type Smile	Duration	Start Smile (s)	Stop Smile (s)	EMG Ref (start)	EMG Ref (stop)
1	F	D	Large	1.72	138	140	7038	7140
1	F	D	Large	1.70	147	149	7497	7599
1	F	D	Small	1.02	183	184	9333	9384
1	F	D	Large	1.91	220	222	11220	11322
1	F	D	Small	0.53	232	233	11832	11883
1	F	D	Small	1.19	245	246	12495	12546
2	F	S	Small	2.80	97	100	4947	5100
2	F	S	Small	4.68	145	150	7395	7650
2	F	S	Small	4.12	180	184	9180	9384
2	F	S	Small	1.78	197	199	10047	10149
2	F	S	Small	1.89	221	223	11271	11373
2	F	S	Large	2.95	227	230	11577	11730
2	F	S	Large	3.02	242	245	12342	12495
2	F	S	Small	2.29	265	267	13515	13617
2	F	S	Small	6.66	268	274	13668	13974
2	F	S	Small	0.73	284	285	14484	14535
2	F	S	Small	5.63	292	298	14892	15198
2	F	S	Small	1.47	317	319	16167	16269
2	F	S	Small	1.80	324	326	16524	16626
2	F	S	Small	0.89	351	352	17901	17952
3	M	D	Small	3.02	161	164	8211	8364
3	M	D	Large	4.38	181	185	9231	9435
3	M	D	Large	9.09	207	216	10557	11016
3	M	D	Large	6.82	240	247	12240	12597
3	M	D	Large	3.63	248	252	12648	12852
3	M	D	Small	1.70	352	354	17952	18054
4	M	S	Small	1.10	69	70	3519	3570
4	M	S	Small	1.25	197	198	10047	10098
4	M	S	Large	2.50	199	201	10149	10251
4	M	S	Small	1.57	235	236	11985	12036
4	M	S	Small	0.75	303	304	15453	15504

4	M	S	Small	1.46	350	351	17850	17901
4	M	S	Small	1.68	357	359	18207	18309
4	M	S	Small	1.31	372	374	18972	19074
5	F	D	Small	1.02	71	72	3621	3672
5	F	D	Small	2.00	164	166	8364	8466
5	F	D	Large	4.35	172	177	8772	9027
5	F	D	Large	3.41	188	192	9588	9792
5	F	D	Small	0.84	197	198	10047	10098
5	F	D	Large	2.42	231	234	11781	11934
5	F	D	Small	0.99	263	264	13413	13464
5	F	D	Large	2.25	268	270	13668	13770
5	F	D	Small	3.45	289	293	14739	14943
6	F	S	Small	1.17	214	215	10914	10965
7	M	D	Small	1.07	107	108	5457	5508
7	M	D	Small	0.77	112	113	5712	5763
7	M	D	Small	0.91	214	215	10914	10965
7	M	D	Small	1.25	216	217	11016	11067
8	M	S	Large	3.28	136	139	6936	7089
8	M	S	Small	1.54	150	152	7650	7752
8	M	S	Large	3.93	153	157	7803	8007
8	M	S	Large	2.21	161	163	8211	8313
8	M	S	Large	2.54	207	210	10557	10710
8	M	S	Large	3.58	231	235	11781	11985
8	M	S	Large	1.92	240	242	12240	12342
9	M	D	Small	1.46	145	146	7395	7446
9	M	D	Small	2.13	158	160	8058	8160
9	M	D	Small	0.94	172	173	8772	8823
9	M	D	Large	4.10	211	215	10761	10965
10	M	S	Small	1.70	75	76	3825	3876
11	M	D	Small	1.40	52	53	2652	2703
11	M	D	Large	2.17	137	139	6987	7089
11	M	D	Small	1.52	156	157	7956	8007
11	M	D	Small	1.30	174	176	8874	8976
11	M	D	Small	0.91	232	233	11832	11883
11	M	D	Small	0.96	248	249	12648	12699
12	F	S	Large	2.05	15	17	765	867

12	F	S	Large	3.67	26	29	1326	1479
12	F	S	Small	1.72	51	53	2601	2703
12	F	S	Small	1.18	97	98	4947	4998
12	F	S	Small	1.63	107	108	5457	5508
12	F	S	Small	1.05	111	112	5661	5712
12	F	S	Large	3.05	115	118	5865	6018
12	F	S	Small	1.46	132	134	6732	6834
12	F	S	Large	4.97	137	142	6987	7242
12	F	S	Small	0.79	144	145	7344	7395
12	F	S	Small	1.96	168	170	8568	8670
12	F	S	Small	0.61	172	173	8772	8823
12	F	S	Small	1.51	176	178	8976	9078
12	F	S	Small	0.93	192	193	9792	9843
12	F	S	Small	1.06	215	216	10965	11016
12	F	S	Small	1.66	224	226	11424	11526
12	F	S	Large	5.42	261	266	13311	13566
12	F	S	Small	0.89	272	273	13872	13923
12	F	S	Small	1.63	274	276	13974	14076
13	M	D	Small	0.80	90	91	4590	4641
13	M	D	Small	2.98	101	104	5151	5304
13	M	D	Small	1.00	109	110	5559	5610
13	M	D	Small	1.45	122	123	6222	6273
13	M	D	Small	0.80	131	132	6681	6732
13	M	D	Small	0.56	133	134	6783	6834
13	M	D	Small	1.11	152	153	7752	7803
13	M	D	Small	2.06	180	182	9180	9282
13	M	D	Small	2.44	200	202	10200	10302
13	M	D	Small	1.53	224	226	11424	11526
13	M	D	Large	1.89	241	242	12291	12342
15	M	S	Small	0.98	149	150	7599	7650
15	M	S	Small	1.03	191	192	9741	9792
15	M	S	Small	1.62	204	206	10404	10506
15	M	S	Small	0.88	221	222	11271	11322
15	M	S	Large	2.90	244	247	12444	12597
17	F	S	Small	4.89	75	80	3825	4080
17	F	S	Large	4.65	157	162	8007	8262

17	F	S	Large	2.61	168	170	8568	8670
17	F	S	Small	5.37	220	226	11220	11526
17	F	S	Small	3.40	266	269	13566	13719
17	F	S	Small	3.70	288	292	14688	14892
17	F	S	Large	1.61	307	309	15657	15759
20	M	D	Small	2.32	40	43	2040	2193
20	M	D	Small	1.43	321	323	16371	16473
21	M	S	Small	0.93	86	87	4386	4437
21	M	S	Small	2.41	91	94	4641	4794
21	M	S	Large	2.43	96	99	4896	5049
21	M	S	Large	2.15	101	103	5151	5253
21	M	S	Small	1.03	104	105	5304	5355
21	M	S	Large	1.25	119	120	6069	6120
21	M	S	Small	0.69	127	128	6477	6528
21	M	S	Large	2.93	140	143	7140	7293
21	M	S	Large	1.30	143	145	7293	7395
21	M	S	Large	1.99	153	155	7803	7905
21	M	S	Small	2.06	212	214	10812	10914
21	M	S	Small	1.19	222	223	11322	11373
22	F	D	Small	1.07	103	105	5253	5355
22	F	D	Small	1.46	113	114	5763	5814
22	F	D	Small	1.43	172	174	8772	8874
23	F	S	Small	1.28	109	110	5559	5610
23	F	S	Small	1.01	143	144	7293	7344
23	F	S	Large	1.83	187	189	9537	9639
24	F	S	Large	2.55	110	113	5610	5763
24	F	S	Large	1.47	144	146	7344	7446
24	F	S	Small	1.17	177	178	9027	9078
24	F	S	Small	1.21	192	193	9792	9843
24	F	S	Small	1.57	198	200	10098	10200
25	F	D	Small	1.25	135	136	6885	6936
25	F	D	Small	1.90	143	145	7293	7395
25	F	D	Small	3.51	181	185	9231	9435
25	F	D	Small	4.78	205	209	10455	10659
25	F	D	Small	3.18	222	225	11322	11475
25	F	D	Small	4.31	241	245	12291	12495

25	F	D	Small	3.26	266	269	13566	13719
25	F	D	Small	3.49	274	277	13974	14127
26	F	S	Small	3.99	99	103	5049	5253
26	F	S	Large	2.68	105	108	5355	5508
26	F	S	Small	0.94	113	114	5763	5814
26	F	S	Small	1.15	146	147	7446	7497
26	F	S	Large	7.16	154	161	7854	8211
27	M	S	Small	1.93	126	128	6426	6528
27	M	S	Small	2.95	207	210	10557	10710
29	M	S	Small	1.95	119	121	6069	6171
29	M	S	Small	1.19	163	164	8313	8364
29	M	S	Small	1.00	201	202	10251	10302
29	M	S	Small	7.34	219	226	11169	11526
30	M	D	Large	1.91	176	178	8976	9078
30	M	D	Small	1.19	256	257	13056	13107
30	M	D	Small	0.94	277	278	14127	14178
30	M	D	Small	0.76	284	285	14484	14535
30	M	D	Small	1.75	296	298	15096	15198
31	M	S	Small	0.90	140	141	7140	7191
31	M	S	Small	6.04	158	164	8058	8364
31	M	S	Small	1.20	169	171	8619	8721
31	M	S	Small	0.97	184	185	9384	9435
31	M	S	Small	1.63	205	207	10455	10557
31	M	S	Large	5.67	212	218	10812	11118
32	M	D	Small	2.34	47	49	2397	2499
32	M	D	Small	2.32	56	58	2856	2958
32	M	D	Small	4.53	151	156	7701	7956
32	M	D	Large	3.23	215	218	10965	11118
32	M	D	Small	3.24	260	263	13260	13413
33	F	S	Large	3.80	131	135	6681	6885
33	F	S	Large	2.44	210	212	10710	10812
33	F	S	Large	5.65	213	219	10863	11169
19	F	D	Small	3.18	49	52	2499	2652
19	F	D	Large	3.01	129	132	6579	6732
19	F	D	Small	3.83	166	170	8466	8670
19	F	D	Small	4.52	198	202	10098	10302

19	F	D	Small	1.59	223	225	11373	11475
19	F	D	Large	2.44	232	235	11832	11985
19	F	D	Large	1.97	257	259	13107	13209
19	F	D	Small	1.16	293	294	14943	14994
19	F	D	Large	4.25	309	313	15759	15963
19	F	D	Large	3.92	317	321	16167	16371
19	F	D	Small	1.64	332	334	16932	17034
19	F	D	Small	1.87	360	362	18360	18462
18	M	D	Small	8.24	47	56	2397	2856
18	M	D	Small	2.01	146	148	7446	7548
28	F	D	Small	1.25	135	136	6885	6936
28	F	D	Small	3.51	181	185	9231	9435
28	F	D	Small	4.52	198	202	10098	10302
28	F	D	Small	4.78	205	209	10455	10659
28	F	D	Small	3.18	222	225	11322	11475
28	F	D	Small	1.59	235	238	11985	12138
35	M	S	Large	5.34	52	57	2652	2907
35	M	S	Small	2.87	125	128	6375	6528
35	M	S	Large	4.59	143	148	7293	7548
35	M	S	Small	2.22	158	160	8058	8160
35	M	S	Small	3.71	173	177	8823	9027
35	M	S	Large	6.3	207	213	10557	10863
35	M	S	Small	4.27	230	234	11730	11934
35	M	S	Small	2.02	241	243	12291	12393
35	M	S	Large	3.39	248	251	12648	12801
35	M	S	Small	2.62	287	289	14637	14739
35	M	S	Large	3.25	302	305	15402	15555
34	F	D	Small	1.51	90	82	4590	4182
34	F	D	Small	1.43	99	100	5049	5100
34	F	D	Small	1.48	101	102	5151	5202
34	F	D	Small	2.01	122	124	6222	6324
34	F	D	Small	1.97	148	150	7548	7650
34	F	D	Small	1.18	151	152	7701	7752
34	F	D	Large	3.09	168	171	8568	8721
34	F	D	Small	1.07	198	199	10098	10149
34	F	D	Small	2.23	202	204	10302	10404

34	F	D	Small	1.12	212	213	10812	10863
34	F	D	Small	1.92	241	243	12291	12393
34	F	D	Small	1.46	265	267	13515	13617
34	F	D	Small	1.51	268	269	13668	13719
34	F	D	Small	2.67	318	321	16218	16371

B. Video Data – Smiles Distribution

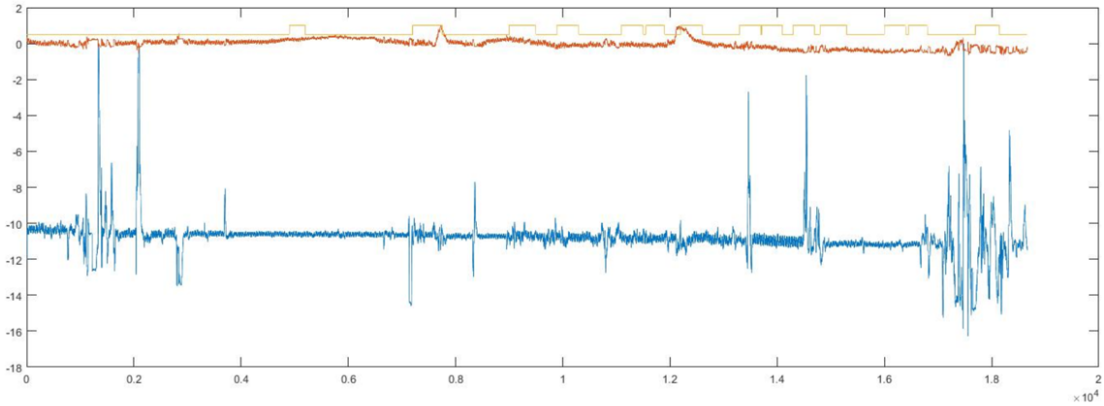
P. Nr.	Group	Gender	Total Smiles	Twitch	Small	Large	Count (w.o. twitch)
1	D	F	8	2	3	3	6
2	S	F	14	0	12	2	14
3	D	M	9	3	2	4	6
4	S	M	12	4	7	1	8
5	D	F	9	0	5	4	9
6	S	F	1	0	1	0	1
7	D	M	9	5	4	0	4
8	S	M	10	3	1	6	7
9	D	M	6	2	3	1	4
10	S	M	2	1	1	0	1
11	D	M	9	3	5	1	6
12	S	F	25	6	14	5	19
13	D	M	14	3	10	1	11
14	S	M	6	1	4	1	5
15	S	F	11	4	4	3	7
16	D	F	0	0	0	0	0
17	D	M	2	0	2	0	2
18	D	F	12	0	7	5	12
19	D	M	3	1	2	0	2
20	S	M	12	0	6	6	12
21	D	F	7	4	3	0	3
22	S	F	4	1	2	1	3
23	S	F	5	0	3	2	5
24	D	F	8	0	8	0	8
25	S	F	5	0	3	2	5
26	S	M	5	3	2	0	2
27	D	F	6	0	6	0	6
28	S	M	4	0	4	0	4
29	D	M	5	0	4	1	5
30	S	M	7	1	5	1	6
31	D	M	9	4	4	1	5
32	S	F	5	2	0	3	3
33	D	F	14	0	13	1	14
34	S	M	11	0	6	5	11

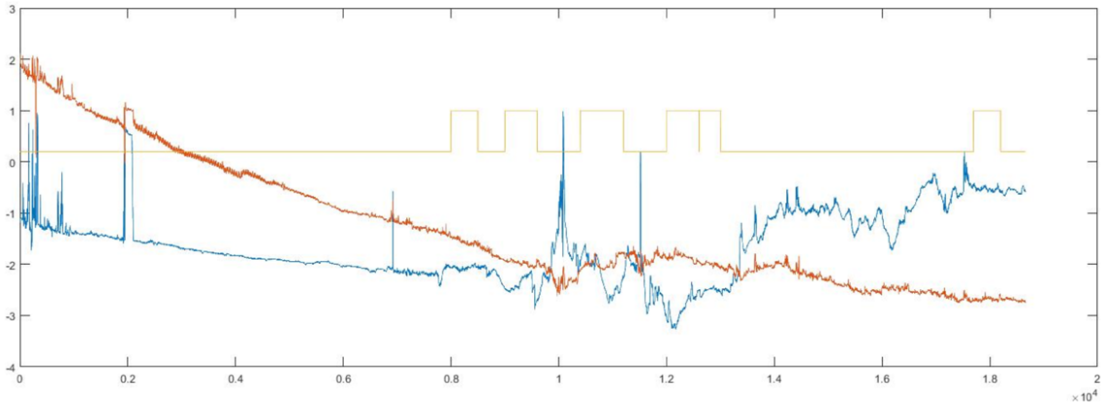
C. Video Data - Frequencies

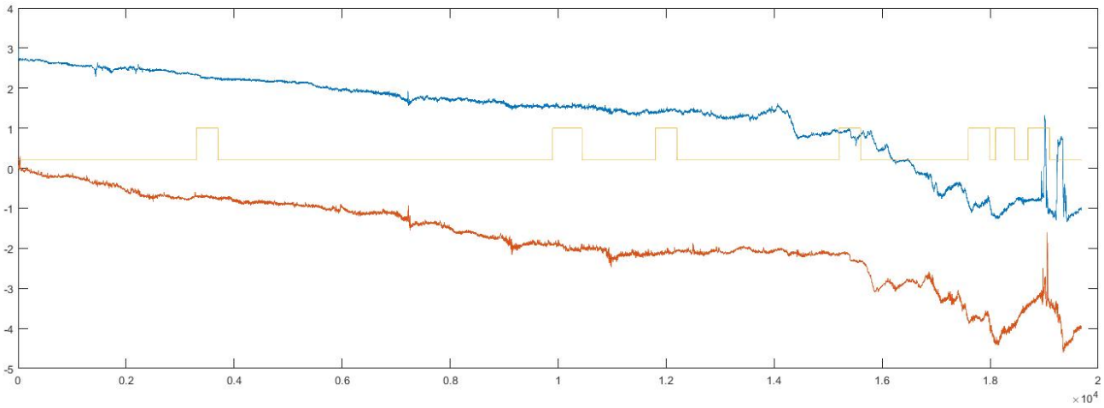
P. Nr.	Group	Gender	Smile Duration (μ)	Total time (s)	Count	Frequency (c/s)	Frequency c/m
1	D	F	1.35	259	6	0.0231660	1.3899614
2	S	F	2.91	291	14	0.0481100	2.8865979
3	D	M	4.77	324	6	0.0185185	1.1111111
4	S	M	1.45	334	8	0.0239521	1.4371257
5	D	F	2.3	239	9	0.0376569	2.2594142
6	S	F	1.17	222	1	0.0045045	0.2702703
7	D	M	1	237	4	0.0168776	1.0126582
8	S	M	2.71	227	7	0.0308370	1.8502203
9	D	M	2.16	180	4	0.0222222	1.3333333
10	S	M	1.7	193	1	0.0051813	0.3108808
11	D	M	1.38	218	6	0.0275229	1.6513761
12	S	F	1.96	275	19	0.0690909	4.1454545
13	D	M	1.51	239	11	0.0460251	2.7615063
14	S	M	1.48	258	5	0.0193798	1.1627907
15	S	F	3.75	263	7	0.0266160	1.5969582
17	D	M	5.13	263	2	0.0076046	0.4562738
18	D	F	2.78	317	12	0.0378549	2.2712934
19	D	M	1.88	323	2	0.0061920	0.3715170
20	S	M	1.7	242	12	0.0495868	2.9752066
21	D	F	1.32	173	3	0.0173410	1.0404624
22	S	F	1.37	203	3	0.0147783	0.8866995
23	S	F	1.36	187	5	0.0267380	1.6042781
24	D	F	3.21	234	8	0.0341880	2.0512821
25	S	F	3.18	175	5	0.0285714	1.7142857
26	S	M	2.44	223	2	0.0089686	0.5381166
27	D	F	3.14	258	6	0.0232558	1.3953488
28	S	M	2.87	218	4	0.0183486	1.1009174
29	D	M	1.31	287	5	0.0174216	1.0452962
30	S	M	2.74	212	6	0.0283019	1.6981132
31	D	M	3.13	241	5	0.0207469	1.2448133
32	S	F	3.96	220	3	0.0136364	0.8181818
33	D	F	1.76	271	14	0.0516605	3.0996310
34	S	M	3.69	280	11	0.0392857	2.3571429

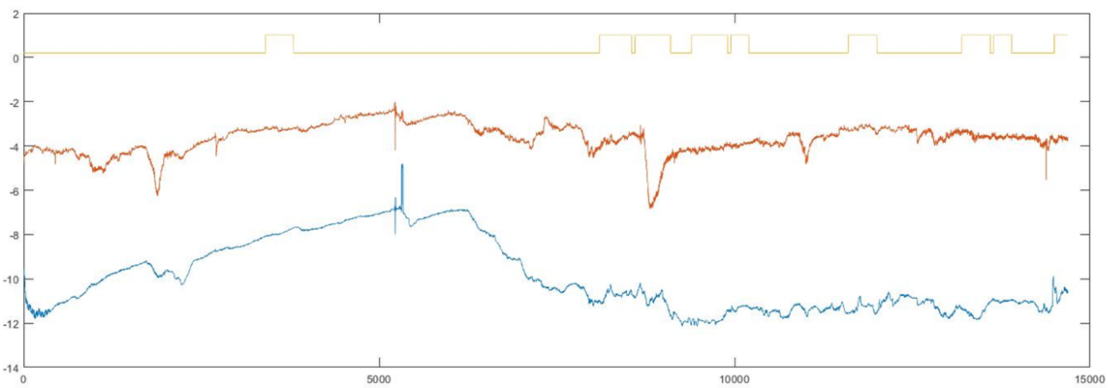
Appendix IV – EMG Data (Combined with video data)

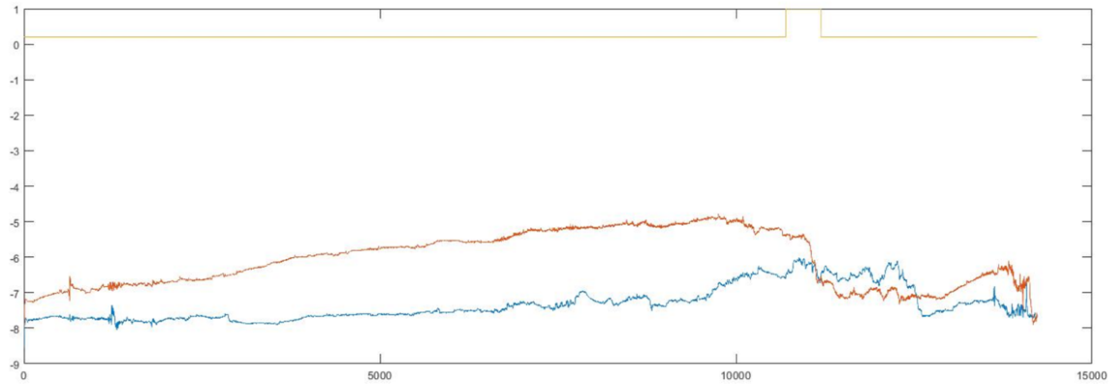
A. Graphs (per participant) – In Chronological Order

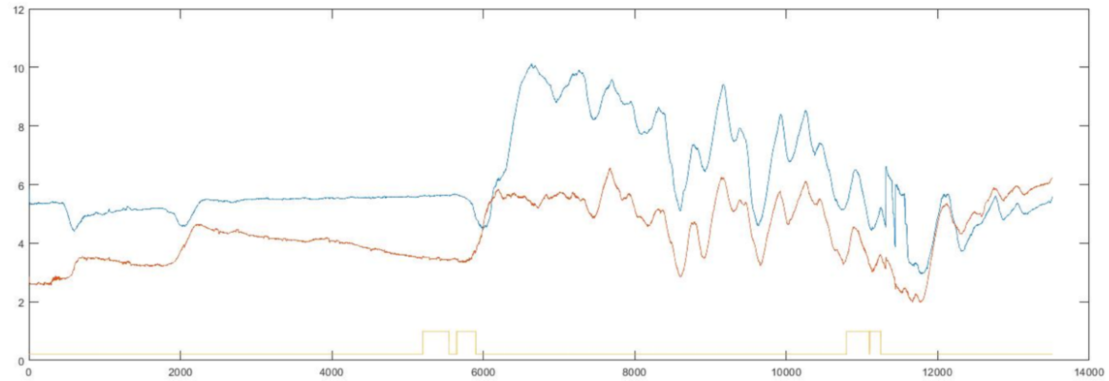


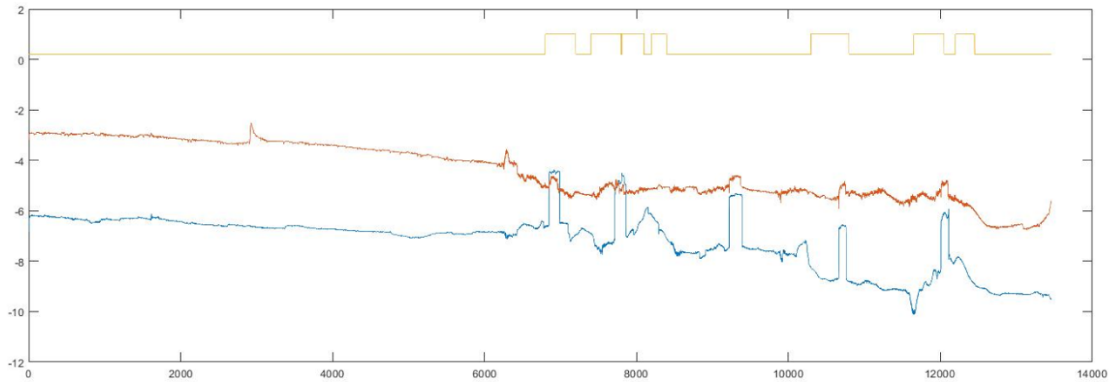


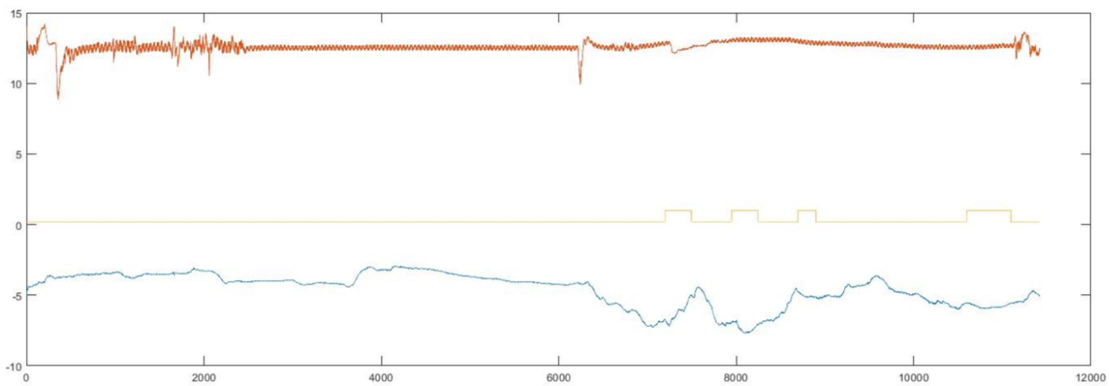


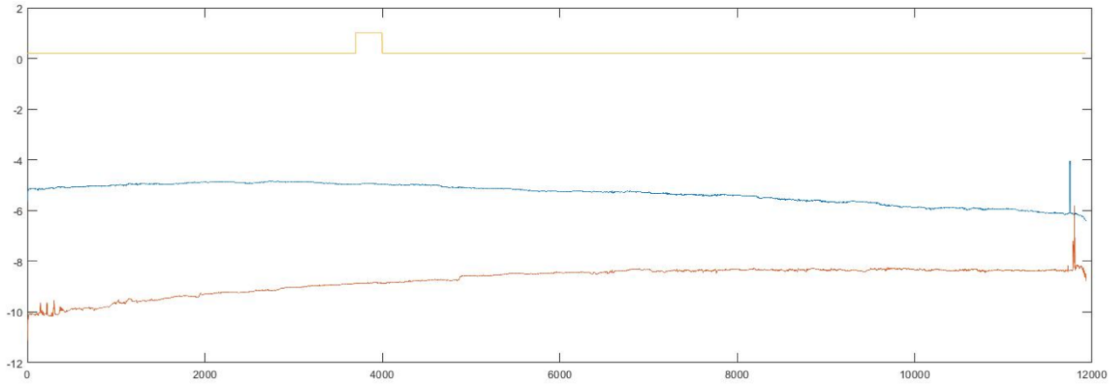


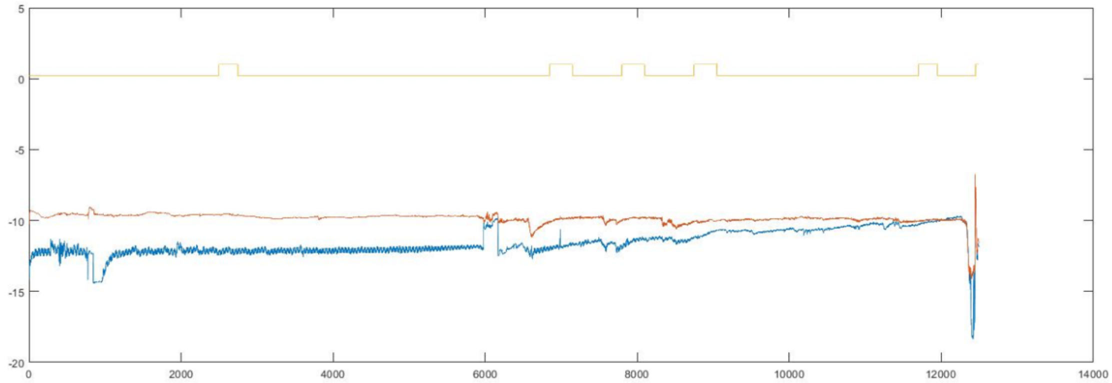

1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
0
5000
10000
15000

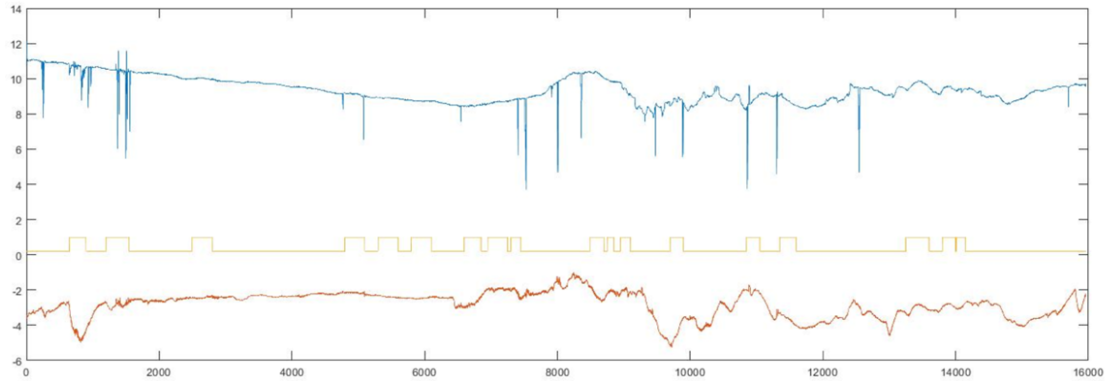

12
10
8
6
4
2
0
0
2000
4000
6000
8000
10000
12000
14000

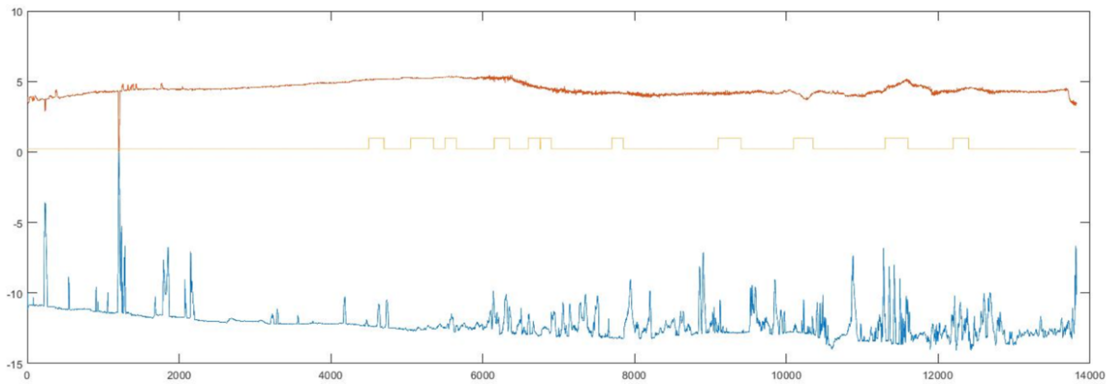

2
0
-2
-4
-6
-8
-10
-12
0
2000
4000
6000
8000
10000
12000
14000

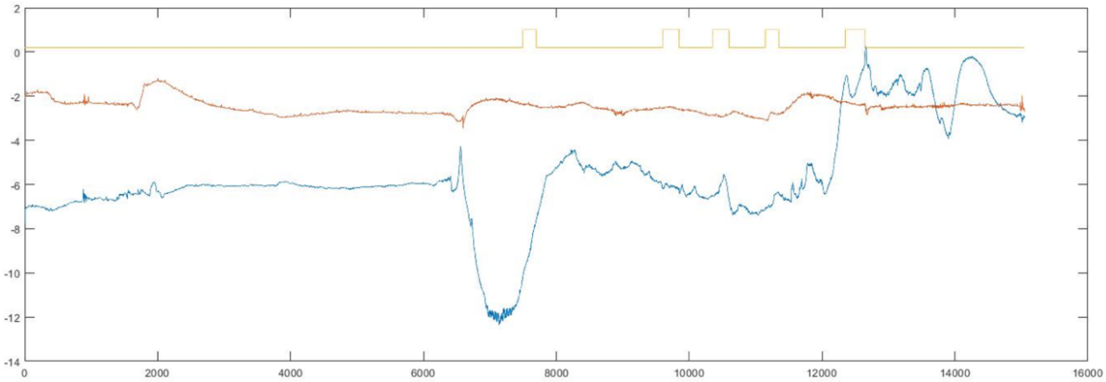

15
10
5
0
-5
-10
0
2000
4000
6000
8000
10000
12000


2
0
-2
-4
-6
-8
-10
-12
0 2000 4000 6000 8000 10000 12000

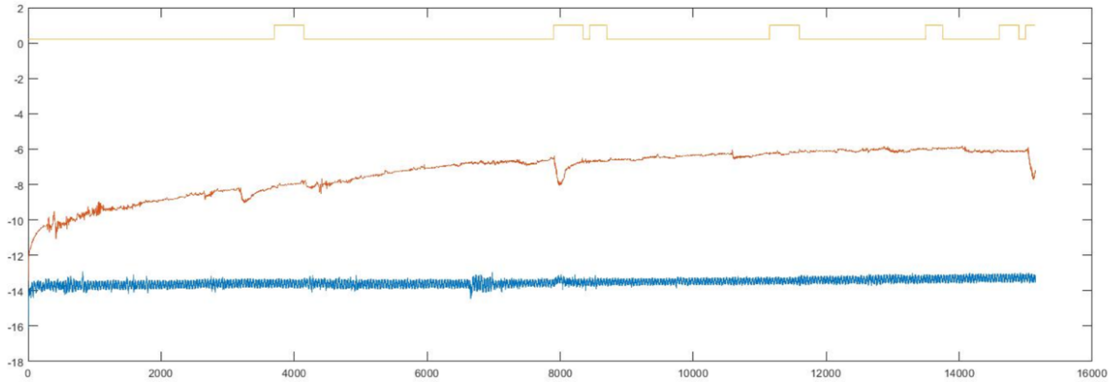

5
0
-5
-10
-15
-20
0 2000 4000 6000 8000 10000 12000 14000


14
12
10
8
6
4
2
0
-2
-4
-6
0 2000 4000 6000 8000 10000 12000 14000 16000

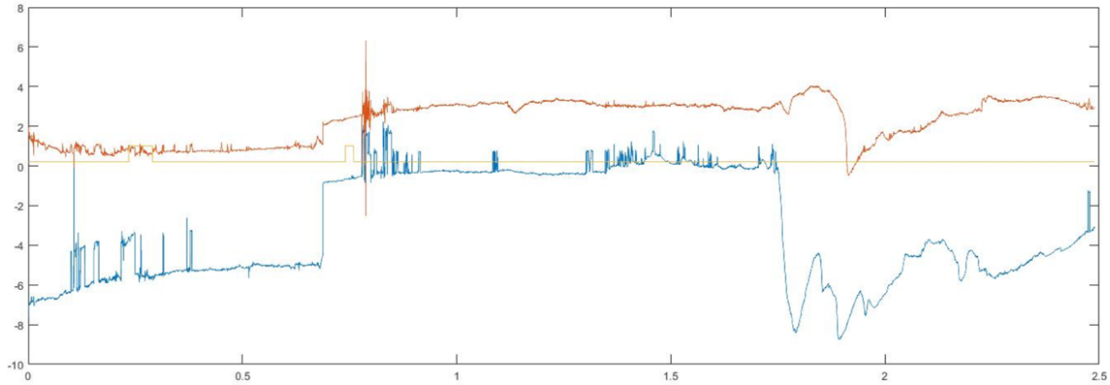

10
5
0
-5
-10
-15
0 2000 4000 6000 8000 10000 12000 14000



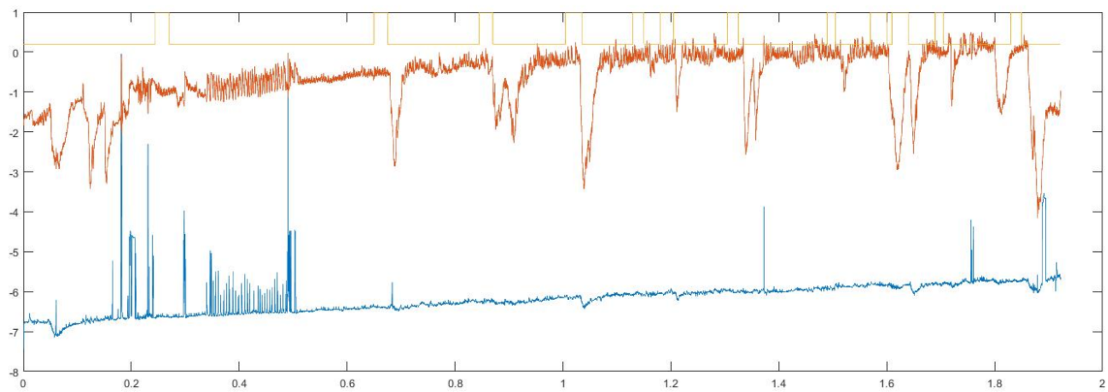
2
0
-2
-4
-6
-8
-10
-12
-14
0
2000
4000
6000
8000
10000
12000
14000
16000



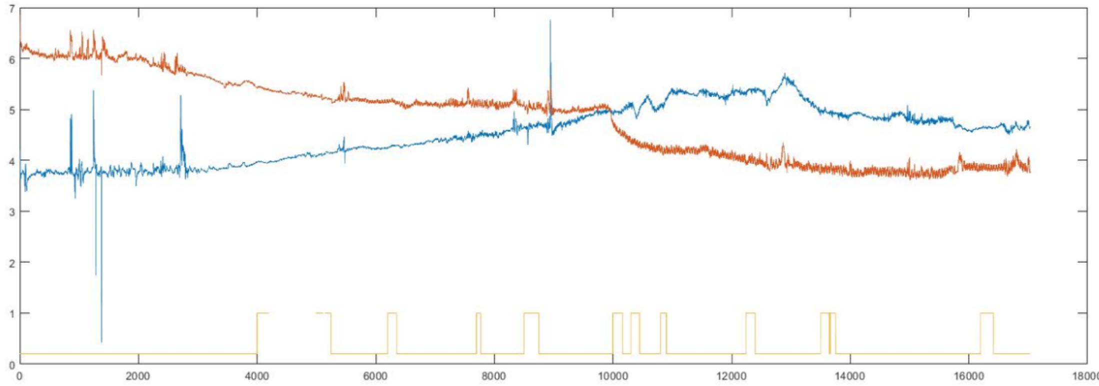
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
2000
4000
6000
8000
10000
12000
14000
16000

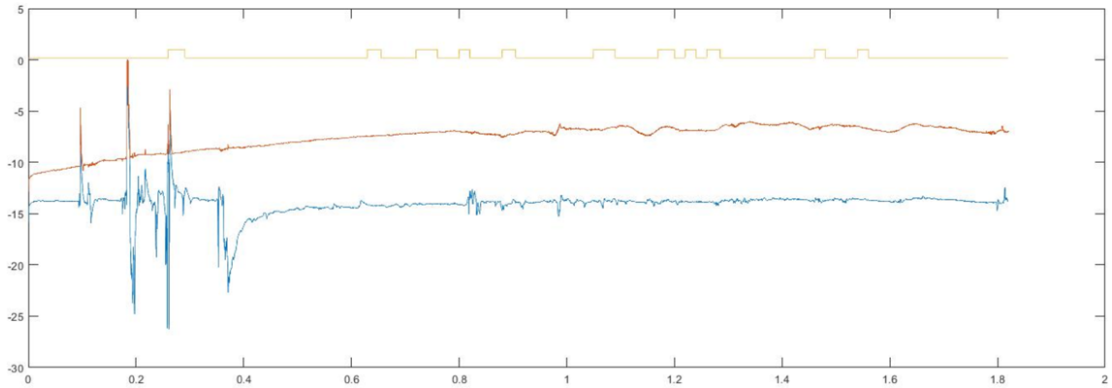


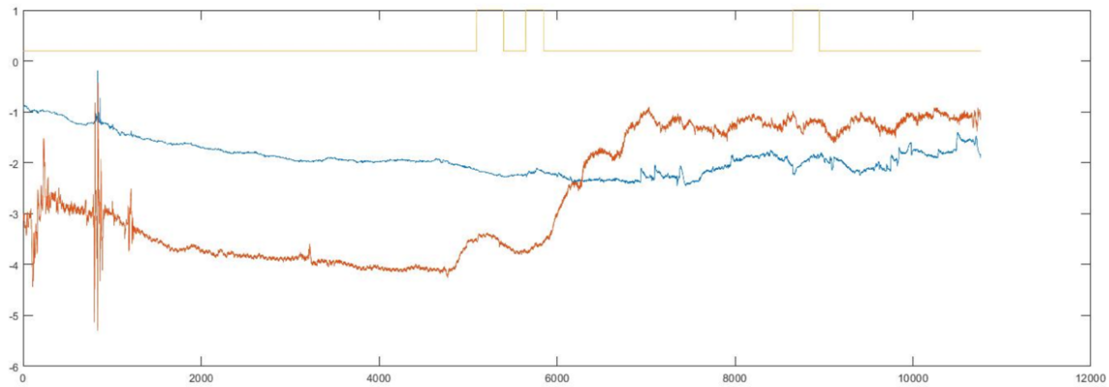
8
6
4
2
0
-2
-4
-6
-8
-10
0
0.5
1
1.5
2
2.5

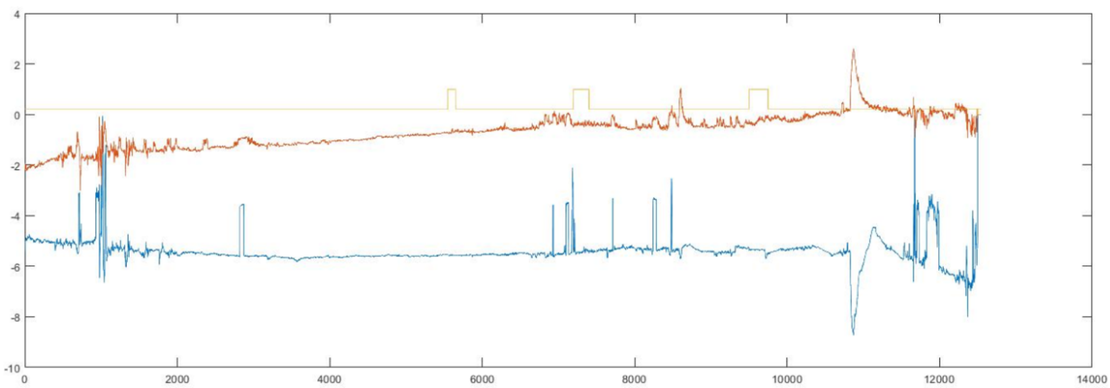


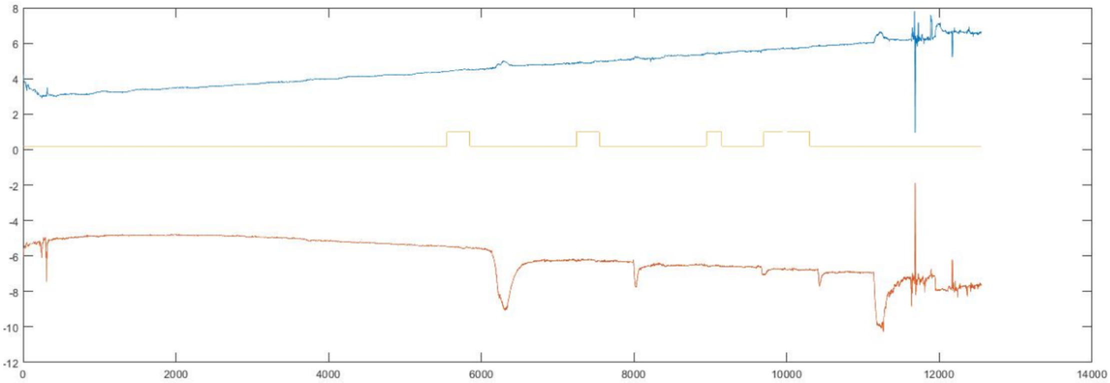
1
0
-1
-2
-3
-4
-5
-6
-7
-8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

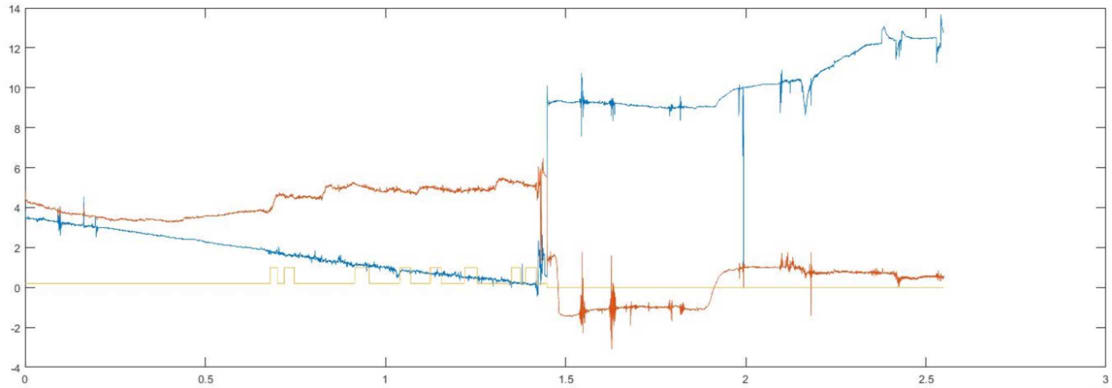

7
6
5
4
3
2
1
0
0 2000 4000 6000 8000 10000 12000 14000 16000 18000

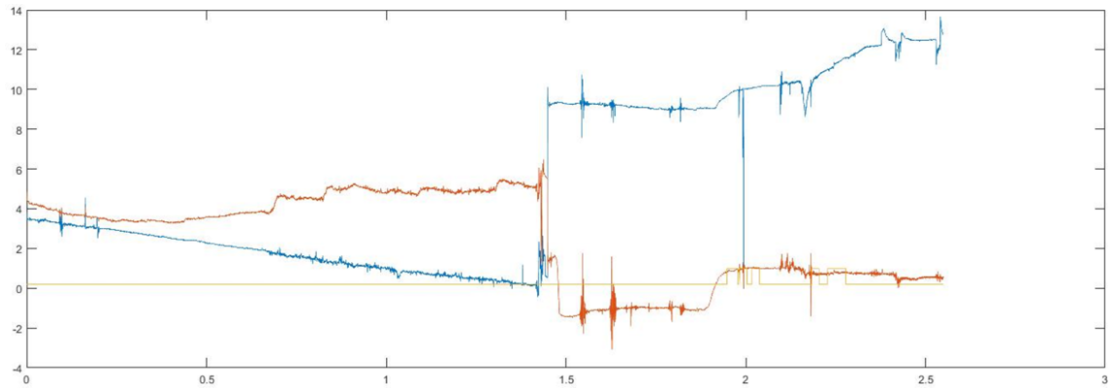

5
0
-5
-10
-15
-20
-25
-30
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2

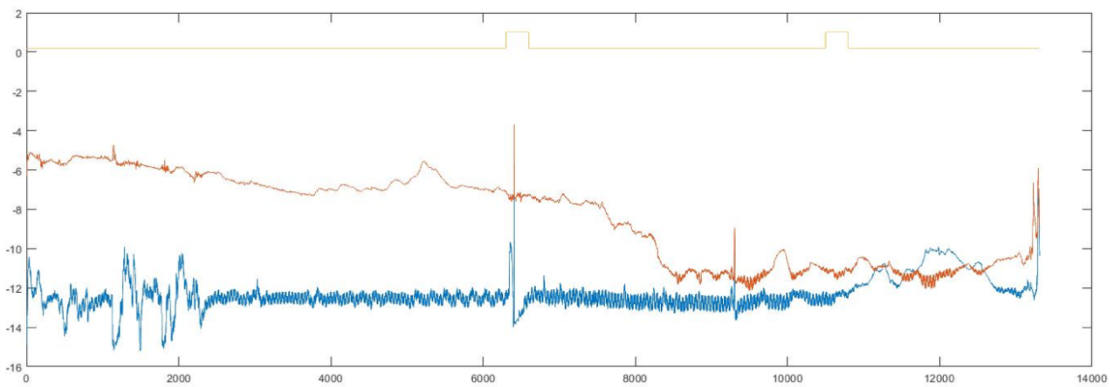

1
0
-1
-2
-3
-4
-5
-6
0 2000 4000 6000 8000 10000 12000

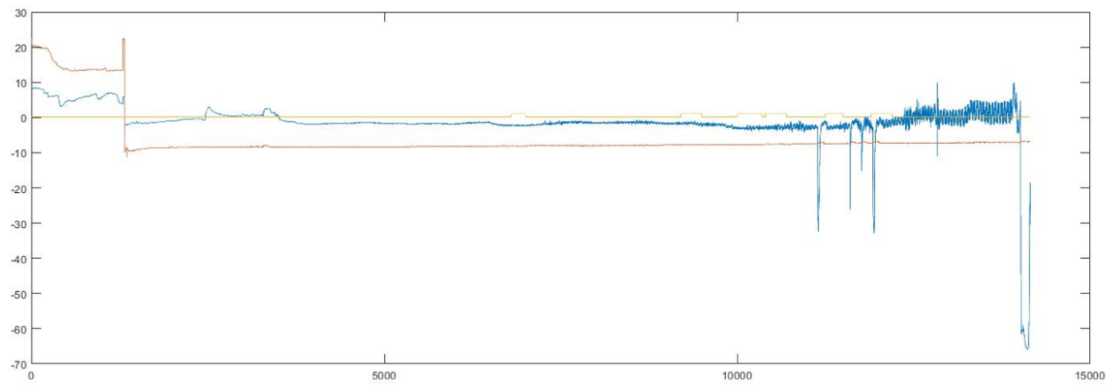

4
2
0
-2
-4
-6
-8
-10
0 2000 4000 6000 8000 10000 12000 14000

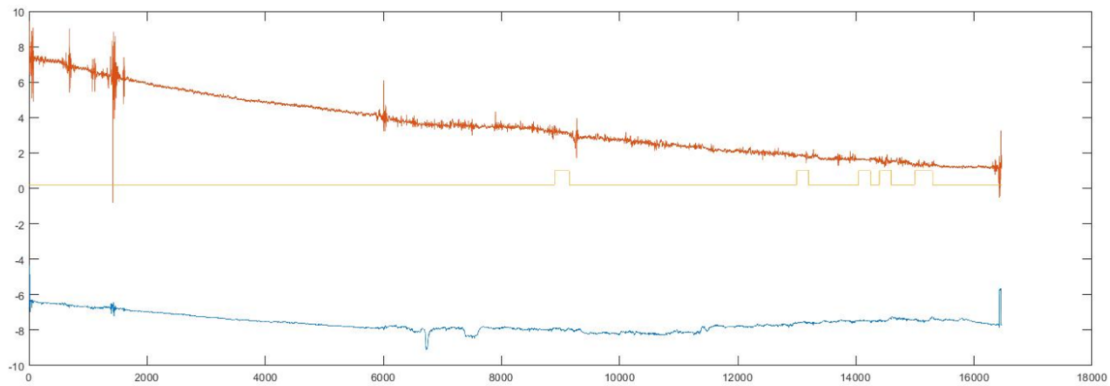

8
6
4
2
0
-2
-4
-6
-8
-10
-12
0
2000
4000
6000
8000
10000
12000
14000

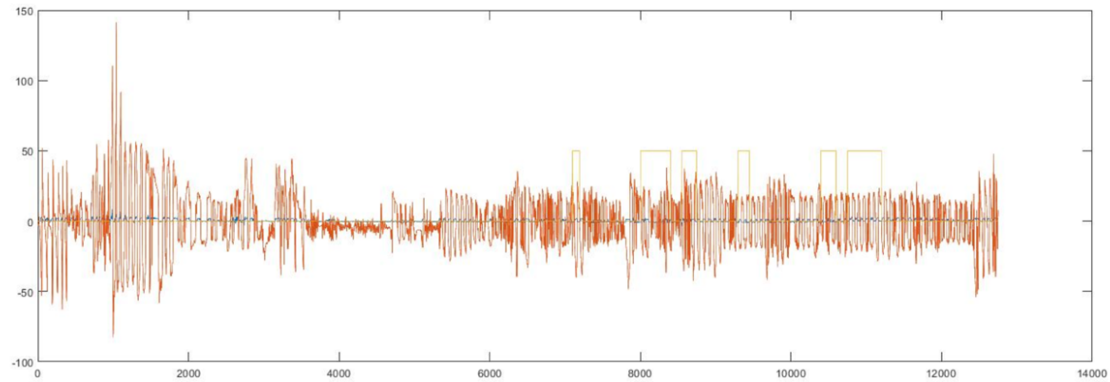

14
12
10
8
6
4
2
0
-2
-4
0
0.5
1
1.5
2
2.5
3

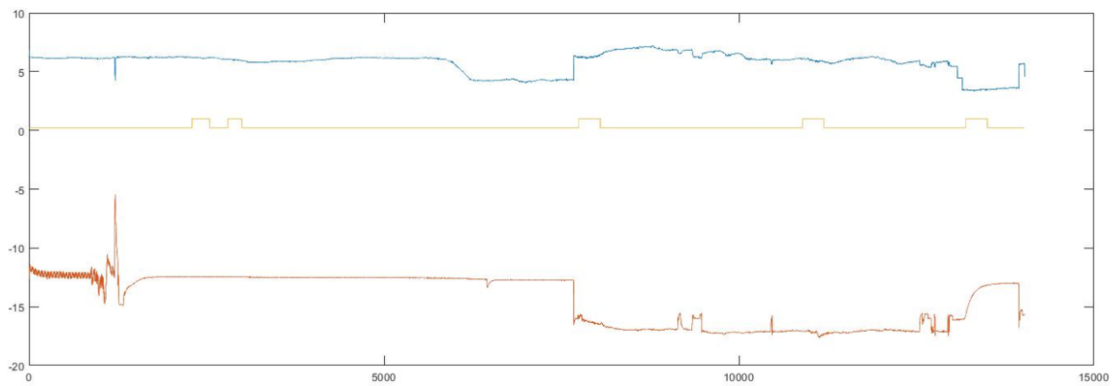

14
12
10
8
6
4
2
0
-2
-4
0
0.5
1
1.5
2
2.5
3

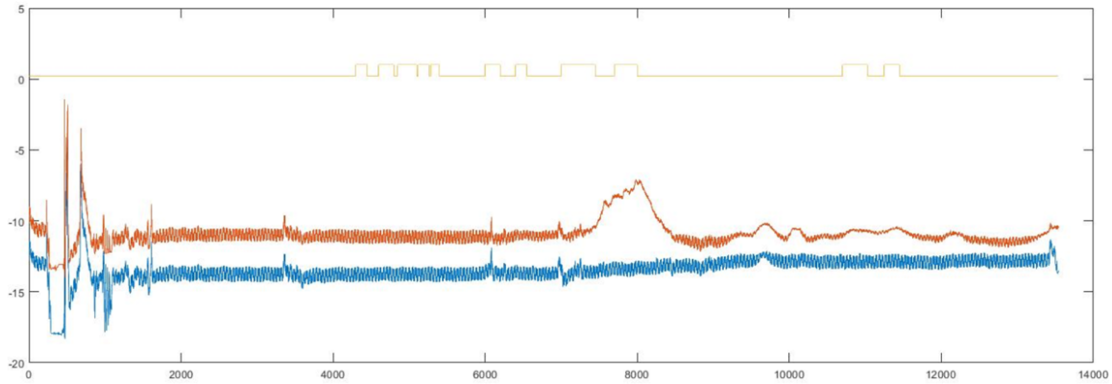

2
0
-2
-4
-6
-8
-10
-12
-14
-16
0
2000
4000
6000
8000
10000
12000
14000

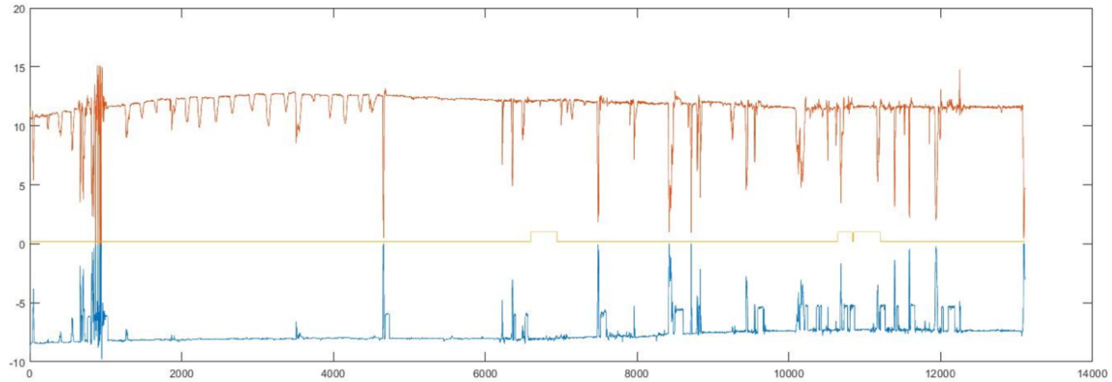

30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0
5000
10000
15000

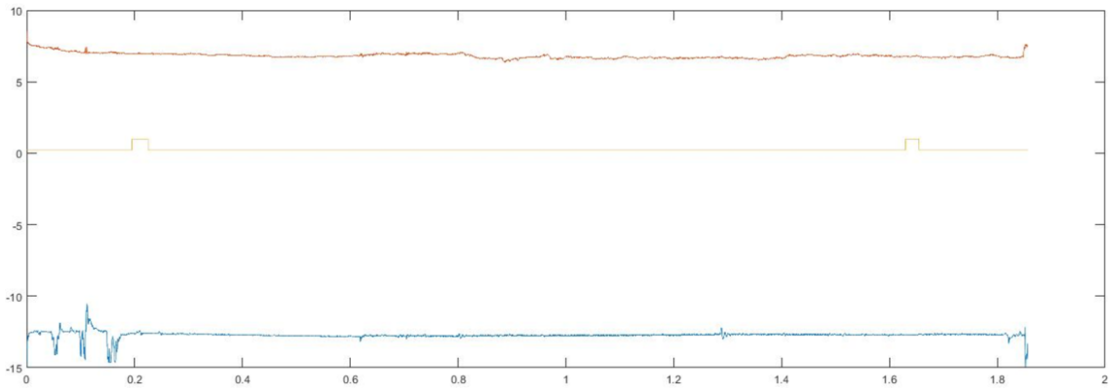

10
8
6
4
2
0
-2
-4
-6
-8
-10
0
2000
4000
6000
8000
10000
12000
14000
16000
18000


150
100
50
0
-50
-100
0
2000
4000
6000
8000
10000
12000
14000


10
5
0
-5
-10
-15
-20
0
5000
10000
15000


5
0
-5
-10
-15
-20
0
2000
4000
6000
8000
10000
12000
14000


20
15
10
5
0
-5
-10
0
2000
4000
6000
8000
10000
12000
14000


10
5
0
-5
-10
-15
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

B. EMG – Raw Data – Types of Smiles

P. Nr.	Group	Gender	Total Smiles	Duchenne	Non-Duchenne	Unidentifiable
1	D	F	6	3	2	1
2	S	F	14	6	4	4
3	D	M	6	2	3	1
4	S	M	8	3	2	1
5	D	F	9	4	4	0
6	S	F	1	0	1	0
7	D	M	4	2	0	2
8	S	M	7	5	1	1
9	D	M	4	1	0	3
10	S	M	1	0	0	1
11	D	M	6	3	2	1
12	S	F	18	5	7	6
13	D	M	11	3	5	3
15	S	M	5	2	3	0
17	S	F	7	2	3	3
18	D	M	2	1	0	1
19	D	F	12	5	7	0
20	D	M	14	2	11	1
21	S	M	11	3	4	4
22	D	F	3	1	1	1
23	S	F	3	3	0	0
24	S	F	5	2	2	1
25	D	F	8	1	2	5
26	S	F	5	3	1	1
27	S	M	2	1	0	1
28	D	F	6	2	1	3
30	D	M	5	0	4	1
31	S	M	6	0	0	6
32	D	M	5	2	1	2
33	S	F	12	2	3	6
34	D	F	3	3	0	0
35	S	M	2	0	1	1

Appendix V – Questionnaire Raw Data

A. Questionnaire data – Dominant Agent

Nr.	Gender	Age	Worked with VR	Ever had a JI	Nationality	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
1	F	21-25	No	Yes	Dutch	4	4	2	4	4	3	4	4	3	4	4	4	4
3	M	21-25	Yes	Yes	Dutch	2	4	2	3	2	4	1	3	2	2	4	1	2
5	F	21-25	No	Yes	German	4	5	4	3	4	3	4	4	2	2	4	5	4
7	M	21-25	No	No	Dutch	4	3	2	2	4	2	3	4	1	2	2	4	4
9	M	26-30	Yes	Yes	Dutch	3	4	4	4	5	3	1	4	3	2	2	3	4
11	M	26-30	Yes	No	Dutch	4	3	4	3	2	4	2	4	2	2	3	4	4
13	M	21-25	Yes	Yes	Dutch	5	4	5	4	4	4	3	3	1	2	3	4	2
16	F	26-30	Yes	Yes	Dutch	4	4	3	4	3	4	2	4	1	4	3	5	4
18	M	21-25	Yes	Yes	Dutch	4	2	2	4	3	4	4	5	2	2	4	4	4
19	F	21-25	No	Yes	Iranian	2	2	4	2	4	2	2	4	4	1	2	5	5
20	M	21-25	Yes	Yes	Dutch	2	3	5	3	5	3	4	4	1	4	3	5	5
22	F	18-20	Yes	Yes	Dutch	4	2	2	2	4	3	3	4	2	4	4	4	2
25	F	21-25	Yes	Yes	Dutch	2	4	4	2	4	3	1	4	2	2	4	3	2
28	F	17	No	Yes	Dutch	2	3	3	2	4	3	2	3	2	2	3	4	2
30	M	18-20	Yes	No	Dutch	5	4	4	4	4	4	2	1	2	5	4	1	2
32	M	21-25	Yes	Yes	German	4	4	3	4	3	4	3	5	2	2	4	4	4
34	F	21-25	Yes	Yes	Dutch	4	3	5	2	3	2	2	4	1	3	3	2	4

B. Questionnaire data – Submissive

Nr.	Gender	Age	Worked with VR	Ever had a JI	Nationality	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
2	F	21-25	Yes	Yes	Dutch	3	3	2	3	4	4	4	3	3	2	3	2	2
4	M	26-30	Yes	Yes	Chinese	2	4	4	4	3	4	4	3	2	4	4	4	3
6	F	18-20	Yes	Yes	Dutch	4	4	2	4	4	4	3	2	3	2	2	3	2
8	M	18-20	Yes	Yes	Dutch	4	4	3	4	4	3	1	2	1	2	3	2	1
10	M	41+	Yes	Yes	Dutch	4	4	4	4	4	4	2	3	4	3	3	2	3
12	F	18-20	Yes	Yes	Dutch	4	5	2	4	2	4	2	2	5	2	4	1	1
15	M	21-25	Yes	Yes	Dutch	4	4	2	3	2	3	2	3	2	2	3	2	2
17	F	17	Yes	No	Dutch	4	4	4	4	4	4	2	3	4	2	3	2	1
21	M	21-25	Yes	Yes	Dutch	4	4	3	3	3	4	3	4	2	4	2	4	4
23	F	18-20	No	Yes	Dutch	4	2	3	2	4	4	4	2	2	2	4	2	2
24	F	21-25	Yes	Yes	Italian	4	5	3	4	3	3	1	3	4	3	3	2	4
26	F	21-25	Yes	Yes	Dutch	2	2	4	3	3	3	4	2	2	4	4	3	3
27	M	21-25	Yes	Yes	Dutch	5	5	4	3	2	4	3	3	2	4	4	2	2
29	M	18-20	No	No	Dutch	4	4	2	2	3	4	1	4	2	3	3	2	3
31	M	18-20	Yes	Yes	Dutch	5	2	4	2	4	4	3	2	4	4	2	2	2
33	F	21-25	Yes	Yes	Dutch	5	4	2	3	3	4	3	2	4	3	3	1	2
35	M	18-20	Yes	No	Dutch	4	2	4	3	4	4	2	3	2	4	4	2	2